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Research Article

THE IMPACT OF CLIMATE CHANGE ON WATER AND ITS RESOURCES

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Abstract

This main goal of this paper is to show that climate change can impact water especially its quantity, variability, timing, form as well as the intensity of precipitation. Moreover the paper gives an overview of physical effects of climate change on water as well as recommendations for mitigation of such consequences and negative effects. One of climate change integral component is also the water and further more it is seen as its primary instrument through which it exhibits certain impacts. Nowadays many regions on the world are facing the challenges of water that are continuing to raise, so it is very important to understand how climate change will affect future societies, because this process cannot be evaluated without understanding its impact on the most vital resource of our planet, thus water. The paper also tries to address that climate change can affect the water cycle directly and through it in indirect way will also impact quantity and quality of water resources that available are available for human needs and demands, that will lead to floods and drought at the same time. When sea levels will raise they will imply serious effect on coastal aquifers that is the main source of urban and regional water supply systems and one side and on the other side will cause higher water temperatures and changes in extremes that will cause water pollution. In this case all these factors such as water supply reliability, health, agriculture, energy and aquatic ecosystems will be impacted by these changes of water. Water is an important factor for sustainable social and economic development that will not be underestimated, however many countries are facing certain water challenges, caused by climate change. Climate change have important implications for water resources that are listed as following: increased evaporation rates, higher proportion of precipitation, earlier and shorter runoff seasons, increased water temperatures as well as decreased water quality.

Introduction

According to World Water Assessment Program Special Report, Water can be seen as an integral component of climate change and it is presented as a primary instrument through which it exhibits its impacts. Moreover, through growing water challenges in many regions in the world, we can see that climate change will affect future societies by its impact on most important and vital resource of our planet that is water.[107]

As prescribed above water is the main medium that climate change does its impact on the ecosystems in our planet, so by this it also effects our live and society. By experiencing high temperatures and extreme weather conditions will affect the rainfall, snow melting process, flow of rivers as well as the quality of water.

The management and usage of water resources impact can be seen at almost every aspect of our life, society and economy as well, especially regarding the food, health, water supply, energy, industry as well as ecosystem functioning. When we are facing climate change, we can experience high water stress, especially in developing countries there for in these situations are needed urgent actions for these issue.[108] De facto if we are not improving the management of water resources, than we will face important negative effects such as poverty reduction and sustainable development regarding the economic and environmental dimensions.

Climate change adaptation has a close nexus with water as well as its role for achievement of sustainable development. However, in order to respond to this nexus in appropriate way, we must also see some development opportunities that are already present. For example there exist various adaptation measures that can be focused for dealing the climate change, by managing land and water resources so that we can mitigate effects of climate change as well to enhance quality of water, by which we can affect indirectly the countries development.

[107] World Water Development Report 3: Water in a Changing World. A joint effort of the 26 United Nations agencies that make up UN-Water.
[108] Gleick, P. H. (lead author). (2000). Water: The Potential Consequences of Climate Variability and Change for the Water Resources of the United States. A report of the National Water Assessment Group for the U.S. Global Change Research Program. Pacific Institute for Studies in Development, Environment, and Security, Oakland, CA, USA.

Therefore, it is very important to mention that there is a need for adequate innovative technological implementation of certain strategies for the process of adaptation and mitigation of climate change effects on water and its resources as well.

It is important to understand that climate change is so important that de facto it is changing our assumptions about water resources. When we face climate change that warms atmosphere, alter the hydrologic cycle, it changes the amount, timing, form as well as the intensity of precipitation that will continue.[109] There also exist and some other changes such as flow of water in watersheds and quality of aquatic and marine environments, that will affect the programs designed for water quality protection as well as the protection of public health and safety.

Moreover, we must admit that resources of water are important for society and ecosystems as well, so we depend on a reliable, clean supply of water that we have to drink so we can sustain our health. Furthermore, water is also an important and vital need for agriculture, energy production, navigation, recreation and manufacturing as well.

Yet, in certain areas, water shortages can be seen as less problematic than increases in runoff, flooding or raising of the sea level, where in these cases they can reduce the *quality of water* and damage infrastructure for transport as well as water delivery.

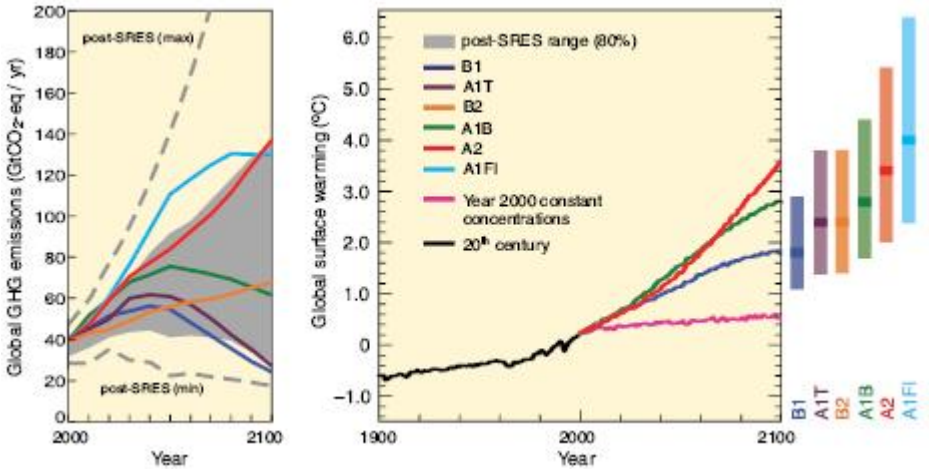
Meanwhile, it is clearly true that in the future, strategies regarding climate change and water management will become even more complex, due to the fact that higher temperatures will increase water demand and as a result the rainfall will decrease, so people will try to look for more irrigation so that they can ensure food security and survive. On the other hand, water supplies available for irrigation will become more variable and will decline in many parts of the world. [110]

But since irrigation is only practiced at 20% of the land that can be used for cultivation, there exist poorest lands that in fact cannot gain from its benefits. Maintaining viable aquatic eco-systems will even stress more the water resources, particularly at poorest places that dependent mainly on them. However, in many regions of the world, water allocations for agriculture needs may decline when combined with the impacts of climate change, high value economic sectors and environmental needs. So on one side this will make to have strong pressure to produce more with less water, as well as to spread benefits of water use wisely. But this is a high challenge in the future, since higher temperatures will decline the potential land on one side and on the other one will also reduce the water productivity.

According to International Panel on Climate Change (IPCC) and its reports regarding this issue, have published the Fourth Assessment Report or called also as AR4 that it is published during 2007. In this report, there are three groups that de facto investigate the physical science of climate change as well as the adaptation to the impacts of climate change and finally they express also the possibilities for mitigation of greenhouse gas (GHG) emissions and global warming that it is illustrated in the following figure2.

[109] IPCC (Intergovernmental Panel on Climate Change). 2008. Technical Paper on Climate Change and Water. IPCC-XXVIII/ Doc. 13, Intergovernmental Panel on Climate Change, Geneva.
www.ipcc.ch/meetings/session28/doc13.pdf
[110] file:///C:/Users/My%20Document/Downloads/i2096e.pdf

Figure2. Prediction for GHG emissions and global warming



Source: Climate Change 2007: Synthesis Report. Fourth Assessment Report of the Intergovernmental Panel on Climate Change, IPCC, Geneva, Switzerland.

AR4 compares different predictions and scenarios that in fact it is a quite difficult process, due to inconsistencies in model behavior and evidence and it has adopted a standard set of scenarios set by IPCC's Special Report on Emissions Scenarios (SRES,), that defines 40 emissions scenarios based on likely profiles of greenhouse gas emissions as a result of impact of economic development and population growth regarding the time period 2000-2100.

According to AR4 reports, there exist climate projections uncertainties that makes harder to evolve appropriate and effective adaptation and mitigation strategies, however the resulted outcomes are obtained from different scenarios obtained from individual models. This is the reason why we see that future projections of temperatures are varying from significant to slight increases for different scenarios shown in the figure. When we try to compare we can claim that predictions of rainfall are less consistent, where we have some models that are predicting increases in rainfall and on the other side we have others that predict decreases for the same scenario. However, the maps reflect the result from ensemble modeling by showing predictions that will show the same trend, whether will be up or down. It is a fact now that climate change is about is to increase for sure, but yet on the other side it is very hard to predict by how much and at what time period.

Impacts on Water Cycle and Water Demand

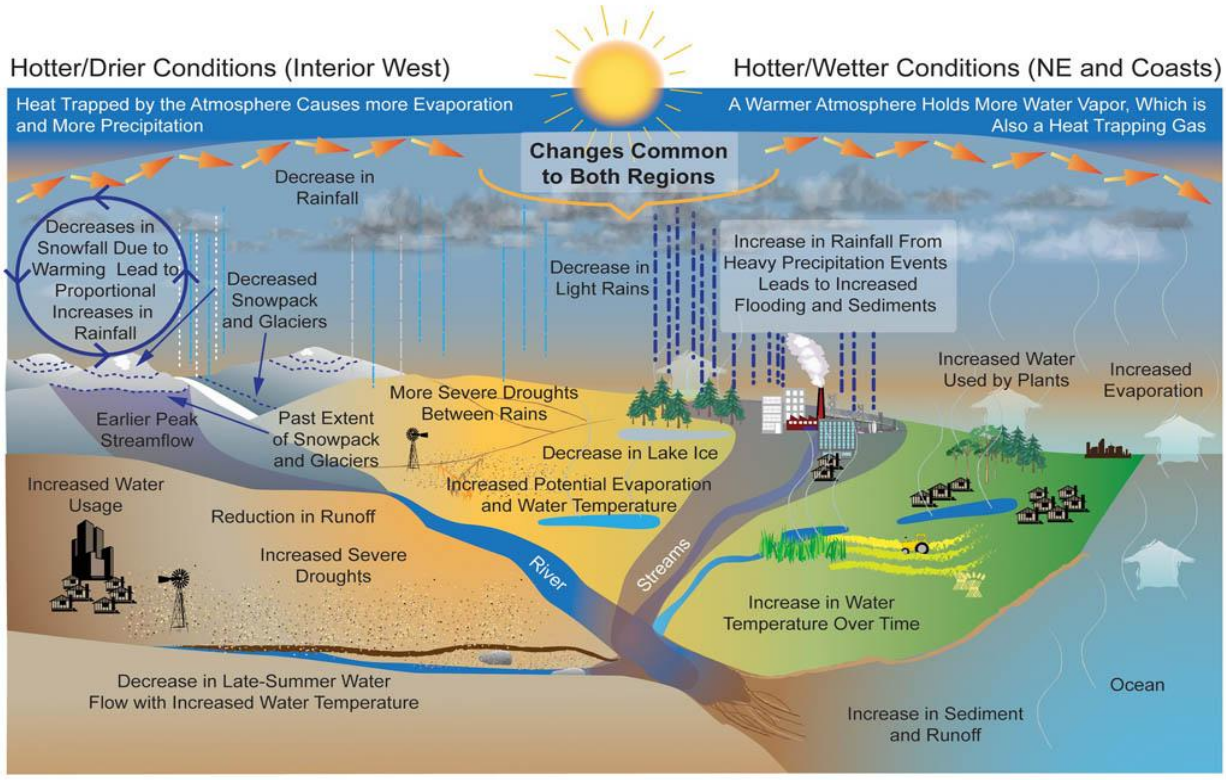
In the following figure it is shown the water cycle which can be understood as a delicate balance of precipitation, evaporation as well as all the steps in between. When we are facing warmer temperatures, there will be an increase of the rate of evaporation of water into the atmosphere, by increasing the atmosphere's capacity to "hold" water. [111] In this case by facing an increased evaporation it can cause to dry out some areas and show excess precipitation on other areas.

The rain falling amount that has experienced changes during storms can be used as evidence that water cycle is experiencing changes already. USGCRP report for climate change and water, has shown that on the past 50 years, rain falling amount during most intense 1% of storms has increased by almost 20%. [112]

[111] USGCRP (2009). *Global Climate Change Impacts in the United States* . Karl, T.R. J.M. Melillo, and T.C. Peterson (eds.). United States Global Change Research Program. Cambridge University Press, New York, NY, USA.
[112] USGCRP (2009). *Global Climate Change Impacts in the United States* . Karl, T.R. J.M. Melillo, and T.C. Peterson (eds.). United States Global Change Research Program. Cambridge University Press, New York, NY, USA.

Due to warming winter temperatures precipitation will fall as rain instead of snow, so by rising temperatures will cause snow to melt earlier. Furthermore, by raising the temperatures, people and animals will need more water to maintain their health condition and survive. Also important economic activities, like producing energy at power plants, raising livestock and growing food crops require more water in this case. That is why is important to notice that amount of water available for these activities can be reduced as our planet gets warmer.

Figure1. Projected climate change on water cycle



Source: USGCRP (2009).

By increasing the air temperatures we can directly raise the stream and lake temperature that will harm aquatic organisms that live in coldwater habitats. Moreover, warmer water will also increase the range of non-native fish species, so they can move into previously coldwater streams.[113]

On the other side we can see that impacts of climate change will enhance water availability and water quality to effect other certain sectors as well such as energy production, infrastructure, human health, agriculture and ecosystems, that are all very important for the wellbeing and human life.

Climate change impacts water supply and quality and these effects can be seen that are also interpreted in spheres such as tourism and recreation. Moreover, quality of lakes, streams, beaches, used for swimming and fishing, can be affected by changes in precipitation, temperature increases and sea level rise. [114]

[113] CCSP (2008). *The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States* . A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research.
[114] CCSP (2009). *Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region* . A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. Titus, J.G. (Coordinating Lead Author), et *al*. U.S. Environmental Protection Agency, Washington, DC, USA.

Also sectors such as agriculture and livestock also are effected by water, where high rainfall level and flooding can damage crops and increase soil erosion so it can delay planting as well.

In fact changes that can affect availability and quality of water are also major concerns for other countries where water resources are already impacted. [115] That is why policy planners will experience challenge of water supply so they need to adopt variety of adaptation practices, to improve the conservation of water supplies, improve the water recycling as well as to develop alternative strategies for water management.

Resources for clean and fresh water are risked by sea level rise, wherein this case the saltwater moves into freshwater areas, so it seeks other sources of fresh water, or the need for desalination. [116] As more freshwater is removed from rivers so they can be used for human needs, saltwater will move the upstream.

As we have seen so far, the effects of climate change on water and water resources can be seen and experienced in many sectors of our life and especially can harm the social and economic sustainable development as well, therefore it should be given an enormous importance to adaptations and mitigations of such harmful effects caused by climate changes.

Conclusion and Reccomandations

This paper has shown that climate change integral component is also water and it is seen as primary instrument through which are exhibits certain impacts of climate change. Moreover, it is clear that many regions on the world today are facing the challenges of water that are continuing to raise, so it is very important to understand how climate change will affect future societies, because this process cannot be evaluated without understanding its impact on water - most vital resource of our planet.

Climate change adaptation has a close nexus with water as well as its role for achievement of sustainable development. However, in order to respond to this nexus in appropriate way, we must also see some development opportunities that are already present.

Predicted impacts of climate change on water and its resources can vary by region, but include increased temperatures and evaporation rates, during winter to experience rain instead of snow, earlier summer drought as well as decreased water quality. There fore as a result will be experienced water shortages, in substantial economic losses in many regions. These kinds of losses can be seen in certain range of sectors, such as agriculture, energy production, recreation, health as well as in the final the well-being and society as well., Although adaptation by water users will mitigate some portion of these costs, yet we will experience frequent shortages that impact the society.

Negative effects of water shortages can be decreased through different strategies such as revising water storage and release programs for reservoirs, adopting crops and cropping practices, adjusting water prices to encourage conservation of water, etc.

This paper aim was to show that water is an important factor for sustainable social and economic development and as such should not be not be underestimated, however nowadays there exist many countries that are facing certain water challenges, caused by climate change.

[115] NRC (2008). *Ecological Impacts of Climate Change* . National Research Council. The National Academies Press, Washington, DC, USA.

[116] https://www3.epa.gov/climatechange/impacts/water.html#ref2

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