◆Research Paper

DOI: 10.5281/zenodo.5835190

Effects of Climate Change on Water Paucity

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Abstract: Climate change's effects on water resources can be magnified when they occur in areas that already have low water resources and frequent droughts and when there are imbalances between water demands and available supplies. According to current climate change models, water resources in Africa will be adversely impacted by climate change. As much as models project the impacts in Africa and the other parts of the world, such as Latin America. Furthermore, by 2050, rainfall in Africa (Sub-Saharan Africa) is projected to decline by 10%, resulting in a 17% reduction in water in the water bodies and underground. With increasing population and food demand worldwide, most freshwater resources have already been depleted, and agricultural production has decreased internationally. Climate change has exacerbated the growth of deserts, and a rise in the size of floods and droughts are two of the most visible consequences. Agricultural production, that is, crop yields in arid and semi-arid regions worldwide, have plummeted, resulting in food shortages and a massive increase in food price inflation. Water scarcity exacerbated by climate change has indirectly and directly affected human beings and animal health to proliferate actively. This review article highlights the effects of climate change on water paucity and scarcity.

Keywords: Agriculture, Atmosphere, Climate, Effects, Rainfall, Water.

Introduction

Water is essential for life on Earth and long-term development, and access to safe drinking water and proper sanitation are among human rights. Water is the most common and vital ecosystem component (Arakawa, 2017; UN-Water, 2019). Water can be found in the atmosphere, on land, at sea, and underground, and it moves from one location to another as part of the water cycle, which is fostered by climate changes (IPCC, 2013). Water's constant transit through the climate system in liquid, solid, and vapor phases and in oceans, cryosphere, land surface, and atmospheric reservoirs.

Earth's Climate System: The climate system is defined as the five components in the geophysical system: (1)Atmosphere(2) Hydrosphere(3) Geosphere(4) Cryosphere and (5) Biosphere. Climate system- is continually changing due to the interactions between these components and external factors. Therefore, an exchange of energy and moisture happen between these spheres as indicated in figure one(1) below.

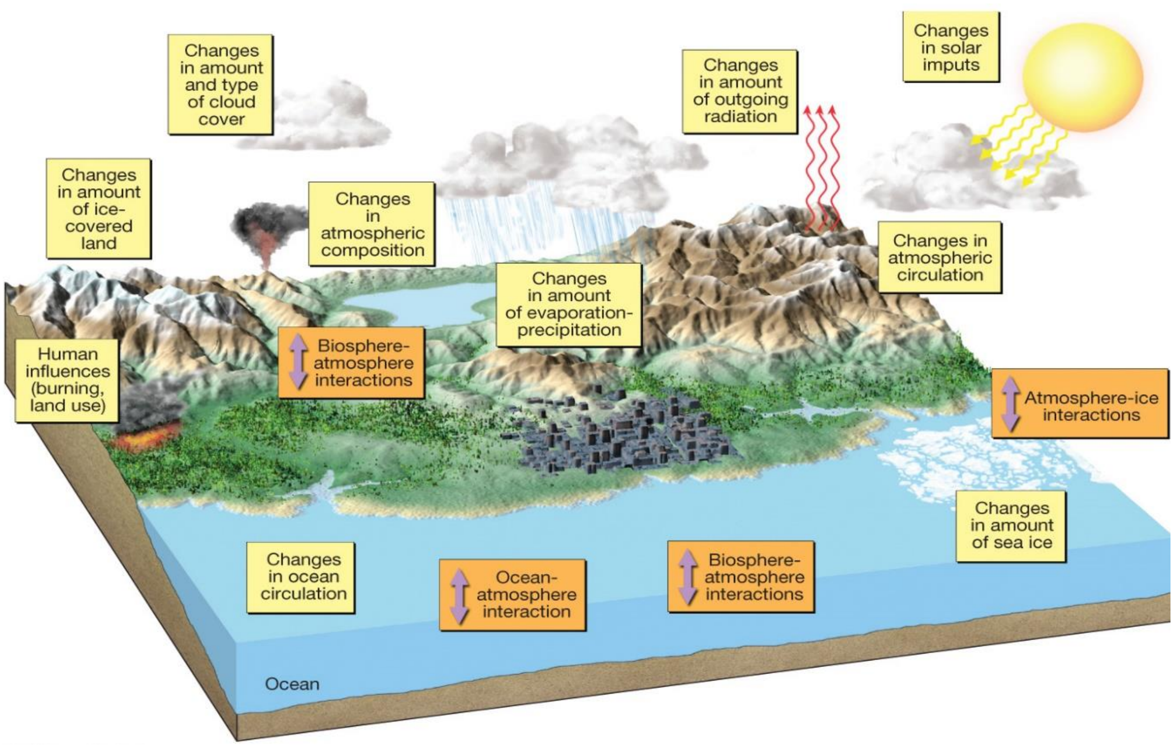

Figure 1 Earth's Climate System. Adopted and modified from Pearson. Inc.

Evaporation, condensation, precipitation, infiltration, runoff, and subsurface movement are the main physical processes of the water cycle. Because much of the water that falls on land as precipitation and supplies soil moisture and river flow is evaporated from the ocean and transported to land by the atmosphere, water movement in the climate system is critical to life on land. Snowfall in the winter can give soil moisture in the spring and river flow in the summer and it is necessary for both natural and human systems (IPCC, 2013). Oceanic salinity, which is a key driver of ocean density and circulation, can be influenced by the passage of fresh water between the atmosphere and the ocean.

Overview of the Earth Climate system: The Earth climatic systems depicts the interactions among different components i.e. external forces and internal forces bringing about changes in the environment.

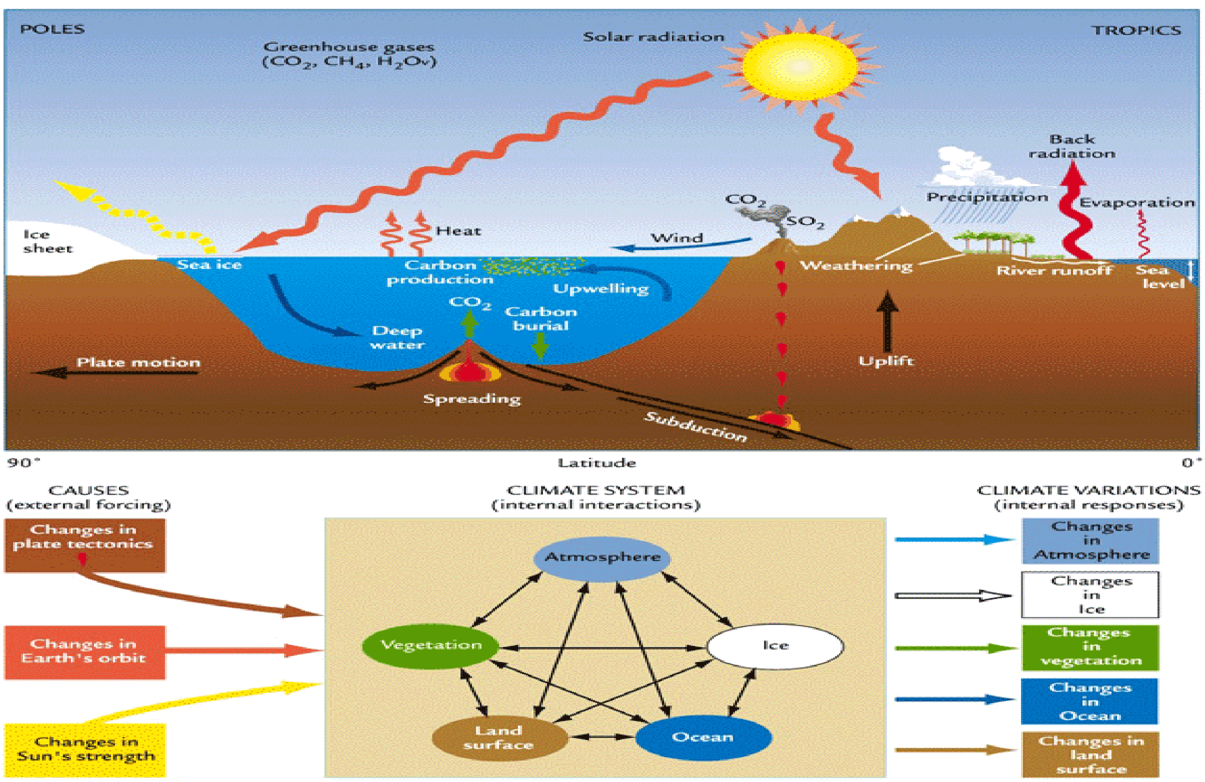

Figure 2 Interactions between external and internal forces on Earth. Adopted from globalchange.gov.

Life on Earth would end in an instant since all living species would perish, and the oceans would eventually dry up due to their immense size and dependence on water. As a result, the water problem is quite severe, as it acts as an item in life and as a subject in the life of the regulator (Sonia et al., 2014). Climate change has a wide range of effects on one of the world's most vital resources, water. The warming of the climate system is undeniable and unparalleled in millennia. The climate and oceans have warmed, snow and ice have decreased, sea levels have risen, and greenhouse gas concentrations have grown (IPCC, 2013). These changes will strain the world's drinking water resources, food production, and property prices (UCAR, 2015).

In general, rising temperatures increase the atmosphere's moisture-holding capacity, causing the hydrological cycle to become more intense (Denicola et al., 2015). When the air temperature rises, the temperature of the water rises as well. Climate factors such as the hydrological cycle are expected to alter dramatically due to global warming and greenhouse gas emissions in the atmosphere (Schewe et al., 2014, Denicola et al., 2015). Water contamination concerns will worsen as water temperatures rise, and many aquatic habitats will suffer as a result.

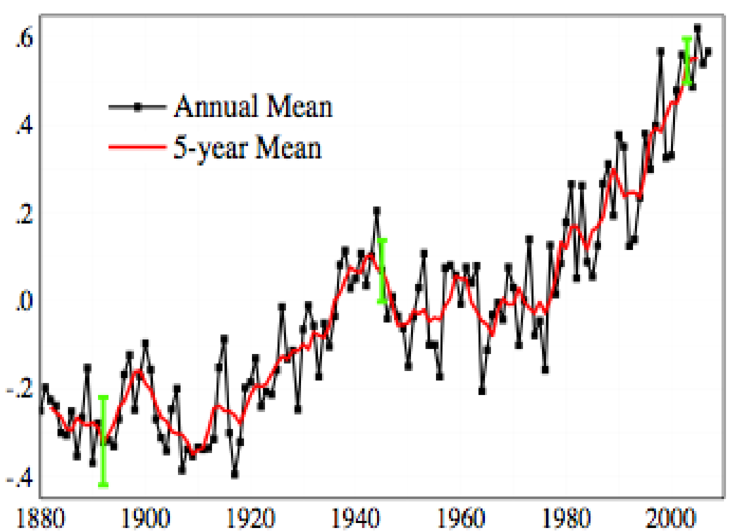

Figure 3 Rising global temperature. Fromnasa.gov/gistemp/graphs

This major change in the hydrological system affects the seasonal distribution, magnitude, and duration of precipitation and evapotranspiration. This could cause changes in water storage, surface runoff, soil moisture, and seasonal snow loads, as well as changes in glacial mass balance (Anders et al., 2014). Weather events redistribute the balance between rain and snow as temperatures fluctuate. According to the IPCC (2014), an increase in average global temperature is very likely to result in changes in precipitation and atmospheric moisture.

Climate models predict a rise in worldwide average annual precipitation in the twenty-first century (Takeuchi, 2002; Arnell, 2004; IPCC, 2013), albeit this will have varied effects on the water cycle in different parts of the world. Notably, available climate forecasts show that mean precipitation will likely increase at high latitudes as well as in mid-latitude wet areas, whereas summer precipitation will likely decrease in mid-latitude and sub-tropical dry areas (Ashton, 2002; IPCC, 2013). Increased flow seasonality was seen in rain-dominated catchments, meaning larger peak flows, lower low flows, and longer dry periods (Burkett et al., 2001; IPCC, 2014). Furthermore, according to one projection, the share of the African population at danger of water stress and scarcity will rise from 47% in 2000 to 65% in 2025.

Literature review

Climate change on water scarcity

Water cycle unpredictability is rising due to global climate change, reducing the predictability of water availability and demand, affecting water quality, worsening water shortages, and posing a threat to global sustainable development (Adhikari, 2011; Denicola et al., 2015). Slower-onset effects from rapid sea-level rise impact coastal areas, posing a direct threat to small, low-lying island states. Simultaneously, rising demand for water for energy, agriculture, industry, and human use is forcing increasingly severe trade-offs for this finite and valuable resource, particularly in places of the world where water scarcity already exists (UN-Water, 2019).

Climate change severely impacts freshwater ecosystems by affecting streamflow and water quality, providing a risk to drinking water even when treated with standard methods (Wada et al., 2016). Increased warmth, higher sediment, and increased nutrient and pollutant loadings as a result of heavy rainfall, lower dilution of pollutants during droughts, and disruption of treatment facilities during floods are all causes of danger. Climate change's impact on the following environmental processes:

Evaporation: The rise in global temperature due to climate change has a direct impact on atmospheric water demand (potential evapotranspiration). Evapotranspiration is an important part of the water cycle, and the pace at which it occurs is determined by the scale of terrestrial biophysical functionality (Djebou & Singh, 2016). Warmer air can store more moisture than air that is cooler. As the Earth warms, more water from seas, lakes, soil, and plants will be absorbed by the air. The drier conditions left behind by this air could significantly impact drinking water supplies and agriculture (Denicola, 2015). On the other hand, by inhibiting the cooling effects of our sweat, the warmer, wetter air may jeopardize human lives in some regions. We may argue that the dryness trend is noticeable all around the world.

Precipitation: When all of that extra warm, very wet air cools down, it rains or snows much more. As a result of the warming planet, we are subjected to more rain and snowstorms. Depending on the latitude band, the yearly precipitation scenarios show a variety of tendencies. The location with the greatest rise in the intensity and frequency of severe weather events (Yasmin, 2017). On the other hand, thunderstorms have become more often and have dropped more precipitation. Some places will get drier as air temperatures and circulation patterns change.

Meanwhile, the rest of the area is likely to become wetter. The high disorder in precipitation patterns, on the other hand, is likely to have a more frequent impact. For example, typhoon recurrence in the Asia-Pacific area has been related to climate change in recent decades (Tu et al., 2009).

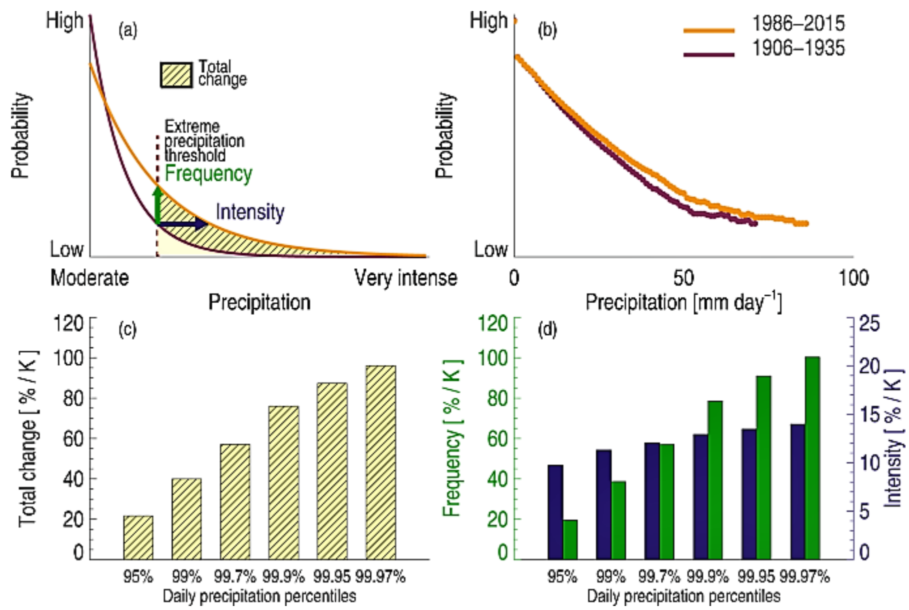

Figure 4 Precipitation frequencies and simulation. From scientific reports

Therefore, it is well put that the intensity of extreme precipitation over the globe increases more impactful with global mean surface temperatures than precipitation. Explaining Figure four(4) shows the global frequency of extreme precipitation increases extensively with the event of seldomness under global warming influenced anthropogenic and natural causes. Meanwhile, research has observed the intensity in daily heavy precipitation events (i.e. rainfall per unit time, temperature increase over time, increased rate in water vapor). Conferring to Myhre et al. (2019), simulations by recent earth system models produce changes in the annual maximum precipitation intensity that are relatively similar to observations with minimal biases.

Impact of climate change on groundwater

Changes in the precipitation system (annual precipitation concentrated in a few precipitation events) combined with land-cover degradation influence ground water recharge dramatically due to climate change. Runoff spikes and unusual discharge peaks occur in clusters over short periods (Sharma et at., 2015). Because groundwater is not fully recharged, water availability becomes a long-term challenge for streams. When groundwater is drained directly for agriculture, household, or industrial usage, the situation becomes even more terrible. Using groundwater to make up for lack of water has become a viable option (Djebou and Singh, 2016).

Sharma et al., (2015) determined that under the high-end scenario, annual replenishable groundwater will fall by 4.6 and 17.8% in 2021 and 2051, respectively, based on temperature increases of 0.32 and 1.28 degrees Celsius from the reference period. A 1.6 and 6.4 percent increase in annual average precipitation from the reference period would only improve recharge levels by 0.6 and 2.4 percent in 2021 and 2051, respectively, under the low-end scenario. Under the worst-case scenario, the cumulative impact of predicted changes in climate factors (temperature and precipitation) would reduce groundwater availability from 24 liters per capita per day (lpcd) presently to 23 lpcd by 2021 and 20 lpcd by 2051 (high-end temperature and low-end precipitation).

Other climate and water-related natural disasters

The intensity of precipitation events and flooding is projected to increase in areas that experience increases in mean precipitation, while there is also a greater risk of droughts in mid-continental areas. Intense and heavy episodic rainfall events with high runoff amounts are interspersed with more extended, relatively dry periods with increased evapotranspiration, particularly in the subtropics. At the same time, freshwater systems remain under serious threat worldwide due to complex drivers such as urbanization, agriculture intensification and soil loss, over extraction of groundwater, and increased energy demand. Climate change further complicates these interactions. Sudden- and slow-onset disasters linked to the hydrological cycle have long been a significant driver of forced migration (Breedlove, 2016; UN-Water, 2019). People and ecosystems are particularly vulnerable to decreasing and more variable precipitation in water-stressed areas due to climate change (OECD, 2014). Ocean warming dominates the increase in energy stored in the climate system, accounting for more than 90% of the energy accumulated between 1971 and 2010 (high confidence). It is virtually sure that the upper ocean (0−700 m) warmed from 1971 to 2010, and it likely warmed between the 1870s and 1971(IPCC, 2013; IPCC, 2014). Warmer temperatures and increasing acidity are making life difficult for sea creatures. Ordinarily, as winter snowpack melts in the springtime, it slowly adds freshwater to rivers and streams and helps to replenish drinking water supplies. However, as the air warms, many areas receive more precipitation as rain rather than snow. This means less water is being stored for later as snowpack (Wada et al., 2016). Changes in snowpack control flood at decreasing rate also negatively affect wildlife and income from skiing and winter tourism.

Effects of Water Scarcity

Development Health Problems

The direct impacts of climate change-induced conditions, such as drought, may favor water acidification (Whitehead et al., 2009). Moreover, more frequent and severe extreme weather events could affect runoff. This may cause soil erosion and affect the mobility and dilution of contaminants, rivers' morphology, and the transfer of sediments in rivers (Arakawa, 2017; UN, 2006). However, the relationship of water quality to weather and climate is very complex and it is difficult to make projections about it under all climate change scenarios (Bates et al., 2008; OECD, 2014). Indirectly, climate change can reduce agricultural productivity, negatively influence nutrition and increase the spread of food-borne illness (UN-Water, 2019).

Loss of agriculture production and productivity

Increased evapotranspiration would lead to greater overall precipitation levels, but precipitation events may become heavier and less frequent, and the geographical patterns of rainfall may change. In regions where essential food production and hunger are significant concerns, addressing climate adaptation – primarily through water-related impacts – is essential to reduce long-term and short-term food security threats (UN-Water, 2019). The decline of irrigation water is 70% of the freshwater used in the world.

Conflicts between ethnic groups and between countries

Figure 5 Dried upstream geographical.co.uk

Only three (3) percent of Earth's water is usable by humans and much of it is unattainable. Nevertheless, we have poorly managed it and used it inefficiently, all of which worsened with rapid population growth and climate change. Unrest, instability and conflict can all be triggered or worsened by water scarcity. The globe, making some regions significantly more stressed than others. The Middle East will be one of the regions most affected by water shortages in the following years. According to an analysis by World Resources Institute, 33 countries will face extremely high water stress in 2040, of which shocking 14 will be in the Middle East, with nine (9) states having a maximum score of five (5). Israeli-Palestinian conflict, India and Pakistan, are example of stress for control of transboundary water. Comparable many have reclassified civil war in Syria as a climate-change war, linking the outburst of conflict to prolonged drought that hit the country between 2006 and 2011. The Blue Nile Rivers dialogue about the great Renascence dam is the Egyptian leader's fear of long-lasting climate change affects the water flow because of water harvested in the dam; but is political issue site of the country to maintain the water use power.

Conclusion

Climate change is already occurring; therefore, it is preferable to adapt to the new situation or mitigate the source by lowering greenhouse gas emissions from all activities. Ecosystem restoration, water harvesting, soil and water conservation, biodiversity preservation, and other measures for enhancing water retention must be implemented. The introduction of drought-tolerant crops and livestock species is also critical. Managements must make efficient use of irrigation water without squandering it. Strong national and international policies on the sustainable use of water are essential. This ensures that no water will be wasted in the face of climate change-induced water scarcity.

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This paper DOI: 10.5281/ zenodo.5835190

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