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Water Scarcity and Climate Change: The Search for an Optimal and Sustainable Management

Abdelhafid Aimar
Associate Professor
University of Jijel
Algeria

Hana Erabti
Assistant Professor
University of Jijel
Algeria

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Athens Institute for Education and Research
8 Valaoritou Street, Kolonaki, 10671 Athens, Greece
Tel: + 30 210 3634210 Fax: + 30 210 3634209 Email: info@atiner.gr
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Abdelhafid Aimar
Associate Professor
University of Jijel
Algeria

Hana Erabti
Assistant Professor
University of Jijel
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Abstract

Since the turn of the 20th century, water scarcity and climate change have become a major global issue as they affect national economies, human and animal lives and the environment. Growing demand for diminishing water resources and extreme climate events are posing serious challenges to governments worldwide in terms of sustainable development, food security and national stability. Population growth, rapid urbanization, rainfall patterns, soil humidity, water-related disasters like floods and droughts are significantly impacting production and threatening human security. Excessive and careless use of water, as well as pollution and salinity constitute serious threats to scarce water resources and deteriorate the quality of water in a considerable number of countries. Unless individuals change the ways water is used and governments and all parties concerned improve water management, many regions will be facing a serious water crisis. This paper raises and analyses a number of water issues with the aim of reaching a better understanding of water scarcity problems in the context of climate change. It seeks to suggest effective ways to face water scarcity and to deal with future risks of climate change. It sheds light on prominent cases and emphasizes the need for local, regional and international cooperation and coordination to cope with climate changes, raise water–use efficiency and sustain scarce water resources.

Keywords: water scarcity, climate change, water-use efficiency, sustainable management, human security

Introduction

Since the turn of the 20th century, water scarcity and climate change have become a major global issue as they affect national economies, human and animal lives and the environment. Touted as "the next oil", water is a vital resource to sustain life on Earth. Humans need it to drink, to produce crops, to generate power, to manufacture goods, and for sanitation. Global demand on diminishing water resources is growing fast. This is affecting quality of life and creating global panic. Extreme climate events are putting further pressures on water resources and seem to be hampering global sustainable development, energy production, food security and national stability.

International institutions and specialized research bodies are warning of the great challenges that the world is facing and will be facing by 2050 and beyond. Population growth, rapid urbanization, rainfall patterns, soil humidity, water-related natural disasters, like floods and droughts, are significantly degrading the environment, impacting economies and threatening human security. Today, about 2.8 billion people live in areas of water scarcity or stress, over 768 million people lack access to safe drinking water and more than 1.3 billion people have unreliable or no access to electricity (Rex, Foster 2014).

Excessive exploitation of groundwater is causing depletion of aquifers, some of which are nonrenewable. This constitutes a serious threat to human security, especially in arid and semi-arid regions which rely almost exclusively on groundwater. Climate change further threatens groundwater availability and use. It is expected to raise competition among different users of water and have profound impacts on national economies. This urges the need for optimal and sustainable water management approaches.

Nowadays, pollution and salinity are deteriorating the quality of water and are posing serious threats to scarce water resources worldwide, particularly in poor developing countries because of inadequate technical and financial capabilities. Pollution, combined with careless use of water, is causing to governments huge financial losses annually. Unless individuals change the ways water is used, and governments and all parties concerned improve water management, many regions will be facing serious water problems in the foreseeable future.

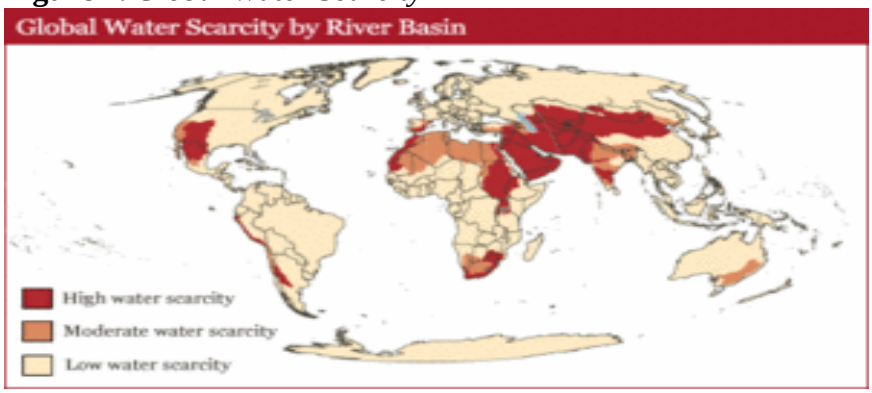
This paper raises and analyses a number of water issues with the aim of reaching a better understanding of water scarcity problems in the context of climate change. It seeks possible ways to tackle the problem of shrinking water resources and rising global water demand. This study tries to suggest effective ways to face water scarcity and to deal with future risks of climate change. It sheds light on prominent cases and emphasizes the need for local, regional and international cooperation and coordination to cope with climate changes, raise water–use efficiency and sustain scarce water resources.

Water Scarcity

Water scarcity refers to the lack or shortage of freshwater for use. It means insufficient water supplies to meet increasing water demands. It is the distinctive feature of arid and semi-arid areas and often occurs in regions suffering drought or water contamination. Water scarcity can also be the outcome of overexploitation of water resources. If water shortages continue, the gap between demand for freshwater and global supply will widen even further over the years.

Availability of 1.000 cubic meters per capita per year in a country or region is considered to be enough to meet the daily requirements of households, agriculture and industry, as well as to sustain local ecosystems. Below this threshold, water becomes scarce. However, countries or regions where water availability is or below 1.700 cubic metres per person per annum are regarded as areas under water stress (WBCSD 2006). It is estimated that about 2.8 billion people live in areas experiencing scarcity or stress. But the number of people living in areas with absolute water scarcity is projected to increase to 4.2bn by 2080 (WB March 2014).

Figure 1. *Global Water Scarcity*



Source : http://www.unwater.org/water-cooperation-2013/

Water resources are very unevenly distributed worldwide in terms of availability and use. Just nine countries possess 60% of the world's available freshwater supply: Brazil, Russia, China, Canada, Indonesia, USA, India, Columbia and the Democratic Republic of Congo (WBCSD 2006). In some countries, like the USA and Russia, per capita water consumption is about 3,000 cubic metres per year, whereas in other countries, like Yemen, this figure is about 100 (Anderson 2014). Freshwater is also inequitably distributed within countries. Like in China and Mexico some areas are water-abundant and others are water scarce.

However, water scarcity is particularly widespread in MENA countries, Africa and parts of Asia, as illustrated in Figure1. MENA countries vary from arid to semi-arid and they share only 0.5% of the world's total freshwater, while the region's population will grow to more than 600 million during the next 25 to 30 years (water encyclopedia 2014). Thus, the Arab region is more

exposed to the dangers of water scarcity, particularly the Gulf region where surface water is quasi inexistent and rainfall is very limited.

Water demand in Arab countries is increasing fast leading to higher water costs. It is reported that the average water consumption per person now is around 700 litres per day in the GCC States compared to 130 litres in the European Union (Bishara 2014). This excessive water consumption in the Gulf region is mainly due to low water tariffs, cheap energy and carelessness. It reflects inefficiency in water resource management and is costing the GCC economies billions of dollars. In this respect, G. Lahn noted that if the Saudi government improves water-use efficiency it can save US$ 36bn in the years to come (Lahn et al. 2013).

Major Causes of Water Scarcity

The causes of water scarcity vary from natural to human. Natural causes are essentially climate change and drought, but human causes are diverse and are mainly population growth, rising demand for food crops, increasing urbanization, over-use of water, rising standards of living, water pollution, water mismanagement, lack of water treatment plants, carelessness of people, land use and resource allocation. However, this paper focuses on what seems to be more prominent and impacting causes.

Climate Change

Increased climate variability is posing new challenges for water resource management because the climate and hydrological cycle are strongly linked (WB 2009). Climate change is particularly affecting precipitation patterns, river flows, groundwater, land temperature and soil humidity. Climate changes are causing floods, droughts, desertification, major storms and wild fires. Droughts and floods are expected to become frequent in different areas at various times. Rises in temperature will change rainfall patterns and increase the rate of evaporation. These intensified climate events are degrading the environment worldwide and deeply affecting economies, food crops, human health, livelihoods and livestock. Poor and arid countries are the most vulnerable.

In the long run, climate change threatens to alter precipitation patterns and aquifer recharge, making water availability less predictable and forcing many parts of the globe to live in severe water shortages. For example, it is forecast that summer flows in southern Europe and some parts of central and Eastern Europe are likely to drop by up to 80%. As a result, Europe's hydropower potential is expected to decrease by an average of 6% over the same period (Alcamo et al. 2007). Furthermore, it is estimated that the number of people living under conditions of water stress in Europe will rise from 28 million to 44 million by 2070 (UNWATER 2013).

More significantly, the warming trend and rainfall changes are forecast to cause more frequent droughts and floods worldwide, as well as extensive forest

fires. Over the last ten years, there have been floods in many countries like Australia, Pakistan, The UK, Saudi Arabia, and Algeria. These floods have resulted in huge human and financial losses as they devastated crops and properties and left thousands of people homeless. Likewise, there have been severe droughts worldwide, particularly in Australia, Africa, Sri Lanka and the Middle East. Protracted droughts in these regions have affected water supplies, especially to farmers and to major cities. Increased water temperatures are also forecast to provoke sea level rise, filling coastal groundwater stocks with seawater in many parts of the world. This will affect water quality and reduce freshwater availability.

From this perspective, the cost of adaptation to the effects of extreme climate variations could be astronomical. According to a World Bank report issued in 2010, the adapting cost to a 2°C increase in global temperature could reach as far as US$ 100bn per annum between 2020 and 2050 (WB 2010). Thus, the world's governments are urgently required to raise preparedness to face the serious threats and uncertainty of climate change. This can particularly be done through investing largely in water infrastructures and their staff. This will likely improve water management, sustain water availability and maintain human security.

Population Growth and Urbanization

The total water available on the planet has not changed in spite of climate variations. However, compared to water availability, the world's population has considerably increased since the second half of the 20th century and will continue to grow in coming decades. Indeed, the water resources that were used a few decades ago by three billion people are now being used by seven billion people and will be used by more than nine billion people by 2050. As a result, water availability is expected to decrease in many regions and water scarcity is likely to become more severe in the years to come due to rising water demands and climate variations.

Water use for household purposes is estimated at 8% of global freshwater withdrawals (WBCSD 2006). But household water demand is forecast to increase fast not only because of population growth but also because of rapid urbanization. Today, more than 50 percent of the world's population lives in urban areas and this rate is expected to accelerate in the future. So, unless there are adequate increases in global water supplies, through conservation and treatment, there will be significant water shortages worldwide in the decades to come. According to a World Bank report, with current practices, the world will face a 40% global shortfall between forecast demand and available supply of water by 2030 (WB March 2014).

What makes matters worse is that about 85% of the world's population lives in the driest half of the planet (UNWATER 2013). The populations of dry and urban regions are forecast to further grow, putting additional pressure on scarce water resources and, therefore, increasing the number of people without access to safe potable water who are already more than 783 million (UNWATER 2013).

Pollution

Pollution is one of the great challenges the world is facing today as it threatens all aspects of natural and human life. It is recognized that pollution is caused by humans because of their misuse of land resources and improper disposal of waste material. It has tremendous impacts on the environment and it poses serious threats to water contamination. In so doing, it deteriorates the quality of water in the entire planet. Indeed, pollution is affecting freshwater availability and making the soil less productive or dangerous to living species.

A wide range of factors related to industrialization and urbanization are behind water pollution. These would include dumping of solid waste, dirty water from factories, pesticides, garbage, toxic debris, household waste, oil slick and deforestation. Statistics show that about two million tons of sewage is discharged into the world's waterways and over 80% of used water worldwide is not collected or treated (Corcoran et al. 2010).

In developing countries, it is estimated that 90 per cent of wastewater flows untreated into rivers, lakes and highly productive coastal areas (Corcoran et al. 2010). For instance, The World Bank recorded in Tunisia alone more than 750 sources of water pollution and 155 million cubic metres of waste every year (Croitoru, Sarraf 2010). Thus, pollution threatens freshwater sustainability, human health, food security and the environment.

Water Leakages

Water leakages occur because of deficient water management. They significantly contribute to water scarcity worldwide. The world loses trillions of gallons of water yearly through leaks in aging pipeline infrastructure and inefficient distribution networks. For example, the US loses six billion gallons daily of expensive treated water (Gallet 2013). Likewise, water leaks in the GCC region, represent about 30% of water consumption as compared to 5% in Europe (Bishara 2014).

Water leaks are expected to increase in the future because water pipelines will continue aging and hence existing water supply infrastructure will be unable to support the growing burden of population growth and industry. For example, it is estimated that OECD countries need to invest at least US$ 200 billion per year to replace aging water infrastructure to guarantee supply, reduce leakage rates and protect water quality (WA 2004). Thus, if it is not tackled properly, water leakage will exacerbate the problem of water scarcity.

The Effects of Water Scarcity

Water scarcity in a changing climate is projected to have widespread effects on humankind, natural life, the world’s economies and the whole environment. Water constraints affect food crops, power generation and industrial production, as well as other related economic and social sectors.

Effects on Humans and Natural Ecosystems

Water scarcity can affect human and natural life. When water is scarce, survival becomes extremely hard. Diseases would spread and become endemic problems due to lack of hygiene. It is estimated that 2.5 billion people do not have access to basic sanitation (WB, March 2014). Today, from 6 to 8 million people die annually as a result of disasters and water-borne diseases (UNWATER 2013).

Animal life in water bodies will be very difficult in water-scarce areas. Likewise, if water is not sufficiently available to plants and trees, they shrivel and subsequently die. This exacerbates droughts, desertification and makes fires more frequent. Therefore, water scarcity is likely to severely undermine the sustainability of the environment and causes widespread disasters.

Moreover, water wastage and overconsumption of energy and food are affecting people's health worldwide. For instance, obesity is becoming a serious global health problem and is increasing significantly. This is mainly due to rising global consumption of meat, dairy products and sugar. The figures issued by WHO indicate that more than 36 million deaths are attributed to chronic non-communicable diseases such as cardio vascular and respiratory diseases and diabetes (WHO 2013). According to some estimates, non-communicable diseases will cost the world's governments more than US$ 30 trillion over the next 20 years (Harvard School of Public Health, WEF 2011).

Effects on Food Production and Security

Population growth is projected to raise food demand by 50% by 2030 and 70% by 2050 (Bruinsma 2009). To meet rising food demands, agricultural outputs should be increased substantially. This will significantly increase both water and energy consumption in the agricultural sector which already accounts for about 70 to 85% of global freshwater withdrawals. It is estimated though about 15-35% of irrigation withdrawals are unsustainable (WBCSD 2006).

Future global agricultural water consumption will rise by about 19% by 2050, and this percentage will be even higher in the absence of any technological progress or policy intervention (UNWATER 2013). According to some statistics, to feed the expected 9.3bn world's population in 2050 will require approximately 50% more water supplies (Aimar 2012). This is likely to result in tensed competition for water with other water-users. In water-scarce areas, farmers would find it increasingly difficult to grow crops and/or raise production to meet growing food demand.

Table1. *Water Consumption in Food Production (1litre/1kg)*

Product	Quantity of water
Beef	**15500**
Chicken	**3900**
Rice	**3300**
Sorghum	**2800**
Soya	**1800**
Wheat	**1300**
Milk (litre)	**1000**
Corn	**900**
Potatoes	**900**

Source: (Aimar 2012).

Moreover, economic growth and increases in individual incomes are changing diets to more meat and dairy consumption. This requires additional water supplies. Table1 shows that the production of 1kg of meat, for example, needs about 15500 litres of freshwater. According to some estimates, global meat consumption will amount to 52kg per capita per annum as compared to 37kg in 1999/2001 (FAO 2006). This dietary shift is expected to have far-reaching effects on global water consumption and will lead to substantial increases in food prices. For instance, prices of corn, rice and wheat are projected to rise by 48 per cent, 40 per cent and 27 per cent respectively by the end of the current decade (Aimar 2012**)**. This expected wave of price increases is likely to generate more poverty in the future and will expose to hunger and death 1.3bn poor people earning less than a dollar per day (Aimar 2012**)**. Thus, global food and human security is in peril.

In the Arab countries, water mismanagement and cheap water and energy have led to haphazard expansion of the agricultural sector and are significantly exacerbating the scarcity of freshwater. In this respect, backward irrigation techniques are contributing to water wastage by about 75 per cent. According to some estimates, agricultural production can be raised four times with the same available quantities of water if countries in the region adopt modern water-saving irrigation systems (Aimar 2012). Indeed, decreasing water resources will sooner or later compel the Arab States, particularly the Gulf States, to choose between using water in agriculture and industry and satisfying urban needs.

Water overconsumption and arid climate conditions in the GCC region are threatening the depletion of fossil aquifers. According to G. Lahn, aquifers in The United Arab Emirates will be depleted in 50 years time (Lahn 2014). Likewise, water in some aquifers in Saudi Arabia has reached dangerous levels. Undoubtedly, the depletion of nonrenewable groundwater increases the region's dependence on desalinated water. The latter is costing the GCC countries millions of barrels of oil daily and threatening the depletion of the region's oil resources, as a shift to renewable energy resources is not economically feasible in the foreseeable future.

Indeed, shrinking groundwater and rising costs of seawater desalination have prompted the oil-rich Gulf States to curb irrigation. For instance, Saudi

Arabia decided to cut cereal production by 12% a year to sustain groundwater availability (Bush 2014). Furthermore, the GCC governments urged national corporations to grab land in Africa and south Asia for agricultural purposes. Land grabbing is expected to reduce food imports and secure the region's food needs. In so doing, the Gulf States will save energy and hundreds of millions of gallons of water yearly and will likely ease or delay the depletion of fossil aquifers.

Effects on Energy and Industry

The industrial sector is the second largest user of water. It is estimated to be consuming about 22% of global water withdrawals (WBCSD 2006). Water in this sector is used in a wide range of industrial processes among which are power generation plants, mineral and oil refineries, natural gas extraction and manufacturing plants. Water withdrawal is particularly high in thermoelectric power plants as they need considerable quantities of water for cooling processes.

Water consumption in industry is generally much lower compared to agriculture. However, global demand for energy is growing faster and additional amounts of water are needed to ensure the expansion of the power industry. According to IEA reports, global energy demand is expected to grow at an annual rate of 1.5% between 2007 and 2030, which makes a total growth of about 40% (IEA 2009). More importantly, energy demand from hydropower and other renewable energy resources will rise by 60% (WWDR, 2009). This is expected to result in an increase of 85% of water consumption by 2035 (Rex, Foster 2014). Demand for energy and water will be particularly significant in Asian and Middle Eastern countries, where water resources are scarce and wastewater treatment and desalination plants are on the increase.

The risks of water constraints on energy and industrial production are forecast to be enormous worldwide. According to a report issued by the Carbon Disclosure Project (CDP) in 2013 on behalf of 530 investors, about 59% of energy companies and 67% of power utilities have experienced water-related impacts over the last five years (CDP 2013). This report particularly highlighted the impacts of water stress or scarcity on direct business operations and supply chain. Among major impacts reported were power plants shut down, decreased power generation, reduced hydropower capacity and financial losses.

Indeed, water-related power generation problems have been reported in a large number of countries. In South Africa, for example, all new power plants have been forced to shift to dry cooling systems at higher costs and lower efficiency as compared to wet cooling processes. In Sri Lanka, about 85% of hydropower generation capacity was lost due to a severe drought in 2012 (WB January 2014). Thus, if current water trends continue, water scarcity will likely make governments and companies unable to sustain power generation and industrial production, particularly in arid regions.

What can be done to Mitigate the Effects of Water Scarcity and Climate Change?

It is ample clear that the gap between rising demand and available water resources will likely widen worldwide in the future. However, it is still within reach for the world's countries to overcome the problems of water scarcity and adapt to severe climate variations through the adoption of three basic operations: reduce, recycle and reuse. Indeed, governments and all parties concerned are required to take a wide range of measures to optimize water use and sustain water availability.

Curbing Water Wastage

People around the world are seldom conscious of the costs of water production, transfer, distribution and treatment. In fact, water must be considered an economic good and, therefore, its consumption must be rationalized. This could be achieved through raising people's awareness, water price adjustment and the use of water-saving systems. In arid and semi-arid regions, household consumption should be controlled trough smart meters because they proved to be effective in reducing water consumption and wastage in many parts of the globe.

Moreover, dry areas should move away from water-based sanitation to dry-flushing systems. In this respect, it is estimated that more than 50 per cent of available water supply is used for toilet flushing and other sanitary activities (Aimar 2012). Thus, this operation can save countries suffering water scarcity millions of gallons of water annually.

Water losses during storage and distribution processes must also be stopped. To do so, governments worldwide should allocate sufficient funds to water pipeline renewals and to establish the most accurate and trusted leak detection systems. Fast detection and repairs of water leaks will help in the fight against water scarcity, raise water-use efficiency and protect the environment.

Integrated Water Management and Good Governance

Integrated water management is based on participation and decentralization and the transfer of water management to users within a coordinated and regulatory framework. The basic idea is to let all parties concerned directly involved in policy-making, alternative designing, investment choices, and water–related decisions. The major aim is to make people feel responsible and aware of water management problems.

Effectiveness and efficiency in water management are essential to sustain water resources and development. Effective water management is related to good governance. The latter is based on two fundamental values (WWDR2 2006):

- **Inclusiveness**. This implies the participation of all parties concerned in water resource management. This also suggests that all group members must receive equal treatment.

- **Accountability**. This suggests that all water users share the responsibility for the good and bad outcomes of water resource management.

Integrated water management and governance is concerned with decisions related to water extraction, storage and use. It also deals with water discharges and allocation between competing water users, including allocation to maintain basic environmental services. Integrated water management is expected to generate consensus on water governance, raise project effectiveness and efficiency, reduce costs and secure service delivery.

Integrated Water Systems

Integrated water systems emphasize energy and water planning to overcome water shortages and to enhance energy and water use efficiency. According to the World Bank, this can be achieved on the basis of the following (WB January 2014):

- Explore the use of multipurpose hydropower dams,
- Integrate water-energy infrastructure,
- Incorporate water constraints into energy planning,
- Strengthen joint energy-water governance and encourage political reform.

Integrated water systems equally seek to reduce water dependency through a set of alternatives. In this respect, the World Bank stresses the following options (WB January 2014):

- Usage of alternative cooling systems in thermal power plants,
- Water treatment and reuse from operations,
- Implementation of renewable energy technologies,
- Exploration of brackish and saline water options,
- Adoption of water and energy conservation systems.

In fact, power-generating plants in several countries have already started using recycled water instead of freshwater for cooling. A good example of water integrated systems is Project Tenorio, a recently built power plant in San Luis Potosi (Mexico), which uses water it buys from a nearby wastewater plant for cooling towers. This operation has enabled the area to reduce groundwater extraction of at least 48 million cubic meters and increased aquifer sustainability. Moreover, by using recycled water instead of freshwater the plant managed to cut water costs by 33% (Rex, Foster 2014).

Improve Irrigation Management

Promotion of more productive uses of water in agriculture is vital to cope with climate change and to save scarce water resources. The world needs to generate more food with the same or less amount of land and water. In other words, we need to raise water and land productivity. Undoubtedly, improving water productivity would help boost sustainability.

To do so, farmers should move away from old and less efficient irrigation techniques to new effective and more water-saving irrigation systems to reduce and optimize water use. Farmers must be involved in making crops more resistant to stress. They must also change cropping techniques to become more water efficient.

Moreover, agriculture should adopt irrigation systems that reuse safe treated wastewater. Governments and investors are required to coordinate development efforts, share knowledge, and provide the necessary technical assistance to farmers to improve crop yields. "Farming First" advanced a six-point action plan for enhancing sustainable water management through agriculture which seems to be worth considering (FF 2010):

a. Safeguard natural resources.
b. Share knowledge.
c. Build local access and capacity.
d. Protect harvests.
e. Enable access to markets.
f. Prioritize research imperatives.

Moreover, to optimize water usage, arid and semi-arid regions are required to explore crop choice. R&D in the agricultural sector has to be bolstered and focused on with this aspect in mind. These regions need to develop water-saving and salt-resistant harvests on the basis of "more crop per drop". They should optimize crops and produce the food that has the highest value in terms of nutrition and productivity.

Water Desalination

Water desalination, which includes both seawater and brackish water, is another important non-conventional water resource. Desalination is currently expensive compared to most alternative sources of water, and only a very small fraction of total human use is satisfied by desalination.

However, seawater desalination is extensively used in the GCC States because of scarce conventional water resources and abundance of oil and gas. It is now estimated that the GCC States produce about 60% of global desalinated water but at higher costs (water encyclopedia 2014). According to G. Lahn, the Saudi government's subsidies to water consumption increased to US$ 1.5bn in 2011, while the Kuwaiti government bears about 90% of the total country's costs of seawater desalination (Lahn et al. 2013).

The Gulf region is projected to become increasingly dependent on desalinated seawater because rainfall there is extremely insufficient and aquifers are nonrenewable (water encyclopedia 2014). This is likely to cause far-reaching economic, social and environmental problems.

Thus, the development of water desalination is a priority for scarce water countries as it is forecast to be the main source of drinking water. In the next thirty years, desalination techniques are projected to become cheaper, creating

possible solutions to water-scarce areas. The participation of the private sector could further help reduce desalination costs and increase economic efficiency.

Water Cooperation

To deal with water scarcity and intensified climate variations the international community should adopt a collective approach. These challenges should be viewed as global as they threaten natural ecosystems and obstruct global economic and social development. Governments need to coordinate and collaborate to raise preparedness to cope with the uncertainty created by climate change.

From this perspective, transboundary rivers and lake basins must be a source of cooperation instead of creating conflicts and exacerbating political tensions. In this context, it is worthwhile noting that nearly 450 agreements on international waters were signed between 1820 and 2007 (UNWATER 2013) and more than 90 international water agreements were drawn up to help manage shared water basins on the African continent (UNEP 2010).

Countries should work together to find and develop new water resources to alleviate water shortages and inefficient water usage. For example, the extinct waterways and ancient lakes in the valley of El-Arish in Sinai (Egypt), which were full of water about 5,000 years ago, might be important sources of water. Likewise, the construction of water pipelines from the Arctic to the south regions of the globe would provide possible solutions to the problems of water scarcity and stress.

International cooperation should equally deal with water pollution. Substantial financial support should be allocated to the construction of sewer networks, wastewater treatment plants and water loss reduction projects. In this respect, it should be noted that the 2009 Istanbul Ministerial Statement embodied a global commitment to "further develop and implement wastewater collection, treatment and reuse" (Corcoran et al. 2010).

The world's governments should also coordinate in terms of water resource development and research, as well as technical innovation and expertise. Developed nations should assist developing countries that lack the necessary technical and financial means to develop water resources. Joint water management programmes would help rehabilitate water supply networks and increase water availability. Cooperation programmes should be geared to achieve global sustainability and water and food security.

Conclusion

The problem of water scarcity and climate change are major threats to global security. They are both impacting natural and human resources which can be sustained only if water is sustained. Thus, water should not be taken for granted. Rather, it must be valued as a substance of life.

Nevertheless, water scarcity is being exacerbated by human practices as well. Fast population growth, rapid urbanization, pollution, water leakages,

overconsumption and carelessness are equally behind the problem of water scarcity and stress. Each of these factors is affecting water availability and threatening sustainability. If current water practices and trends are maintained, there will be a serious water disaster for future generations.

To deal with water shortages and subsequent decreases in global energy and agricultural productions, a number of tough measures are needed. Water wastage must be curbed and global water consumption must be optimized. This can be done through raising people's awareness and installing water-saving devices in buildings. Irrigation must shift to water-saving modern techniques and power-generation plants must adopt water integrated planning. Governments should also encourage farming and energy sectors to increasingly use safe treated water.

Moreover, governments worldwide are required to increase investment in water infrastructures to curb water losses and raise efficiency. They should also work collectively to find solutions to water pollution problems to preserve human health, food security and the environment. The construction of more wastewater treatment plants worldwide is extremely vital to protect water resources and sustain water availability.

To avert a global water and food crisis in the future land and water productivity has to be raised continuously to meet the increasing needs of a fast growing global population. In this respect, international cooperation should be intensified to adopt common and well-coordinated resource development policies. The whole world should work together to save the Earth and humanity from imminent water and climate disasters and to secure livelihoods for future generations.

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