Geophysical Research Abstracts
Vol. 13, EGU2011-9571, 2011
EGU General Assembly 2011

Impacts of global climate change on water resources: assessment, challenges, and remedies

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Population explosion and its many associated effects (e.g. industrialization, urbanization, water pollution, deforestation) are already causing enormous stress on our water resources, environment, ecosystem, and health. According to WHO/UNICEF estimates, about 900 million people still lack access to safe drinking water, about 2.5 billion people lack access to proper sanitation, and millions of people die every year from water-related diseases (e.g. malaria, typhoid, cholera). There are convincing reasons to believe that this situation will only worsen in the future as a result of the impacts of global climate change.

The gist of the global climate change problem may be presented as follows. Human activities, especially since the Industrial Revolution, have led to increases in the atmospheric concentration of trace gases (e.g. carbon dioxide, methane, nitrous oxide) that trap heat in the atmosphere. With the rise in the concentrations of these gases, the energy balance of the Earth's climate system and the behavior of the climate will be changed. The ways in which the changes will happen are not fully understood; however, a most likely effect is an increase in global temperature. With the projected increase in temperature, there is a general consensus among scientists that the global hydrologic cycle will intensify and that hydrologic extremes (e.g. floods, droughts) will become more frequent and more severe. Other ways in which climate change could directly or indirectly influence our water resources include sea level rises and bush fires.

In view of the potential impacts of global climate change on our environment and water resources, any sincere effort towards proper planning, development, and management of our future water resources will need to overcome many challenges globally, regionally, and locally. These challenges are both biophysical science-related ('hard science') and human science-related ('soft science'). The biophysical science challenges include, among others: (1) identification of the actual causes of climate change and their future levels; (2) development of Global Climate Models or General Circulation Models (GCMs) that can adequately incorporate these causes to generate dependable future climate projections at coarser scales; (3) formulation of suitable techniques to 'transform' (i.e. downscale) the GCM outputs to regional and local scales (e.g. basin scale) for hydrologic analysis and predictions; and (4) reliable estimation of the associated uncertainties in all of these. The human science challenges, on the other hand, have social, political, economic, environmental, and other facets that often act in complex and interconnected ways; proper communication of our climate-water scientific research activities and outcomes to fellow scientists and engineers, policy makers, economists, industrialists, non-governmental organizations, farmers, the media, and the public at large is also a tremendously difficult task in this respect.

The purpose of this study is to detail these two broad types of challenges and the sub-challenges therein to highlight the need for an integrated framework to study the impacts of global climate change on our water resources planning, development, and management. The vital role of water researchers in the formulation of such an integrated framework is also discussed.