

# Chapter 10

## Impact of Climate Change on Groundwater Resources

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### ABSTRACT

*Climate change poses uncertainties to the supply and management of water resources. While climate change affects surface water resources directly through changes in the major long-term climate variables such as air temperature, precipitation, and evapotranspiration, the relationship between the changing climate variables and groundwater is more complicated and poorly understood. The greater variability in rainfall could mean more frequent and prolonged periods of high or low groundwater levels, and saline intrusion in coastal aquifers due to sea level rise and resource reduction. This chapter presents the likely impact of climate change on groundwater resources and methodology to assess the impact of climate change on groundwater resources.*

### INTRODUCTION

Water is indispensable for life, but its availability at a sustainable quality and quantity is threatened by many factors, of which climate plays a leading role. The Intergovernmental Panel on Climate Change (IPCC) defines climate as “the average weather in terms of the mean and its variability over a certain time-span and a certain area” and a statistically significant variation of the mean state of the climate or of its variability lasting for decades or longer, is referred to as climate change.

Evidence is mounting that we are in a period of climate change brought about by increasing atmospheric concentrations of greenhouse gases.

Atmospheric carbon dioxide levels have continually increased since the 1950s. The continuation of this phenomenon may significantly alter global and local climate characteristics, including temperature and precipitation. The Intergovernmental Panel on Climate Change (IPCC) estimates that the global mean surface temperature has increased  $0.6 \pm 0.2$  °C since 1861, and predicts an increase of 2 to 4 °C over the next 100 years. Global sea levels have risen between 10 and 25 cm since the late 19<sup>th</sup> century. As a direct consequence of warmer temperatures, the hydrologic cycle will undergo significant impact with accompanying changes in the rates of precipitation and evaporation. Predictions include higher incidences of severe weather

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events, a higher likelihood of flooding, and more droughts. The impact would be particularly severe in the tropical areas, which mainly consist of developing countries, including India.

Climate change can have profound effects on the hydrologic cycle through precipitation, evapotranspiration, and soil moisture with increasing temperatures. The hydrologic cycle will be intensified with more evaporation and more precipitation. However, the extra precipitation will be unequally distributed around the globe. Some parts of the world may see significant reductions in precipitation or major alterations in the timing of wet and dry seasons. Information on the local or regional impacts of climate change on hydrological processes and water resources is becoming more important.

Groundwater resources are related to climate change through the direct interaction with surface water resources, such as lakes and rivers, and indirectly through the recharge process. The direct effect of climate change on groundwater resources depends upon the change in the volume and distribution of groundwater recharge. Therefore, quantifying the impact of climate change on groundwater resources requires not only reliable forecasting of changes in the major climatic variables, but also accurate estimation of groundwater recharge.

The effects of global warming and climatic change require multi-disciplinary research, especially when considering hydrology and global water resources. This chapter discusses the likely impact of climate change on soil moisture, groundwater recharge, coastal aquifers; present status of research studies; and methodology to assess the impact of climate change on groundwater resources.

## **BACKGROUND**

Changes in regional temperature and precipitation have important implications for all aspects of the

hydrologic cycle. Variations in these parameters determine the amount of water that reaches the surface, evaporates or transpires back to the atmosphere, becomes stored as snow or ice, infiltrates into the groundwater system, runs off the land, and ultimately becomes base flow to streams and rivers.

Temperature increases affect the hydrologic cycle by directly increasing evaporation of available surface water and vegetation transpiration. Consequently, these changes can influence precipitation amounts, timings and intensity rates, and indirectly impact the flux and storage of water in surface and subsurface reservoirs (i.e., lakes, soil moisture, groundwater). In addition, there may be other associated impacts, such as sea water intrusion, water quality deterioration, potable water shortage, etc.

Many rivers and streams that are fed by glacier runoff could be significantly impacted as a result of climate change. As glacier retreat accelerates, increased summer runoff could occur. However, when the glaciers have largely melted, the late summer and fall glacial input into streams and rivers may be lost, resulting in a significant reduction in flow in some cases.

Hydrological impact assessments of watersheds (and aquifers) require information on changes in evapotranspiration because it is a key component of the water balance. However, climate-change scenarios tend to be expressed in terms of changes in temperature and precipitation. Consequently, the effects of global warming on potential evaporation (or more inclusively, evapotranspiration) are not simple to estimate. Many global scenarios suggest an increase in potential evaporation, but these factors may be outweighed locally or regionally by other factors reducing evaporation. Various models may be used to calculate potential evaporation using data on net radiation, temperature, humidity, and wind speed, and sometimes plant physiological properties. The estimated effect of a change in climate on potential evaporation depends on the characteristics of the site.

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