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The Impact of Climate Change and Variability on Groundwater Resources in Jordan: Literature Review.

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ABSTRACT: Water is vital for life; it is a major contributing factor to economic-socio development and food security specifically in arid areas, semi-arid areas, and those currently suffering a scarcity of water resources. Moreover, its availability at acceptable quality and quantity is undermined by many factors, in which climate change plays a significant role in the hydrological cycle in changing the present situation and then causes the redistribution of water resources by raising the surface air temperature and evapotranspiration rates. Therefore, the variability in rainfall characteristics and the temperature are among the critical climate change impacts on water recourses. Hence, research and understanding of impacts climate change on groundwater is more complicated than it is on surface water and still very limited. Thereby, this paper aims to enhance knowledge on climate change, groundwater resources, it also presents the definitions, categorizations of groundwater, and the methods applied to estimate the groundwater recharge to serve as an introduction to this study. On other hand, it focuses on global and local perspectives regarding the impacts of climate change and its effects on specifically groundwater resources. Also, this paper seeks to study climate change perspectives and impacts on groundwater resources in Jordan as it depends mainly on water sources supplies for many purposes (drinking, domestic and agricultural). Findings were that change of climate and variability is caused primarily by the effects of unprecedented atmospheric levels of anthropogenic and has a profound impact on aquifers systems (decline in groundwater level over time) response to change in the hydrological cycle. Furthermore, the investigation of previous studies in Jordan revealed that a warming trend of mean minimum and maximum temperature records and a negative trend in precipitation. On the other hand, future projections point to the continuous rise of temperature, highly variable rainfall, and increased frequency of extreme weather events.

KEYWORDS: Climate Change, Future Projections, Groundwater Resources, Hydrological Cycle, Jordan.

I. INTRODUCTION

Water is essential for life, is a major contributing factor to economic development and food security, and its availability at acceptable quality and quantity is undermined by many factors not only by population and economy. Many other factors have an influence on water supply and demand, which climate is considered to be a significant deciding factor in the hydrological cycle in changing the world of the present situation and then causes the redistribution of water resources [1;2;3;4; 5; 6; 7; 8].The water crisis is an essential issue for the Jordanian government in recent decades, due to increased demand due to rapid population growth and massive refugee influx related to region political turmoil, reduced precipitation, multiple drought years, and depletion of water resources as a result of excessive over pumping. In the last few years, there has been a growing interest in water resources quantity and quality in Jordan. Moreover, the water available from existing renewable resources is expected to decline by 2025 to below 91 m^3/c.d, which is very low compared with the 1000 m^3/c.d international water poverty line [9].

Jordan is reliant on the variety of water sources order to achieve rising demand. These resources can mainly be classified into conventional as well as non-conventional classifications. Surface and groundwater are conventional resources but treated wastewater and desalinated water represent non-conventional. Surface-water sources consist offlood flow and base flow. The former is the water derived from groundwater drainage through springs, and it is estimated that the total average annual runoff is 686MCM [10]. On the other hand, groundwater in Jordan is of two types, renewable and fossil, the fossil water making up 5% of the total storage. The most essential resource that may be exploited in Jordan is groundwater, which varies in quantity and quality and can be found at depths of up to 1000 meters. The estimated safe annual yield of all renewable groundwater is 275 million cubic meters (MCM). In contrast, the annual extraction is 418 MCM, while the non-renewable fossil aquifers also provide 143 MCM per annum for the next 50 years. Currently, groundwater provides more than 45% of the total water resources in Jordan [11; 12; 13].Reviews by the Intergovernmental Panel on Climate Change (IPCC) Global Climate Change Assessment Report have reported that the global mean temperature has already risen by 1 ° C overall (relative to 1850 to 1900)[14], have reported that in arid areas, semi-arid areas and those currently suffering a scarcity of water resources (such as the Middle East and North Africa)face much greater water deficits in the future, not only in terms of quantity but also in terms of quality[15]. However, the most important consequences of climate change are the change in rainfall amount, forms, spatial and temporal variability, and the temperature, which is more severe in some parts of the earth and will be the effect on replenishment of groundwater storage. Thereby, this paper aims to disseminate, and depict work was done previously in the past and the future on the effect of climate change on groundwater resources. It also focuses on reviewing perspectives will be undertaken nationally, regionally, and globally in terms of how climate change affects past and future availability of groundwater resources and sustainability, with a spotlight on Jordan being one of the poorest countries, as the country is characterized by an arid climate with low precipitation. However, that will also be required to serve as an introduction to the study of research.

Concepts of Climate Variability and Change: The atmosphere, hydrosphere, cry sphere, and biosphere are four intricately interrelated subsystems of the climate system that change under the influence of macroscopic generating and modifying factors such as solar thermal, Earth's rotation, and gravity [16]. Every one of those sub - systems is governed by specific factors that cause the evolution of its observables across quite varied periods [17]. Although weather and climate are related but are not quite the same thing. Additionally, the difference between weather and climate is a temporal measure.Climate change is described as a long-term shift in the statistical distribution of weather patterns (climate state) which lasts for decades to millions of years. A shift in average meteorological conditions or the distribution of occurrences around at that mean might be the cause [18; 19; 20;21]. Climate change also has serious implication for food security, physical, and agriculture, as well as ecological, human health, human-managed systems, water quantity and quality, and land productivity [22; 23; 24;25; 26; 26; 27; 28; 29].

The evidence of human-caused climate change has been thoroughly established through declarations by leading research associations, scientific investigations, and published scientific agreement[30;31; 32; 33; 34; 35].
Moreover, there is increasing consensus that the increase in anthropogenic greenhouse gas emissions is partly responsible for the observed rise in global temperature since the mid-20th century, scientific controversy continues on many topics, including that of the relative size of individual causes of climate change like sulfate aerosols [36; 37]. Human activities are considered as the primary reason for the increase of greenhouse gases, leading to climate change in different areas around the world [38;39; 40; 41]. Climate fluctuation and variation occur on all time scales across the Earth as a result of natural processes. Human impact on the climate system is evident, and recent anthropogenic emissions of greenhouse gases are the highest in history.[30; 33;37, 21, 32, 34, 15, 35, 36, 31]. They researched the causes of climate change all over the world. They concluded that climate change is caused primarily by the effects of unprecedented atmospheric levels of anthropogenic since pre-industrial greenhouse gas emissions from human activities. However, greenhouse gas emissions affect the energy imbalance in Earth's climate system due to increasing concentrations of heat-trapping gases.

Research indicates that the mean global air temperature during the twentieth century has raised by approximately 0.6 ° C due to an increase in atmospheric greenhouse gases [42]. In addition, the Ar5 of the Intergovernmental Panel on Climate Change (IPCC) from 2015 provides evidence indicating human activities have caused global warming. Many researchers revealed widespread melting of snow and ice, rising sea levels, widespread changes in precipitation amounts, ocean salinity, and wind patterns, and an increase in the occurrence of extreme weather, such as droughts, heavy precipitation, heat waves, and the intensity of tropical cyclones[14].However, change of the climate and variability may influence ecosystems, food security, the productivity of land, agriculture, tourism, water quantity and quality, human health, economic, socio-political consequences, agriculture structures, planning and designing of hydraulic structures [43; 44; 45; 46]. Furthermore, in several African countries, food security is already being affected, and researchers are researching possible links between climate change and the probability of military conflicts. We are already seeing the first climate refugees as people are displaced by rising sea levels, Arctic permafrost melting, and other extreme weather conditions [46].

Furthermore, rainfall and temperature patterns are regarded minor indicators of climate change[47; 48; 49]. The two factors, rainfall, and temperature are linked. A rise in Earth's temperature causes more evaporate and clouds, which leads to more rainfall. Global-mean surface temperature (GMST) is the most important indicator of global climate change, because (i) it is directly related to the planetary energy balance (Fourier 1827) and increases quasi-linearly with cumulative greenhouse gas emissions (IPCC, 2013), and (ii) GMST is directly related to most climate impacts and risks (50). As a result, both the scientific community and the general public are very interested in the evolution of GMST over time[51,52]. The IPCC (2013, 2018) reports that the global

mean temperature has already risen by 1 ° C overall (relative to 1850 to 1900) (14; 15). According to NASA, 2018 the half temperature has risen during the last 30 years. Moreover, Earth's surface temperature is rising and set to continue increasing into the future[53; 54; 15]. Furthermore, according to an independent analysis by the National Aeronautics and Space Administration NASA and the National Oceanic and Atmospheric Administration (NOAA) that the earth's global surface temperature in 2018 was the fourth warmest since 1880.
On the other hand, precipitation is an essential component of the water cycle and is the most critical and active variable associated with atmospheric circulation in weather and climate studies [28,29]. In the water cycle, water vapor condenses into clouds from which precipitation may fall, bringing water back to the surface from the atmosphere, providing a primary source of fresh water essential to Earth's life [56]. The mean global annual rainfall is estimated to be around 1000 mm; (57) quote 1050 mm, while (58) measure a cumulative mean of 1123 mm.

In addition, various studies around the world on the climate change phenomenon have been implemented and assessed over the last decades[59;40;60;61;62;63; 47;64;65;66;67]. [59]conducted a study on reviews of the past and future trends of climate change in Malaysia: trends, contributors, impacts, mitigation, and adaptations by the review encompasses historical Climatic data includes daily average rainfall, temperatures, unusual weather occurrences, and mean sea level. The study concluded that mean annual temperature, occurrences of extreme weather events, and mean sea level are increasing while variability is shown in precipitation. Future forecasts point to a steady increase in temperature and mean sea level until the end of the 21st century, extremely variable precipitation, and higher frequency of extreme weather events. Moreover, the author shows that the energy and waste management sectors are the major contributors to climate change.Trend analysis of rainfall pattern over the Central India during 1901–2010 has been conducted by [40].

Revised Mann-Kendall (RMK) test, Sen’s slope estimator, and innovative trend method (ITM) used to evaluate of trends of precipitation for 20 stations. The conclusion of the study that Similar trends were generally obtained for monthly, annual, and seasonal rainfalls from the RMK and ITM tests. However, the study indicated there is no significant trend in the station for the January and October months based on the obtained results of RMK test, the results of the ITM test showed that almost all stations have declining trends in the seasons of annual (16 stations), summer (16 stations) and monsoon (11 stations), while winter (12 stations) and post-monsoon (11 stations) seasons are generally showing increasing trends.(60) used trend detection through parametric and non-parametric tests to inspect and analyze the change of rainfall and temperature in north-central Ethiopia where the period under investigation was 1901 to 2014. However, their researchers have arrived at the conclusion that the Palmer drought severity index value proved the increasing trend of the number of drought years while annual rainfall have decreased with a rate of 15.03, 1.93 and 13.12 mm per decade respectively. The rate of change of temperature was found to be 0.046, 0.067, and 0.026 °C per decade for mean, minimum and maximum respectively. The climate variability and drought frequency over potential crop-growing regions of Ethiopia during 1983−2012 were analyzed by [61]. The author used Mann–Kendall statistical method and GIS to evaluate climate variability and drought characterization in Ethiopia over three decades. The result showed that the ninetieth percentile of rainfall, the number of rainy days with precipitation>10 mm/day, and the highest 10 d total rainfall were increased overtime at most of the stations. On the other hand, extreme maximum temperature (90th percentile) increased more than 45% of the weather stations, while extreme minimum temperature (90th percentile) increased 53% of the weather stations. On the other hand, several researchers have used GIS to investigate land use and land cover change.(Addisu, Selassie, Fissha, & Gedif, 2015) used time-series trend analysis to address the national and local issues of climate change in the highlands of Ethiopia and Lake Tana Sub-basin in particular. In this study, however, the climate record has been used for 40 years. They revealed that the mean, maximum, and minimum temperature had a general increasing trend, whereas the rainfall amount showed a general decreasing trend in Lake Tana Sub-basin.

[63] conducted a spatial and temporal trend analysis of temperature and precipitation in the whole of Iran for 40 years. Their analysis showed that the spatial calculations of the trends showed that no identical system exists in the country, but there was no special trend in most parts of Iran and only a few parts of the country have a positive or negative trend. Moreover, the seasonal precipitations trend was negative in most times of the year. All temperature indexes have had positive and negative trends with much dispersion in autumn. [47] carried out trend analysis in annual temperature and precipitation using the Mann Kendall test for the nine states to assess the climate change in the Northeastern United States. The result showed a significant increase in temperature trends, and precipitation trends in just six states are also significantly increasing. [64] carried out statistical and analyzed on number climatic stations in the Arabian Peninsula for the period 1978-2009and found out the annual rainfall showed a significant declining trend 47.8 mm/decade in the past half of the analysis historical,

with a relatively great interannual changeability, although the maximum, mean and minimum temperatures have increased significantly at a rate of 0.71, 0.60, and 0.48°C per decade, respectively.[65] reviewed Analyzing Climatic and Hydrologic Trends in Lebanon. This study indicated that there are no significant changes in rainfall trends but there is an increase in temperature, which increases snowmelt and decreases its spatial coverage.[66] used slopes of the regression lines, and the statistical significance for climatic trends by means of the Mann–Kendall, Mann–Whitney and Mann–Kendall rank statistic tests in the south, west, and southwest of Iran for the period 1966–2005. The authors detect a warming trend in annual temperature mean, temperature maximum and temperature minimum at the majority of the stations which mostly began in the 1970s .[67] studied trend analysis of annual and seasonal rainfall time series in the Mediterranean area in southern Italy for the period 1918–1999. However, the study indicated that many stations show a significant negative trend in cumulate precipitation, a positive trend has also been reported for a limited number of gauged sites. Furthermore, fluctuation during the period 1940–1950, which was one of the driest ever experienced.

In Jordan, several scientific studies have detected climate change in past years[69;43;70;24;71;72;73;74].Temporal and Spatial Analysis of Climate Change at Northern Jordanian Badia has been conducted by (69). They reported an increase in air temperature at an annual rate of 0.02-0.06 C / year and a decrease in annual rainfall at an annual rate of 2.6-0.5 mm/year. [43] used time series plots and Mann-Kendall test to detect variability and trends in daily rainfall in Amman-Zarqa Basin in Jordan. However, the period under consideration is from 47-77 years. The author detects that the trend toward decreased wet season duration correlated with the decreasing number of rainy days for most stations. Also, the maximum and average daily rainfall for most stations is increasing in trend. [70] studied the climate change implication on Jordan. They used software MATLAB and GIS for weather forecasting. However, the data used were from 1979-2008. The output results were converted into geographical maps to forecast for the period (2009–2018). The study concluded that total rainfall in the northern region will increase to 30 while total rainfall in the southern region is expected to decrease to 50 mm. [24]carried out analyzed on fourteen meteorological stations distributed over Jordan for a period of more than 50 years. The result showed that there were increasing trends in autumn rainfall while in the annual rainfall there were increasing trends in the northwest part of the country and decreasing trends in the rest of the country.

[71] carried out a study on trend analysis rainfall and temperature. The study area at three locations in Jordan (Irbid, Amman, and Raba), using linear trend analysis for 30 years to forecast and project precipitation and maximum temperature for 20 years. The result showed that positive trend in mean maximum temperature and a negative trend in total precipitation at three sites in the study area. [74] analyzed the trend analysis of temperature and precipitation in Jordan. The study concluded that there is no visible trend indicating an annual precipitation and maximum temperature. [72] have been conducted a study on climate variability in Jordan. However, their study indicated that insignificant, declining trend in precipitation. [73] examined the trend analysis of temperature and precipitation in Jordan, using Lag-one serial correlation and Mann-Kendall rank tests and stochastic climatic trends. The study indicated none of the precipitation series showed significant trends; furthermore, the slope forecasts showed negative changes in the total annual precipitation for most stations and a warming trend of mean minimum and maximum temperature records for different stations in Jordan. Moreover, the analysis indicates that the mean annual minimum and maximum temperature records in Jordan have a warming trend over the period 1964 to 1999.

However, the review of previous studies showed around the world on the climate change phenomenon that a significant negative trend in cumulate precipitation and asignificant increase in temperature trends. On the other hand, future projections point to the continuous rise of temperature and mean sea level till the end of the 21st century, highly variable rainfall, and increased frequency of extreme weather events. Furthermore, the investigation of previous studies in Jordan revealed that a warming trend of mean minimum and maximum temperature records and a negative trend in precipitation Southern rest of the country, on the contrary, a positive trend in total precipitation in the northwest of the country. On the other hand, future projections point to the continuous rise of temperature and mean sea level till the end of the 21st century, highly variable rainfall, and increased frequency of extreme weather events.

Groundwater Resources: The groundwater is one of the most important natural resources in the world. It plays an important role in supplying water to a large part of the world population for use in irrigation, drinking water, and industrial purposes. Physical and economic water scarcity occurs on many of the populated continents. The quantity and quality of groundwater issues pose a major set of problems and challenges facing the world during this century (75).

“Ground water means different things to different people” [76; 78]. [76] defines groundwater as groundwater (is) any surface water that has not yet been exchanged. Thus, only water entering from the ground by infiltration is known as groundwater by this definition, and water recharging from stream or lake beds is not.While, technically one groundwater definition is: "cohesive subsurface water which moves as a result of gravity" (78). On the other hand, [78] categorized groundwater based on the complexity of hydrological and subsequent physical/chemical characteristics, which they assume extend over spatial and temporal scales, but this complexity can be divided into three main groups: (1) shallow groundwater areas are formed by precipitation and recharge of the soil, (2) areas of shallow groundwater primarily formed by interaction with surface water bodies like lakes and rivers; and (3) aquifer areas that have not recently received major inputs from the surface because they are isolated in-depth and are older than the young recharge. However, a variety of methods can be used to estimate the groundwater recharge. As a matter of principle, measures of surface water, unsaturated zone, or saturated zone can be used to determine recharge. Approaches include physical, chemical, or isotope methods as well as numerical modeling [79]. Groundwater is the main water supply in Jordan due to the scarcity of surface water supplies, which provides for more than 45% of total water availability, and most groundwater systems are already exploited beyond their estimated safe yield [80]. Annual safe yield from all renewable groundwater is estimated at 275 million cubic meters (MCM), while annual extraction is 418 MCM at twice the rate of recharge for the aquifers approximately. Also, the non-renewable fossil aquifers have 143 MCM per year for the next 50 years [12].

Several studies and methods around the Jordan have been studied in terms of both quality and quantity of groundwater recharge, aquifer properties, pollution sources, and knowledge on the relationship between neighboring basins to use water resources sustainably over the past decades[81;80;82;12;83].[81]studied Geospatial Techniques for Improved Water Management in Jordan. Their research was focused on evaluating groundwater extraction records relating to irrigated areas and estimating crop water consumption in three water basins: Yarmouk, Amman-Zarqa, and Azraq.On the other hand, the over-abstraction of groundwater was estimated to range from 144% to 360% of the safe yield in the three basins. Over Exploitation of Groundwater in the Centre of Amman Zarqa Basin—Jordan: Evaluation of Well Data and GRACE Satellite Observations has also studied by [80]. The results showed with results of previous studies in other areas in Jordan and shows that, until now, no sustainable water management is applied. They concluded that the average drawdown trend observed at wells data was calculated to be 1.64 $m \cdot a^{-1}$ in the last 15 years. Furthermore, the results showed the linear trend from GRACE adjusted terrestrial water storage in the concentrated water column over the study region there is a decline in groundwater at a rate of up to approximately −10 mm per annual. This value is equal to around 160 mm per annual in groundwater change concentrated over the model region. [82] has been generated groundwater vulnerability map for Amman Zarqa Basin (AZB)based on information derived and calculated from processed remote sensing information and laboratory analysis, they found out that, the vulnerability map shows approximately 77 %, roughly 2919 km2 of the AZB, classified as very low to low, which could lead to sources of pollution due to the absence of possible hazards and low vulnerabilities. Moreover, approximately 14 % (530 km2) are categorized within the moderate vulnerability region. Approximately 5 % (about 19 km2) of the study area lies below. Around 5 %of the study region (around 19 km2) lies below Just 4 %can be classified as very high-risk areas. On the other hand, due to its thick cover of partly marly sequences, the Kurnub Sandstone aquifer (K) is generally well covered in the central and eastern portion of the AZB. However, the Kurnub aquifer may pose a potential risk from the Zarqa River recharged infiltrating surface water, which is highly polluted due to industrial activities located along the river.

Application of GIS and remote sensing to groundwater exploration in Al-Wala Basin in Jordan has been studied by [12]. The results showed that spatial distribution of the most promising groundwater exploration sites depended on the interrelated lithology, topography, and geological structure factors. The highest percentage of groundwater wells was within the alluvial and wadi sediments, which the digitally classified Landsat 7 ETM+ ETM+ accurately identified. The study revealed remote sensing and GIS provide powerful tools to map promising groundwater exploration sites. The groundwater wells data, however, will contribute to refining the final positions of the most promising sites.[83] assessed the levels of selenium in the groundwater basin of Amman Zarqa to determine the quality of the groundwater. Based on geological correlation and statistical analysis of major/minor constituents and Piper tri-linear diagrams. The analysis also indicates the average concentrations of Se in the lower, middle, and upper aquifers of the basin were 3.41, 32.99, and 9.19 lg/L, respectively. Researchers suggest that the primary factors influencing groundwater chemistry are the carbonate / phosphate dissolution, oxidation-reduction processes, and fertilizer / irrigation return flow. Also, they suggested the high variability in concentrations of Se might be correlated to the possibility of a multi-source Se origin in the area.

However, the review of previous studies showed the important groundwater resources, definitions, categorized groundwater, and methods to estimate the groundwater recharge. Furthermore, the investigation of several previous studies in Jordan relating to groundwater resources of abstraction, the average drawdown trend, the hazard, and the vulnerability of groundwater.

Climate Change and Groundwater: Research on climate change impacts and related adaptation to water demand is still very limited [84]. Climate change directly affects surface water quality through changes in significant long-term climate variables such as air temperature, precipitation, and evapotranspiration, and the relationship between changing climate variables and groundwater (a hidden resource) is more complex and poorly understood [85; 38; 6]. The impacts of climate change will put to stress on groundwater resources by impeding recharge capacities in some areas and being called upon to fill potential gaps in the supply of surface water due to increased precipitation variability [7]. Moreover, groundwater residence periods can range from days to tens of thousands of years or more, which delays and disperses the climate effects and challenges efforts to identify climate variability and change responses in groundwater. The predicted consequences of climate change on groundwater recharge are a challenge in hydrogeological research because there are still significant doubts, particularly in arid and semi-arid areas [86]. Many studies have been conducted on the effects of climate change on surface water, but very little research is available on the possible impacts of climate change on groundwater [87; 88; 89; 6; 90; 91; 86; 92]. While groundwater is the world's primary source of drinking water, it plays a vital role in preserving an area's ecological value.

Climate change impacts on groundwater resources global perspectives: Authors and researchers studied and evaluated the effect of climate change on water resources over the past years in South Africa, southern Mali, Bangladesh, China, Australia, Turkey, Spain. [7] have been discussed the impacts of climate change on groundwater. The study presents overviews of the effects of climate change on groundwater resources and finding that climate change can have profound effects on aquifers systems response to change in the hydrological cycle through precipitation, runoff, and soil moisture. However, the study is based primarily on previous literature where there is no use of a climate model to describe the finding of the researcher. [29] investigated the significance of direct and indirect impacts of climate change on groundwater resources in the Olifants River Basin, and found that the decrease in water availability due to increased demand, combined with the expected decrease in the region's runoff, would result in increased water stress. [93] studied the impact of climate change on groundwater resources in the Klela Basin, southern Mali, using MODFLOW to simulate groundwater dynamics and RCP4.5 (Representative Concentration Scenario 4.5 W/m2) climate scenario. The finding of the study shows that a decrease in groundwater levels over time. [94] studied the impact of climate change on regional water balances in Bangladesh and found that a decline in groundwater level due to an increase in irrigation water use both future and historic time. The results also revealed from this study indicate that more significant impact than irrigation development only on and runoff and evapotranspiration. Effects of Land Use and Climate Change on Groundwater and Ecosystems at the Middle Reaches of the Tarim River Using the MIKE SHE Integrated Hydrological Model has been studied by [75]. The result showed that the major contributor to groundwater recharge is natural flooding. The results also demonstrate that there will be significant groundwater depletion and environmental destruction in the region after the glaciers melt in the Tian Shan Mountains, causing great difficulties for local people. (86) studied the Assessment of future groundwater recharge in semi-arid regions under climate change scenarios (Serral-Salinas aquifer, SE Spain), using simulations of the regional climate model (RCM) and a proposal for a range of models to determine the impacts of climate change. The finding of the study also shows that the ensemble of predictions estimates a 14 % reduction in mean annual recharge for A2 scenario and a 58 % reduction for A1B scenario. Reduced future recharge values will be obtained if only the mean change is imposed. [95] implemented a study to evaluate the impact of climate change on groundwater resources in a small Mediterranean watershed in Turkey, using water hydrological model with SWAT Soil and Water Assessment Tools, according to the simulation results, almost all water budget components have decreased and found that lack of water is expected to be a problem in thefuture.

Climate change impacts on groundwater resources in Jordan: In Jordan, climate change is real, especially in relation to increasing temperatures and declines in rainfall. This will further emphasize the quantity and quality of limited and stressed water resources available in Jordan [96]. Throughout the past years in Jordan, scientists and researchers researched and analyzed the impacts of climate change on groundwater resources.[10] has conducted a study on the impact of global warming on groundwater resources of Jordan at 18 weather stations distributed within Jordan and reported that the global climate change would significantly impact Jordan's available groundwater resources. [97] studied Climate change impacts on Azraq basin by using water

evaluation and planning program (WEAP). The result from this study indicates that water demand under the scenario of climate change has increased dramatically due to increased temperature and reduced precipitation.
These studies showed that change of climate and variability especially in an increase in temperature and decline in precipitation have profound effects on aquifers systems (decline in groundwater level over time) response to change in the hydrological cycle through precipitation, evaporation, runoff and soil moisture both future and historic time. Climate change has resulted in increasing demands for groundwater due to increase in water use and its demand rate and will cause damage in environmental in most regions, especially those areas that depend on groundwater as a source, causing great difficulties for developing countries that aims to achieve sustainable development goals in addition to affecting the local population.

II. CONCLUSION

Climate change is one of our society's most serious and significant challenges. This phenomenon concerns all countries all over the world, especially on water resources, where most countries in the world facing a water crisis, and climate change exacerbate this problem. Moreover, Climate change is caused primarily by the effects of unprecedented atmospheric levels of anthropogenic since pre-industrial greenhouse gas emissions from human activities. The impact of climate change on ecological, physical, human-managed systems, food safety, land production, agriculture, water quantity, and human health is significant. On the other hand, the impacts of climate change will put to stress on groundwater resources response to change in the hydrological cycle through precipitation, evaporation, runoff, and soil moisture both future and historic time. This research aims to address this critical issue by identifying variations in air temperature and rainfall, which are thought to be the two most important indicators of climate change. Additionally, scientists and governments cope up to these challenging conditions in order to deal with potential climate-related challenges. Also, these studies demonstrate that change of climate and variability especially in an increase in temperature and decline in precipitation have profound effects on groundwater resources. Its demand rate will cause damage in environmental in most regions, especially those areas that depend on groundwater as a source, causing great difficulties for developing countries that aims to achieve sustainable development goals in addition to affecting the local population.

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