Climate Change and Impact on Water Resources

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Abstract - Impacts of climate change and climate variability on the water resources are likely to affect irrigated agriculture, installed power capacity, environmental flows in the dry season and higher flows during the wet season, thereby causing severe droughts and floods in urban and rural areas. As the earth's temperature continues to rise, we can expect a significant impact on our fresh water supplies with the potential for devastating effects on food, water and energy. Water scarcity is expected to become an ever-increasing problem in the future, for various reasons. First, the distribution of precipitation in space and time is very uneven, leading to tremendous temporal variability in water resources worldwide. If all the freshwater on the planet were divided equally among the global population, there would be 5,000 to 6,000 cubic metre of water available for everyone, every year. Second, the rate of evaporation varies a great deal, depending on temperature and relative humidity, which impacts the amount of water available to replenish groundwater supplies. The combination of shorter duration but more intense rainfall (meaning more runoff and less infiltration) combined with increased evapotranspiration (the sum of evaporation and plant transpiration from the earth's land surface to atmosphere) and increased irrigation is expected to lead to groundwater depletion. This research paper quantifies the possible impacts of the climate change on the water resources within the constraints of the uncertainty of climate change predictions. The paper ends by informing that the study can be useful for the formulation of the National and State Action Plans on Climate Change undertaken by the country.

Keywords – Water, Climate, energy, resources and environment

I. INTRODUCTION

The vast majority of the Earth's water resources are salt water, with only 2.5% being fresh water. Approximately 70% of the fresh water available on the planet is frozen in the icecaps of Antarctica and Greenland leaving the remaining 30% (equal to only 0.7% of total water resources worldwide) available for consumption. From this remaining 0.7%, roughly 87% is allocated to agricultural purposes (IPCC 2007). These statistics are particularly illustrative of the drastic problem of water scarcity facing the world. Water scarcity is defined as per capita supplies less than 1700 m3/year (IPCC 2007).

Water resources are important to both society and ecosystems. We depend on a reliable, clean supply of drinking water to sustain our health. We also need water for agriculture, energy production, navigation, recreation, and manufacturing. Many of these uses put pressure on water resources, stresses that are likely to be exacerbated by climate change. In many areas, climate change is likely to increase *water demand* while shrinking *water supplies*. This shifting balance would challenge water managers to simultaneously meet the needs of growing communities, sensitive ecosystems, farmers, ranchers, energy producers, and manufacturers. In some areas, water shortages will be less of a problem than increases in runoff, flooding, or sea level rise. These effects can reduce the *quality of water* and can damage the infrastructure that we use to transport and deliver water.

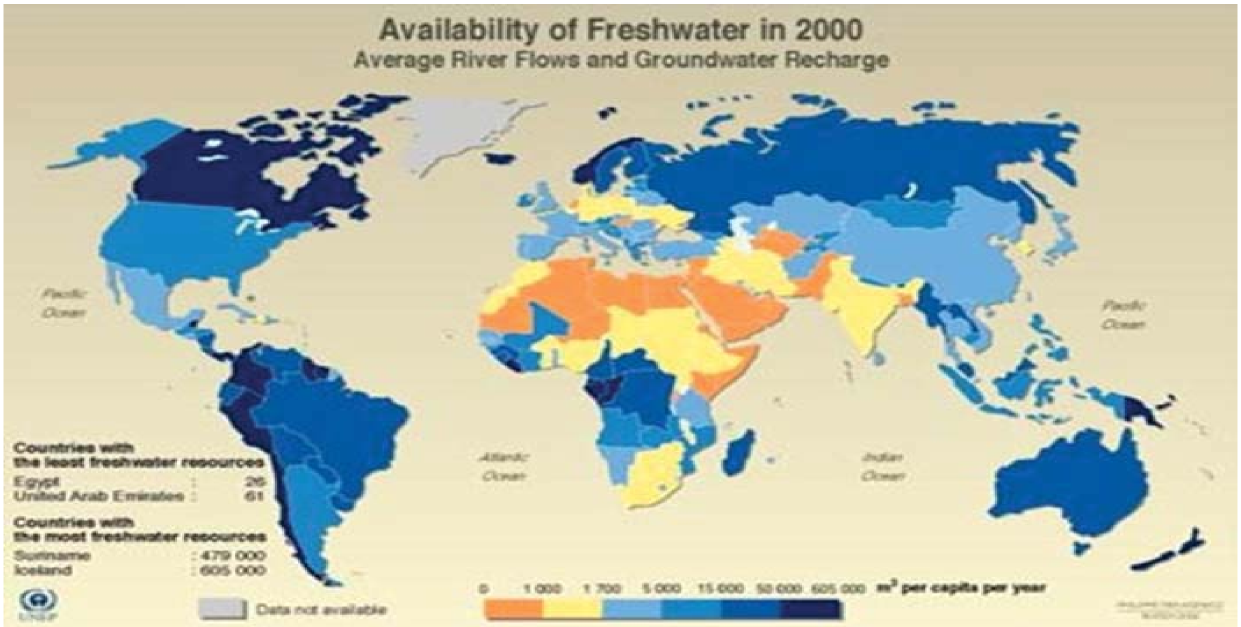
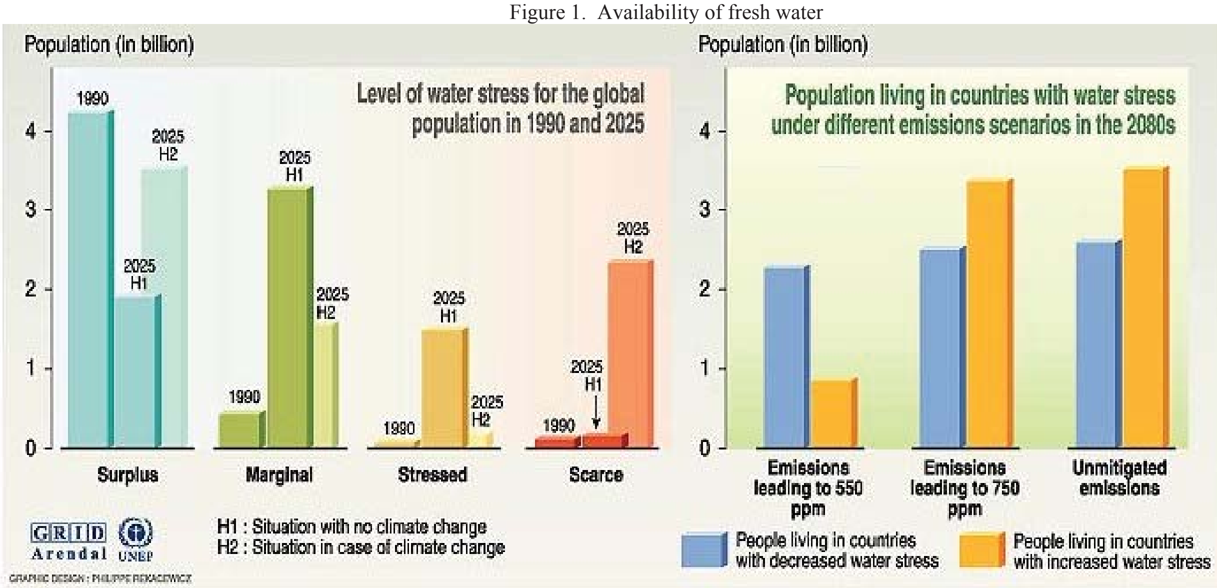


Figure 1. Availability of fresh water



Source: Climate change 1995, Impacts, adaptations and mitigation of climate change: scientific-technical analyses, contribution of working group 2 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge press university, 1996; Climate change and its impacts, stabilisation of CO2 in the atmosphere, Hadley centre for climate prediction and research,the meteorological office, London, 1999.

Figure 2. DWT Decomposition model

According to the Comprehensive Assessment of Water Management in Agriculture, one in three people are already facing water shortages (2007). Around 1.2 billion people, or almost one-fifth of the world's population, live in areas of physical scarcity, while another 1.6 billion people, or almost one quarter of the world's population, live in a developing country that lacks the necessary infrastructure to take water from rivers and aquifers (known as an economic water shortage).

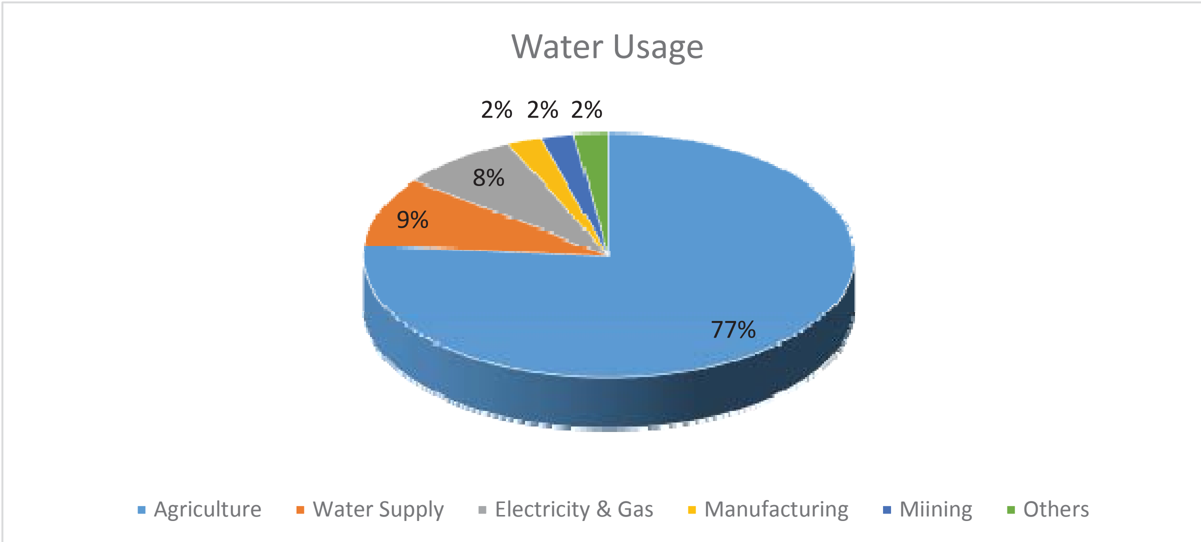


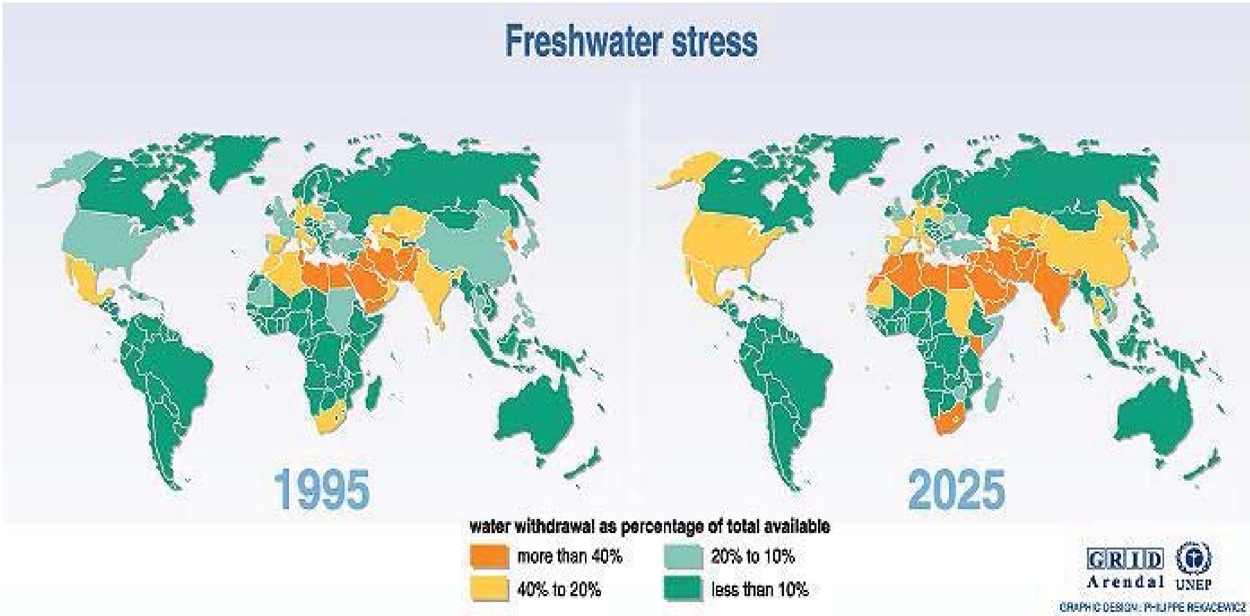
Figure 3. Water use in the World (2010)

There are four main factors aggravating water scarcity are:

- Population growth: in the last century, world population has tripled. It is expected to rise from the present 6.5 billion to 8.9 billion by 2050. Water use has been growing at more than twice the rate of population increase in the last century, and, although there is no global water scarcity as such, an increasing number of regions are chronically short of water.
- Increased urbanization will focus on the demand for water among a more concentrated population. Asian cities alone are expected to grow by 1 billion people in the next 20 years.
- High level of consumption: as the world becomes more developed, the amount of domestic water used by each person is expected to rise significantly.
- Climate change will shrink the resources of freshwater.

II. WATER & CLIMATE CHANGE

Water scarcity is expected to become an ever-increasing problem in the future, for various reasons. First, the distribution of precipitation in space and time is very uneven, leading to tremendous temporal variability in water resources worldwide (Oki et al, 2006). For example, the Atacama Desert in Chile, the driest place on earth, receives imperceptible annual quantities of rainfall each year. On the other hand, Mawsynram, Assam, India receives over 450 inches annually. If all the freshwater on the planet were divided equally among the global population, there would be 5,000 to 6,000 cubic metre of water available for everyone, every year (Vorosmarty 2000).Second, the rate of evaporation varies a great deal, depending on temperature and relative humidity, which impacts the amount of water available to replenish groundwater supplies. The combination of shorter duration but more intense rainfall (meaning more runoff and less infiltration) combined with increased evapotranspiration (the sum of evaporation and plant transpiration from the earth's land surface to atmosphere) and increased irrigation is expected to lead to groundwater depletion (Konikow and Kendy.



Source: Global environment outlook 2000 (GEO), UNEP, Earthscan, London, 1999.

Figure 4. Fresh water and Climate change

A. Impacts On Water Cycle And Water Demand –

The water cycle is a delicate balance of precipitation, evaporation, and all of the steps in between. Warmer temperatures increase the rate of evaporation of water into the atmosphere, in effect increasing the atmosphere's capacity to "hold" water. Increased evaporation may dry out some areas and fall as excess precipitation on other areas.

Changes in the amount of rain falling during storms provide evidence that the water cycle is already changing. Over the past 50 years, the amount of rain falling during the most intense 1% of storms increased by almost 20%. Warming winter temperatures cause more precipitation to fall as rain rather than snow. Furthermore, rising temperatures cause snow to begin melting earlier in the year. This alters the timing of streamflow in rivers that have their sources in mountainous areas.

As temperatures rise, people and animals need more water to maintain their health and thrive. Many important economic activities, like producing *energy* at power plants, raising livestock, and growing *food crops*, also require water. The amount of water available for these activities may be reduced as Earth warms, and if competition for water resources increases.

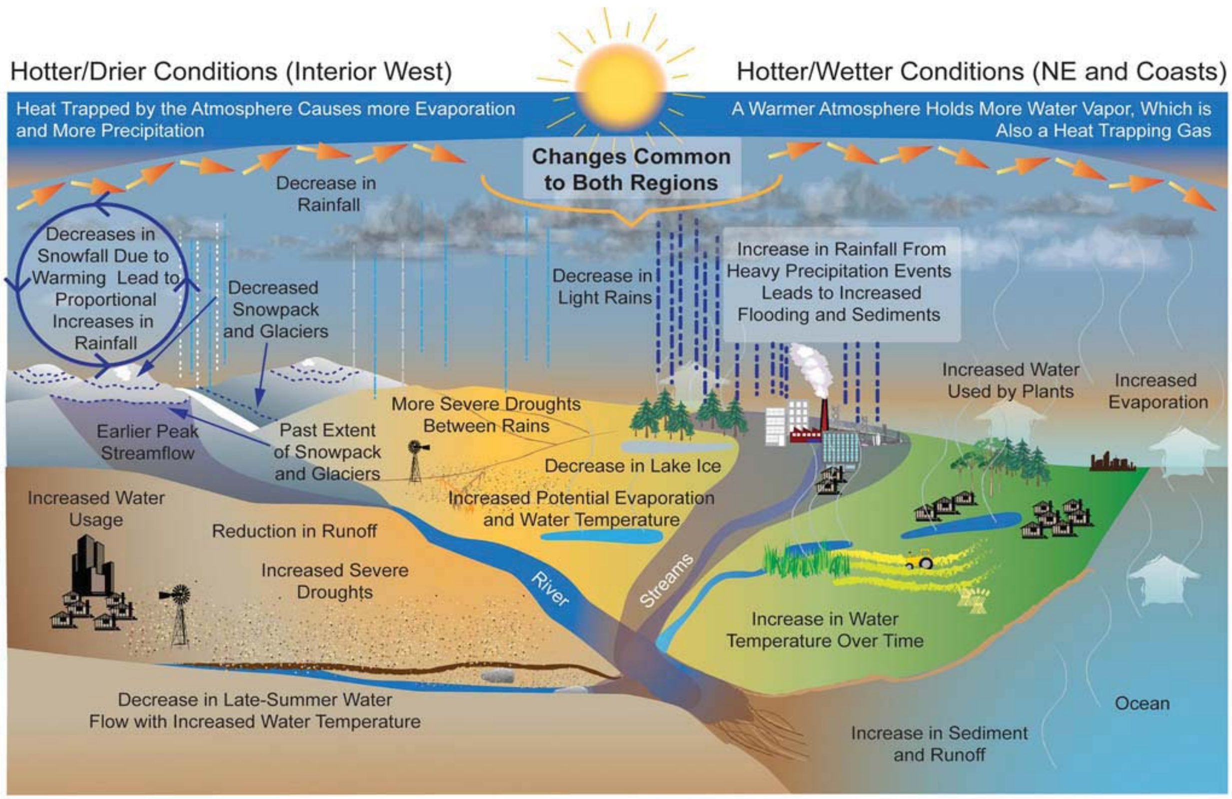


Figure 5. Impact of Climate Change

B. *Impact on Water Quality and Supply-*

Water quality could suffer in areas experiencing increases in rainfall. For example, in the Northeast and Midwest increases in heavy precipitation events could cause problems for the water infrastructure, as sewer systems and water treatment plants are overwhelmed by the increased volumes of water. Heavy downpours can increase the amount of runoff into rivers and lakes, washing sediment, nutrients, pollutants, trash, animal waste, and other materials into water supplies, making them unusable, unsafe, or in need of water treatment.

Freshwater resources along the coasts face risks from sea level rise. As the sea level rises saltwater move into freshwater areas. This may force water managers to seek other sources of fresh water, or increase the need for desalination (or removal of salt from the water) for some coastal freshwater aquifers used as drinking water supply. Drought can cause coastal water resources to become more saline as freshwater supplies from rivers are reduced. Water infrastructure in coastal cities, including sewer systems and wastewater treatment facilities, faces risks from rising sea levels and the damaging impacts of storm surges.

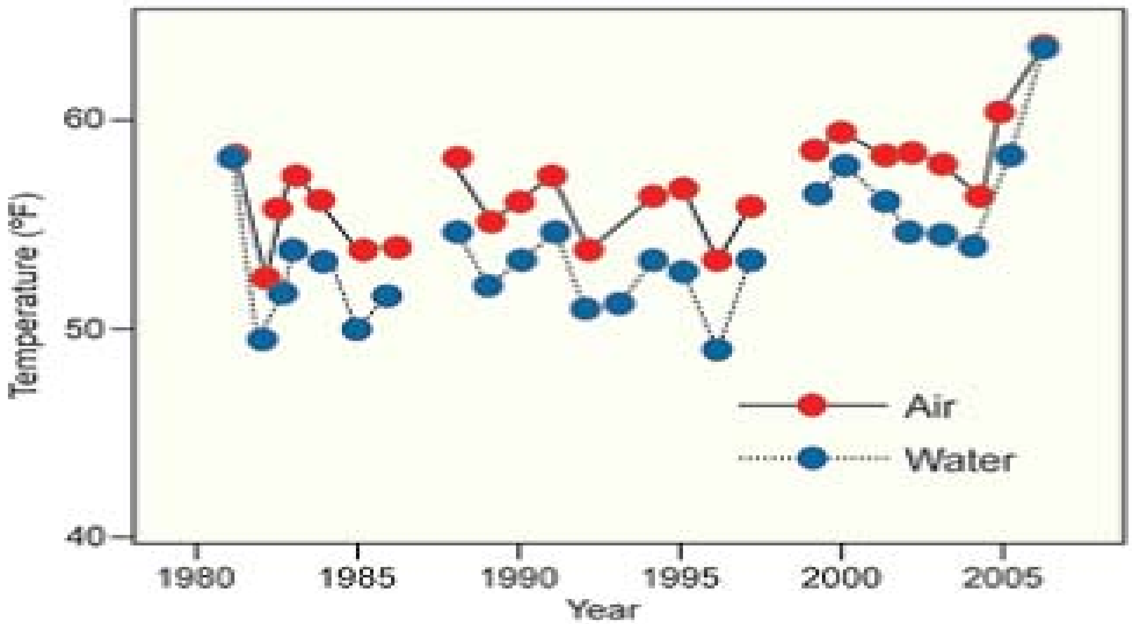


Figure 6. Impact on Water Quality

III. CONCLUSION

- Warming air temperature can directly raise stream and lake temperatures, which can harm aquatic organisms that live in cold water habitats, such as trout.
- Warmer water can increase the range of non-native fish species, permitting them to move into previously cold water streams. The population of native fish species often decreases as non-native fish prey on and out-compete them for food.
- The impacts of climate change on water availability and water quality will affect many sectors, including energy production, infrastructure, human health, agriculture, and ecosystems.
- Changes in the timing of stream flow can also have an impact on the ability to produce hydroelectricity.
- Lower water flows would also reduce the amount of water available to cool fossil-fuel and nuclear power plants.
- Climate change impacts on water supply and quality will also affect tourism and recreation. The quality of lakes, streams, coastal beaches, and other water bodies that are used for swimming, fishing, and other recreational activities can be affected by changes in precipitation, increases in temperature, and sea level rise.
- Winter sport activities that depend on the production of snow and ice could be limited in the future as temperatures increase.
- Agriculture and livestock depend on water. Heavy rainfall and flooding can damage crops and increase soil erosion and delay planting.
- Areas that experience more frequent droughts will have less water available for crops and livestock.
- Aquatic species that live in only cold water environments, such as salmon, will be affected by rising water temperatures. Changing water temperatures would also affect the geographic range of fish species.
- Changes in the seasonal distribution and amount of precipitation over the particular area or region.
- An increase in precipitation intensity under most situations i.e. it rains heavily in short duration rather than for long duration.
- A change in the balance between snow and rain as it alters the balance between two.
- Increased evapotranspiration and a reduction in soil moisture due to increase in the temperature of the atmosphere.
- Changes in vegetation cover resulting from changes in temperature and precipitation.
- Consequent changes in management of land resources as a result of global warming.
- Increases in fire risk in many areas.

- Increased coastal inundation and wetland loss from sea level rises.

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