CLIMATE CHANGE AND ITS EFFECTS ON FRESHWATER RESOURCES, FLOODING, AND DROUGHT WITH RELATED EFFECTS ON SOME ECONOMIC SECTORS

R. Meissner
Research Associate at the African Water Issues Research Unit at the University of Pretoria, South Africa

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Summary

The earth/atmosphere environment contains a fixed volume of water. The volume of water is, for example, exactly the same now as it was during the period of the Roman Empire. Yet, a number of elements are putting more stress on this volume of water the world has. Population growth, expanding agriculture, and urbanization are but a few of the factors that contribute to the growing utilization of water. Together these factors have a direct impact on the quantity and quality of water to be used by humans and ecosystems alike. Another element that has the potential to affect both the quantity and quality of water is global climate change. It is not only influencing water resources across the globe, but it could also be responsible for more frequent and severe floods and droughts. Because of its possible effects on freshwater resources, global climate change could also bring about a number of changes in the way humans use water for economic purposes. The economic sectors that are most vulnerable to global climate change are agriculture, electricity generation, navigation and water use in the domestic sphere. The effects will not only differ from region to region and state to state, but also between different socio-economic realms.

1. Introduction

Through the hydrological cycle land and water are brought together in an

interdependent manner. The climate of a region regulates the volume of water that an aquatic system receives via seasonal rotations. The seasonal pattern of temperature and precipitation, and the variation, thereof, govern stream flow and the production of water. There is a finite amount of water on earth, which cannot be increased or decreased - except maybe for an odd meteor bringing moisture into the atmosphere or astronauts that take some water out with them on a space mission.

Global, regional, and local climates influence the provision of water and water loss (volume) from a system, such as river basins or lake catchment areas. In hot, dry, and windy conditions, the evaporation rate of water from soil and other water surfaces is quite high. For instance, evaporation from the lower part of the Orange River in South Africa, where the climate is predominantly dry, as much as 3 000 to 4 000 millimeters (mm) can evaporate from the river's surface into the atmosphere. The climatic conditions that have an effect on evaporation can have a similar influence on the transpiration rate of plants. The drier and windier a region is, the higher the transpiration rate of plants.

What this suggests is that climate change with global, regional, and local dimensions could impact on the water resources and weather conditions that influence water related conditions, most notably flooding and drought. Besides, there could also be impacts on the different sectors of the global, regional, domestic, and geographical economies that are dependent on water for sustainable production levels. These sectors can include agriculture, industry, and the domestic (household) economic spheres. Some aspects related to these economic sectors can therefore be affected by global climate change (GCC).

There is an increased and incongruous literature with respect to climate change and the likely impacts it will have on all levels of society. We can therefore assume that considerable uncertainty regarding the intensity, timing and direction of climate change and its impacts on freshwater resources exists. Nonetheless, to make some sense in the face of this inherent uncertainty in the climate change discourse, and its likely influence on freshwater resources, this chapter will look at some of the impacts of climate change on freshwater resources, flooding and drought, in general, and also the likely impacts this could have on some human economic sectors, that are dependent on these water supplies.

2. The Global Water Budget and Its Distribution

Freshwater is one of the most important resources required for humans for a wide variety of personal, cultural, religious and economic activities. These range from sports and recreation and consumption for biological functioning to a variety of economic activities. There is more than enough water in the global environment to slack the thirst of the world at present. Just how much water does the earth/atmosphere environment contain and how is it distributed among continents, regions, states, regions within states, socio-economic dimensions and seasons?

The hydrosphere consists of water in all its forms on earth. Around 97.2 % of the hydrosphere consists of ocean saltwater; the remaining 2.8% is freshwater. The largest

freshwater reservoirs are ice sheets and mountain glaciers in the Polar Regions and other parts of the world such as high altitude mountain ranges for instance the Alps and Himalayas. The water found in these reserves accounts for about 2.15 % of the hydrosphere. Freshwater resources can also be found beneath the earth's surface. Groundwater, constitutes 0.63 % of the hydrosphere. The remaining 0.02 % is distributed in the following manner throughout the hydrosphere:

- Stream channels 0.0001 %.
- The atmosphere 0.001 %.
- Soil water (water within reach of plant roots) 0.009 %.
- Inland seas and saline lakes 0.008 %.

Although the atmosphere retains a small portion of the overall water budget - 0.001 % - this reservoir is of utmost importance to human and other life support systems. The reason for this is that it is the supply of precipitation that feeds freshwater reserves on the earth's surface and underneath it. Also, some human activities, such as dry-land farming, rely on precipitation, especially rainfall.

Because the earth/atmosphere environment has a certain amount of water, a balance must be maintained with respect to the flow of water in the hydrosphere. The volume of water in the different sectors of the hydrosphere remains constant from year to year. The flow of water links the atmosphere with the two other components on the earth's surface - land and oceans. The balance between the flows from the earth's surface to the atmosphere and back is roughly zero. The same amount of water that evaporates from the surface to the atmosphere will eventually precipitate back to the surface.

Annually the sun evaporates about 500 000 cubic kilometers (km^3) of water. The proportion that is evaporated from the oceans is about 86 % and 14 % from land surfaces, which makes up the overall volume. A similar volume of water is returned to these surfaces in the form of rain, hail, snow or sleet. During the hydrological cycle a larger proportion of the water is returned to the land than evaporates from it. In the region of about 71 500 km^3 evaporates on a yearly basis from the land, while about 110 300 km^3 gets returned to it. The hydrological cycle is therefore an important component in the distribution of freshwater resources across the hydrosphere.

Because water is abundant at the global level, this false sense of security is compounded by the fact that water is not available in the same amount to all continents and regions across the globe. The total amount of water in the earth/atmosphere environment amounts to about 1 360 million km^3. Because most (97.2 %) is contained in the oceans and about 37 million km^3 is in freshwater. Of this, three-fourths are accumulated in glaciers and icebergs. Another 8 million km^3 of freshwater comes in the form of groundwater. Of the remaining freshwater, 200 000 km^3 is stored in rivers and lakes.

Of the 110 000 km^3 that is precipitated annually over the earth's surface, 70 000 km^3 evaporates back into the atmosphere and 40 000 km^3 gets stored in rivers, lakes and groundwater reservoirs. Of this run-off to rivers and lakes, between 26 000 to 31 000 km^3 is lost to floods that end up in the sea. This leaves 9 000 to 14 000 km^3 of renewable freshwater to be used by humans and other terrestrial non-human life forms.

Currently about 4 500 km³ of water is used annually across the globe. In essence there is enough water to serve human purposes. There is a catch however. Not all this water is distributed equally across the entire population of the world. Water is not only distributed across the globe with respect to the population it carries. Water is also unevenly dispensed across continents, regions, countries, regions within countries, socio-economic sectors and seasons.

Latin America and North America has the highest water availability per capita, followed by Africa, Asia, and Europe which have far less. The distribution of water per continent is roughly as follows:

- East Asia and the Pacific region have 5 400 cubic meters (m³) per capita.
- Europe and Central Asia have 14 300 m³ per capita.
- Latin America and the Caribbean have 27 000 m³ per capita.
- The Middle East and North Africa have 1 000 m³ per capita.
- South Asia has 4 100 m³ per capita.
- Sub-Saharan Africa has an availability of 8 400 m³ per capita.

This availability of freshwater per capita does not remain static, but fluctuates as populations increase and the rate of socio-economic development waxes and wanes. The increase of water use is therefore directly proportional to population growth and a higher socio-economic development pattern. Freshwater per capita per country also shows a maldistribution of the precious resource between states. Canada has about 92 142 m³ per capita, the United States 9 168 m³ per capita, while some countries in Africa and Asia has far less. South Africa has 1 208 m³ per capita and Pakistan 1 938 m³ per capita available to them.

Within regions in countries, water is also unequally distributed. India has 2 500 m³ per capita, while the state of Rajasthan has access to only 550 m³ per capita per year. Bangladesh suffers annually from the scourges of monsoon flooding, while in the dry season there is a critical shortage of water.

Water scarcities can become a problem when there is a limited amount of water available in proportion with the size of the population and socio-economic development of a state. A state that has 1 000 to 1 600 m³ per capita per year is categorized as water stressed. Major problems with respect to the supply of water can be experienced by such states in times of drought. Where water availability is less than 1 000 m³ per person per year, states are classified as water scarce. When water availability falls below this level, the scarcity of water can be a crippling limitation on socio-economic development, environmental quality and the distribution of people.

Within the next 25 years water shortages will show a dramatic increase. By 2025 it is estimated that between 46 and 52 states, with an estimated combined population of about three billion people will reach the stage of water stress. This will mean that this large population will have between 1 000 and 1 600 m³ per capita of water to support their basic needs and economic activities. It is within this same period that projected impacts of anthropogenic induced climate change will start rearing its head. It is not yet certain how, with what effect climate change will impact on water resources. Climate

change could have a negative influence on the future outlook of these 46 to 52 countries with respect to socio-economic development.

The likely impact of climate change, in all its forms, could therefore have a direct effect on the different reservoirs of water and ultimately on the use of water from these reserves by humans and other life forms on the planet. Subsequently, impacts of climate change will be felt in the different economic sectors of society and especially in agriculture, industry, hydropower production, navigation and the domestic sectors.

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Biographical Sketch

Richard Meissner received his training as a political scientist at the Rand Afrikaans University (RAU) in Johannesburg. He obtained a Magister Artium (M.A.) degree in Political Studies from the same university in 1999 and is currently busy with a D.Phil. in International Relations at the University of Pretoria (UP). He was one of the first students in South Africa to complete a Master's thesis on water politics.

He was employed by the Political Studies department at the Rand Afrikaans University from 1996 to 1998 as a research assistant. He is currently employed as a research associate by the African Water Issues Research Unit (AWIRU) which he joined in 1999. He was involved in a number of studies regarding the management of national and international water resources in Southern Africa and the Middle East. He has also written a number of articles which were published in accredited journals. His scope of interest lies within the field of water politics and particularly the interaction of diverse actors within the domestic and international domains regarding water resource issues. Richard Meissner is a member of the South African Political Studies Association and the South African Institute of International Affairs.