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The Impacts of Climate Change on Groundwater: A Review

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ABSTRACT
Groundwater is considered to be the second largest reservoir of fresh water in the world, which meets the needs of humans due to anthropogenic activities in various parts of the ground. Recently, the impact of climate change on the groundwater has been taken into consideration so that groundwater can be safely managed and used in a balanced manner. Water is considered to be a vital element of world security and the relationship between ground water and climate change is considered significant. Currently, it is difficult to determine the extent and direction of fires so that groundwater can be managed. Also, this article aims to increase the knowledge about the effects of climate change on groundwater resources which includes general information about groundwater, climate change, effects on groundwater resources, and information about sustainable management of groundwater. It deeply affects the water system which reduces the level of groundwater over time and affects the hydrological cycle. The results of this article have been obtained based on the review which may be useful for future researchers and policy makers in the field of sustainable groundwater management in the context of climate change.

Keywords: Impact, Climate Change, Groundwater, Sustainable Groundwater Management

INTRODUCTION
Water is considered as the most useful and renewable resource for humans. Without water, life is impossible because air and water are the characteristics of life. 2/3 of the human body is made up of water (Priyan, 2021). Also, water has been called an essential substance not only for humans but also for the survival of animals, plants, and all other ecosystems. The sustainable quality and quantity of water are threatened by various factors such as agricultural production based on climate change, and the effect of climate change on the quantity, quality, and other factors of groundwater which are still not fully understood (Sharan et al., 2021).

In hot climates, there is a high water demand, which is used in large quantities for drinking and irrigation. In the coming decades, the movement of groundwater to rivers, lakes, and other areas is considered to be a major factor that will decrease and the groundwater amount increase in pumping water (Ferguson and Gleeson, 2012). The effects of global warming and climate change require multi-disciplinary research, especially hydrology and international water resources. The International Panel on Climate Change (IPCC) estimated that the average global temperature has increased by 0.2 ± 0.6°C since 1861 and predicts a rise of 2 to 4°C over the next 100 years. These elevations have a significant direct effect on both precipitation and evaporation in the hydrological cycle (Heath, 1993). Groundwater sustainability is a process of international equity value that has adverse impacts on the environment, society and economy (Gleeson *et al*., 2010). Complex studies on climate change and groundwater are very important at present. The unknown management of groundwater has an important role in the development of water strategies that regulate human and ecosystem needs. There are also few reviews on climate change and groundwater (Dima *et al*., 2021). In this article the effects of climate change are focused on groundwater and sustainable management of groundwater it is very important to protect the groundwater to use the groundwater safely and correctly to use the groundwater continuously.

CLIMATE CHANGE
Climate change is a hypothesis and since the beginning of the transition period of climate on the surface of the earth has changed dramatically, the last ten years of the 21st century are the warmest (Cheng and Zhu, 2018). The average temperature of the world has increased by 1 centigrade and the level of carbon dioxide in the atmosphere has increased from 416 PPM. Based on this climate change has been considered the first line of

study by environmental scientists. It has an impact on the creation and decision-making of social and economic policies at the national and international levels. Little is known about how much warming will occur in the future and how it will affect different areas of life (Berhail, 2019). The level of greenhouse gases has increased significantly since the industrial age which has caused the warming of the earth's surface in the atmosphere and increased the temperature of the world's surface. The increasing concentration of carbon dioxide and greenhouse gases in the atmosphere. It is particularly significant because of the steady rise in global average temperature over the past 150 years (Cerveny *et al*., 2017).

GROUNDWATER

All over the world groundwater is considered one of the most important natural resources which is used on a large scale in the world for irrigation, drinking, and industrial purposes. The physical, chemical, and economic depletion of groundwater occurs at a high level on large continents. Groundwater is a vital source of freshwater that is used by humans, animals, and plants in various parts of the ecosystem. Approximately 1.5-3 billion people use groundwater as drinking water (Velis et al., 2017). Accordingly, it was said that surface water systems such as dams, canals, lakes, etc have less than 1% of freshwater 99% of which is groundwater and cannot be used which means that 1% of water is applicable globally (Du Plessis, 2017). Groundwater infiltrates from the surface of the earth. Groundwater is classified according to the hydrological cycle and based on physical/chemical characteristics which are divided into three main groups; Groundwater storage by rainwater, the amount of shallow water in the ground interacts with the amount of surface water, areas of groundwater that have recently been taken from the surface (Schmidt. S *et al*., 2012).

IMPACT OF CLIMATE CHANGE ON GROUNDWATER

Climate change is one of the primary influencing factors on groundwater and rain is considered to be an element of climate change that has a direct effect on the nutrition of groundwater. Climate change affects both the quantity and quality of groundwater systems which increases the evaporation rate in the warming region which in turn affects the rate of groundwater variability (Amanambu *et al*., 2020). As a result of changes in hydrological processes there is a change in the quality of groundwater (Kløve et al., 2014). With the increase in temperature, there is a change in the biological, chemical, and physical properties of groundwater which changes the quality of groundwater. Climate change is considered one of the most important and potential factors affecting groundwater availability (Afshar *et al*., 2021). Groundwater level changes also have other negative impacts. Many studies have been done on climate change on surface water but there are very few and limited studies on climate change on groundwater. Climate change directly effects the quality of groundwater in the long term so it is said that the relationship between climate change and groundwater is very complex (Moseki, 2017).

SUSTAINABLE GROUNDWATER MANAGEMENT

The sustainable management of groundwater is considered to be the most important part of environmental, economic, social, and technical development. For example, different technologies are used to extract groundwater, which changes the quantity and quality of groundwater (Brown, 2018). Climate change has been considered as one of the biggest challenges for the present and future generations which may potentially harm nature due to these interventions and impacts. The demand for water in every sectorial organization is increasing and climate change has an impact on water availability which has created a great challenge for water resource managers (Swain *et al*., 2022). For the management of the effects of drought which is related to the groundwater the people of the area where the drought prevails should use the surface and groundwater together to manage the situation affected by the drought in a good way (Singh *et al*., 2019).

CONCLUSION

Climate change is a global challenge, affecting water resources worldwide. Groundwater, a vital part of these resources, is significantly impacted by climate change, leading to ecological, physical, and human-made system repercussions. Future climate change is expected to intensify pressure on groundwater due to alterations in the hydrologic cycle. Hydrological scientists advocate evaluating climate change and socio-economic factors for sustainable groundwater management. This study aims to increase knowledge about the relationship between

climate change and groundwater, providing insights into sustainable management methods for researchers and developers. Findings indicate that climate change, evidenced by rising temperatures and reduced precipitation, directly lowers groundwater levels, resulting in drought and associated health, economic, political, and social challenges. The study identifies established standards for sustainable groundwater management proposed by previous researchers for effective utilization of groundwater resources.

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