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RESEARCH ARTICLE
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Effect of changing in Some Sulaymaniyah Climate Elements on Rates of Evapotranspiration from the period 1979 to 2022, Iraq

Akram Muhildin AbdulRahman[1] **Jawhar Hamalaw Khalid [2]** **Hiwa Bayez sharif [1]**
Aso Kamal Tayyib [2] **Laila Umer [2]**

[1] Sulaymaniyah Directory of Agricultural Research, Ministry of Agricultural and Water Resources, Sulaymaniyah, IRAQ.
[2] Sulaymaniyah Directorate of Meteorology and Seismology, Ministry of Transportation, Sulaymaniyah, IRAQ.

*Corresponding Author: Absrh2010@gmail.com.

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ABSTRACT

The present work implementation was achieved in Sulaimaniyah city, north of Iraq In locations N35.55, and E45.44 to study the effect of local climate changes during the study period on the annual rates of evaporations, Daily meteorological Data on Evaporation, Temperature, Relative humidity, Wind speed, and Rainfall for analyzing data using the standardized Penman-Monteith (PM) equation for short canopy reference evapotranspiration value, under current conditions, The month of June is considered the most variable compared to the rest of the months during the study period as evaporation rates decreased by an average of 3.75 mm. Evaporation levels exhibit seasonal variability, as evidenced by the annual evaporation rates. During the colder and rainier months, specifically October through March, a decreasing trend in evaporation rates was observed throughout the study. Conversely, in the warmer months (April through September), the highest annual radiation in 2021, 17.5 (MJ m^{-2} day^{-1}), marked an increase from 1982's 15.5 (MJ m^{-2} day^{-1}). Over 43 years, the average annual rate of radiation change is approximately 0.0263, indicating a gradual increase. Over 43 years (1979-2022), Evapotranspiration ranged from 3.68mm to 4.4mm, increasing due to higher temperatures and solar radiation. Higher wind speeds generally increase evapotranspiration due to enhanced evaporation and transpiration processes. When comparing the changes in wind speed during the years of the study, the wind speed increased at a general rate for all years of the study amounting to 1.4(m. $sec.^{-1}$) and the change between each year and the following year varied between an increase and a decrease from the general rate of these changes. The rainfall data from 1979 to 2022 shows notable yearly fluctuations. The 1980s and early 2000s had lower rainfall, while the 1990s and late 2000s experienced higher amounts, with a decrease again in the 2020s .average annual increase of 0.22% and an average value of 46.00%. The standard deviation of 3.17 suggests most values fall within 42.83% to 49.17%. High relative humidity years (e.g., 1982, 1988, 1992, 2003, 2015, 2019) indicate near-saturation air, leading to reduced evapotranspiration rates due to lower vapour pressure gradients and transpiration efficiency. Conversely, low-humidity years (e.g., 1984, 1987, 2000, 2008, 2013, 2021) show a higher capacity for air to absorb water vapour.

***Keywords*:** Evapotranspiration, Relative Humidity, Rainfall, Temperature, wind speed.

INTRODUCTION

Generating climate change data projections is fraught with uncertainties at every stage. These uncertainties arise from the input data and uncontrollable local factors in regionalization, presenting significant challenges. A study by [1] observed that water resource management studies often begin with regionalized CC predictions and precipitation forecasts, focusing particularly on potential changes in evapotranspiration and reference evapotranspiration. This focus is vital for assessing possible shifts in water availability in semi-arid areas, which is critical due to [2] highlighted that, in Spain, regionalization and model-related uncertainties are more pronounced in the creation of regionalized precipitation series. In contrast, uncertainties in emissions play a lesser role in temperature series, which align more closely with historical reference series. Despite these uncertainties, these projections remain crucial for understanding the impacts of climate change (CC) on water resources and for developing effective adaptation strategies. [3] emphasized that climate changes could alter evaporation rates and intensify the hydrological cycle .its significant consumption of scarce precipitation.

Although there have been limited catchment-scale studies comparing water yield between annual and perennial plants, significant land cover changes from agricultural expansion and reversion have been noted since the mid-20th century. In eastern North America, much of the land originally forested or grass-covered has reverted to forests and successional fields, a trend driven by factors like low profitability and concerns over soil erosion. [4] While the increase in evapotranspiration rates with temperature is well-established [5]. Note that various other factors, such as humidity also influence it. Increased humidity can reduce transpiration, moderating the effects of higher temperatures on evaporation. Hence, considering concurrent humidity changes is essential when estimating ET under changing climatic conditions. This study accounts for diverse microclimates to understand the varying impacts of climate change .The primary objective of this study is to examine the direct effects of local climate changes in the study area on climate elements and to lay the groundwork for future research on climate change and its implications for the environment and human life. In collaboration with the Department of Meteorology and Seismic Monitoring in Sulaymaniyah Governorate, daily monitoring and data documentation have been undertaken. [6]

Lastly, radiation, particularly solar radiation, is critical for converting liquid water into vapour during evaporation and transpiration. [7] indicate that changes in radiation patterns, resulting from natural variability or anthropogenic climate change, can significantly affect evapotranspiration rates and patterns, with implications for regional water availability and ecosystem functionality. Quantifying the effects of climate change on agricultural systems is inherently challenging due to several scientific complexities. Three major factors contribute to this challenge: First, Global Warming Models and Incomplete Variables: Foremost is the reliance on numerical models to project the impact of global warming on future climate patterns. These global-scale models, while sophisticated, often do not encompass all the influencing factors, such as the oceans' role in CO2 absorption. This leads to a significant gap in the accuracy and reliability of predictions. Moreover, the data used in these models can be inconsistent. For instance, predictions about greenhouse gas emissions vary significantly based on human activities, including fossil fuel consumption and emissions, technological advancements, economic development, and population growth in different countries. Each element introduces uncertainty into the models [8]; [9]. Second: Regional Application of Global Model Results: Another significant hurdle is translating the results of these global climate models into actionable insights for specific regions. Global models typically provide general predictions, such as increases or decreases in temperature and precipitation. However, applying these broad trends to particular localities requires a process of regionalization. If this process is not meticulously executed, it can lead to inaccuracies and misrepresentations in how global climate trends affect specific regions [10]. Third: Limitations of Current

Evapotranspiration Models: Lastly, the current empirical (based on temperature and radiation data) and semi-empirical (such as the Penman-Monteith models) approaches to modelling evapotranspiration (ETo) are not well-equipped to factor in the nuanced changes brought about by climate change. These models, in their present form, are constrained in their ability to accurately reflect the effects of climate change on ETo. They are predominantly suitable for conducting sensitivity analyses, rather than offering comprehensive, future-proofed predictions about ETo under shifting climatic conditions [11]

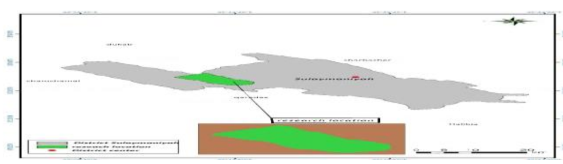


Figure 1. Location study

Method:

Climate Data: Data from the Department of Meteorology and Seismic Monitoring in Sulaymaniyah and the Department of Agricultural Research for the period 1979 until 2022 were used for the analysis, the most important climatic factors that affect evapotranspiration are temperature, relative humidity, wind, rainfall, and solar energy. Bazian is a very important agricultural area southwest of Sulaymaniyah city, the reason that made us care about this region is that it contains a huge numbers of agricultural greenhouses amounting to approximately 17,000 greenhouses, in addition to its importance as an agricultural area. (fig. 1) which includes in northeastern Iraq, Bazian, the study area may be identified by the way its surface looks overall it is surrounded by small plains and valleys positioned on the western slopes between longitude (35o.49'.00" N) and latitude (45o.25'.00" E). Monthly means of daily climate data from 1979 were used to make the daily mean ETo calculations. The daily ETo means were multiplied by the days per month to obtain monthly totals, and the monthly totals were summed to obtain the annual total, Eto. The reference value of evaporation and evapotranspiration
ion was calculated using the FAO Penman-Monteith equation using the ready-made computer program (CropWat V. 8) and according to the following equation FAO Penman-Monteith equation for estimating evapotranspiration. [12]

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}$$

ET_o reference evapotranspiration [mm day^{-1}]
R_n net radiation at the crop surface [MJ m^{-2} day^{-1}], megajoule per square meter and per day.
G soil heat flux density [MJ m^{-2} day^{-1}], megajoule per square meter and per day.
T mean daily air temperature at 2 m height [°C].

u_2 wind speed at 2 m height [m s^{-1}].
e_s saturation vapour pressure [kPa].
e_a actual vapour pressure [kPa].
e_s - e_a saturation vapour pressure deficit [kPa].
Δ slope vapour pressure curve [kPa °C^{-1}].
γ psychrometric constant [kPa °C^{-1}].

Results & Discussion

1- Changes in evaporation over the years of study.

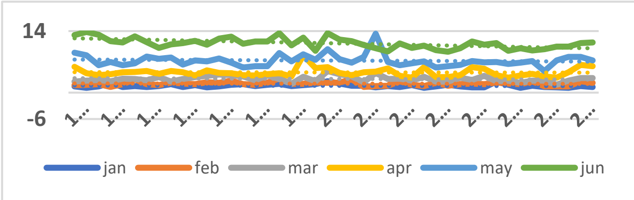
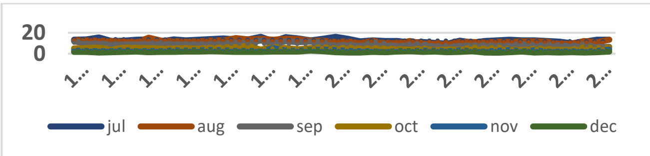


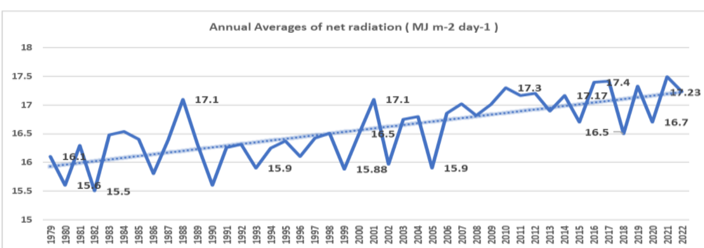
Fig (1). Annual Averages of Evaporation rates (mm) for Jan., Feb., Mar., Apr., May, and Jun months for the study period, Source (Sulaymaniyah Meteorology Department).



Fi. (2) Annual Averages of Evaporation rates (mm) for Jul., Aug., Sep., Aoc., Nov.,t and Dec. months for the study period Source, (Sulaymaniyah Meteorology Department).

The Sulaymaniyah meteorology station measures the evaporation rate from a standardized open water surface using a "pan" at various outdoor locations .Similar measurements are conducted worldwide. The rate of water evaporation, whether from a surface or through stomata on leaves, is influenced by climatic and weather conditions .Key factors include solar radiation, temperature, relative humidity, and wind. [13]

Figures 1 and 2 demonstrate that evaporation levels vary seasonally. In the cold and rainy months (October to March), there is a trend of decreasing annual evaporation rates over the study years. In contrast, during the warm months (April to September), evaporation rates do not exhibit significant fluctuations over the years. The decrease in evaporation during the cold and rainy months is attributed to increasing humidity. The air holds a certain amount of water vapour, and when humidity rises, the evaporation rate tends to decrease. [14] In contrast, during the warm months, the higher temperatures lead to greater kinetic energy of molecules at the substance's surface, resulting in a faster evaporation rate. the measurement of evaporation at the Sulaymaniyah meteorology station introduces factors influencing evaporation, highlights seasonal variations in evaporation rates, and explains the observed trends based on climatic conditions [15].

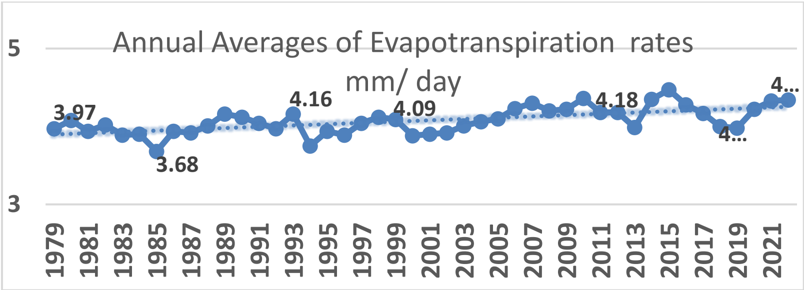


1-Changes in Radiation over years of study and its impact on Evapotranspiration

Fig. (3) Annual Averages of Radiation rates (MJ m-2 day-1) for the study period (1979- 2022). Source, (Sulaymaniyah Meteorology Department).

The evaporation process requires a considerable amount of energy, which is supplied by solar radiation. Figure 3 illustrates the solar radiation levels throughout the study years, highlighting the variation and increase in the amount of solar radiation available for evaporation. Solar radiation exhibits fluctuations based on the season and weather conditions. [16] In 2021, the annual radiation rate peaked at 17.5 MJ m^{-2} day^{-1}, surpassing the levels observed in other years of the study. Comparing this to the 1982 levels of 15.5 MJ m^{-2} day^{-1}, there has been a noticeable increase, as depicted in Figure 3. The average rate of change in radiation over the 43 years is approximately 0.0263 units per year, indicating a gradual rise in radiation levels over time [17].

In his [18] they have explained the effects of climate change, noting an increase in the number of daylight hours over the years in all seasons, particularly in the hot months of June and July. Transpiration, the release of water vapor from plants, primarily occurs through small pores called stomata on their leaves. Solar radiation plays a crucial role in influencing transpiration by driving the process of photosynthesis, the conversion of sunlight into energy by plants. Sunlight provides the necessary energy for photosynthesis, prompting plants to open their stomata to absorb carbon dioxide. This opening allows water vapour to escape from the plant into the atmosphere.



2-vapotranspiration Values change over study years Figure 4, shows the annual averages of Evapotranspiration from 1979- 2022. Source,
(Sulaymaniyah Meteorology Department).

The analysis of evapotranspiration (ET) over 43 years from 1979 to 2022 is presented in Figure (4) The data reveal that the lowest ET value recorded during this period was 3.68 mm in 1985, while the highest was 4.4 mm in 2015. A trend analysis of ET values indicates a discernible upward trajectory over the years. This increase is attributed primarily to rising temperatures, which have averaged an increase of 1.3°C, as reported by [19]. Elevated temperatures, coupled with intensified solar radiation, typically lead to augmented rates of evaporation and transpiration, as warmer air can retain more moisture, thus facilitating the transition of water from liquid to vapor. Furthermore, radiative forcing – the discrepancy between incoming solar radiation and outgoing infrared radiation – plays a crucial role in modulating temperature variations. Fluctuations in radiative forcing, particularly those linked to climate change, exert a significant impact on regional and global ET patterns. Additionally, climate change has been associated with increased wind speeds, as noted by [20]. This increase contributes to lower humidity levels, as the air becomes less saturated with moisture, thereby enhancing the capacity for drier air to absorb more water vapor Changes that occurred in annual temperature (C°) averages during the study period and the impact of that on the rate of Evapotranspiration and the effect of that on changes in evapotranspiration.

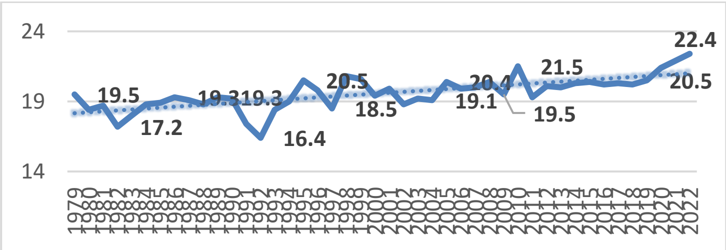


Figure 5, shows the annual averages of temperature for the period 1979- 2022. Source,
(Sulaymaniyah Meteorology Department).

As shown in Figure (5) there's a shred of significant evidence that the air temperature degree has increased over these years. However, there are clear changes between a decrease and a rise in temperatures the change towards an increase is making evaporation a component of the energy balance at the Earth's surface, this temperature changes affect this balance affecting not only water availability but also local climate conditions Changes in evaporation and transpiration rates can affect ecosystems and biodiversity [21]. Especially in areas where vegetation is sensitive to water availability, like our region. The impact of changing temperature on evapotranspiration rate is a significant factor in hydrology and water resource management; Evapotranspiration is the combined process of water evaporation from surfaces (such as soil and water bodies) and plant transpiration. Here's a brief analysis of the relationship between temperature and evapotranspiration [22].

From Figure 5, Warmer temperatures generally lead to increased evapotranspiration rates. This is because higher temperatures enhance the evaporation of water from surfaces. Higher temperatures can stimulate plants to undergo transpiration at a faster rate, as they tend to open their stomata more to cool themselves through the release of water vapour [23]. elevated temperatures, especially with reduced precipitation, can result in increased evapotranspiration without a corresponding increase in available water. This situation can contribute to drought conditions. climate change can alter temperature patterns, potentially leading to shifts in evapotranspiration rates. This can profoundly affect regional and local water cycles [24]. Wind Speed (m. sec.$^{-1}$) changes over the years of the study period and the effect of that on changes in evapotranspiration.

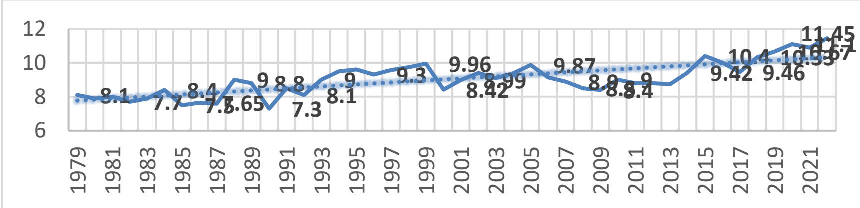


Figure 6, shows the annual averages of Wind Spead (m. sec. $^{-1}$) for the period 1979- 2022. Source, (Sulaymaniyah Meteorology Department)

Figure (6) clearly shows how wind speed changes throughout the study years as temperature degrees change; from the chart, higher wind speeds generally result in increased evapotranspiration due to enhanced evaporation and transpiration processes. However, it's essential to consider other environmental factors, such as temperature, humidity, and solar radiation, as they also play crucial roles in the overall water balance in ecosystems [25]. Reported that Wind disrupts the boundary layer of still air that forms near the surface. This boundary layer can act as a barrier to evaporation, and wind helps thin this layer, allowing for more efficient evaporation. Wind plays a significant role in evapotranspiration, affecting both the rate of water vapour loss from surfaces and the transpiration from plants [26].

When comparing the changes in wind speed during the study, the wind speed increased at a general rate for all years of the study amounting to 1.4(m. sec. $^{-1}$). The change between each year and the following year varied between an increase and a decrease from the general rate of these changes [27]. Wind speed is one of several factors that contribute to the microclimate around plants. It affects the exchange of heat and moisture between the plant and its surroundings. In windy conditions, the drying effect on leaves can increase water loss through transpiration. Transpiration is the process by which plants release water vapour through small pores (stomata) in their leaves. Higher wind speeds can accelerate transpiration by removing the water vapour from the vicinity of the leaves. This creates a more favorable gradient for water movement from the plant to the atmosphere [28]. Changes in rainfall (mm) amounts during the years of study and their impact on evapotranspiration processes

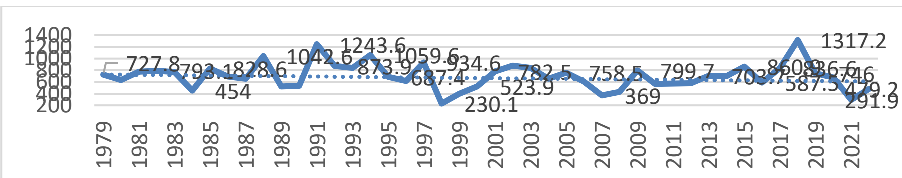


Figure (7) shows the annual averages of Rainfall amounts (mm) for the period 1979- 2022 source, (Sulaymaniyah Meteorology Department)

Figure 7 shows significant year-to-year variability in rainfall from 1979 to 2022. There are periods of both sharp increase and decrease. The 1980s and the early 2000s show relatively lower amounts, the 1990s and late 2000s show higher amounts, and there's a notable decrease again in the 2020s [29].

1979 -1980s: The data starts with 727.8 mm in 1979 and shows variability through the 1980s, with amounts ranging from as low as 454.0 mm (in 1986) to as high as 1042.6 mm (in 1989). This decade shows considerable fluctuation without a clear long-term trend.

1990s: This decade begins with lower amounts (around 520.8 mm in 1990) and sees a significant increase, peaking at 1243.6 mm in 1992. The rest of the 1990s fluctuates but generally stays higher than the early 1980s.

2000 :2010 - The early 2000s start with lower figures (230.1 mm in 2000 being a notable low) and then gradually increase, with some fluctuation, reaching 1317.2 mm by 2010, the highest in your dataset. 2010 - 2022: Post-2010, the data again shows variability, with a general decrease from the 2010 peak. The lowest in this period is 291.9 mm in 2021, indicating a significant

decrease towards the end. the average rate of change in rainfall over this period is approximately -5.78 mm per year. This indicates a general decrease in rainfall amounts from 1979 to 2022. [30], [31]
Also, rainfall adds moisture to the soil. When the soil is moist, more water is available for evaporation and plant uptake. This can lead to an increase in evapotranspiration rates, as plants will transpire more water when it is readily available, and evaporation from the soil surface will be higher compared to dry conditions. As well as Rainfall can also alter local humidity and temperature. Higher humidity levels following rain can reduce the evapotranspiration rate because the air holds more moisture, leading to a smaller gradient between the moisture in the air and the moisture in the soil or plants. Lower temperatures can also reduce evapotranspiration since warmer temperatures typically increase evaporation and transpiration rates [32]. During and immediately after rainfall events, cloud cover is usually more extensive. This reduces solar radiation, which can decrease the energy available for evaporation. In the short term, this might lead to a decrease in evapotranspiration rates. Rainfall can affect plant growth and leaf area, impacting transpiration. After sustained periods of rainfall and increased soil moisture, plants may grow more vigorously, with greater leaf area, leading to increased transpiration. Conversely, during periods of low rainfall and water stress, plants may reduce their leaf area or close their stomata to conserve water, leading to lower [33].
Excessive rainfall can lead to surface runoff, especially in areas with compacted soil, slopes, or poor infiltration capacity. Runoff carries water away from the area, which can reduce the amount of water that infiltrates the soil and becomes available for evapotranspiration. Additionally, if the soil becomes saturated, oxygen levels in the soil can drop, potentially stressing plants and reducing transpiration. The impact of rainfall on evapotranspiration can also be seasonal. For example, in arid and semi-arid regions, rainy seasons can see a significant increase in evapotranspiration due to higher soil moisture and plant growth, while dry seasons may see reduced evapotranspiration [34] Changes in annual Relative humidity (%) averages during the study period and the impact of that on the rate of Evapotranspiration and the effect of that on changes in evapotranspiration

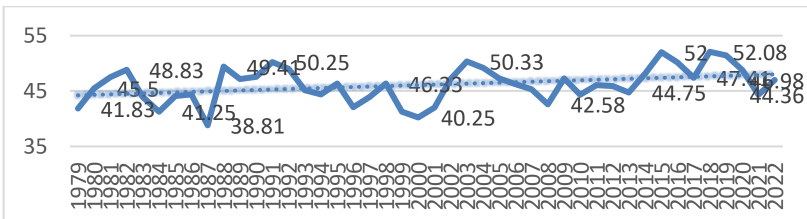


Figure (8) shows the annual averages of Relative Humidity (%) for the period 1979- 2022, Source, (Sulaymaniyah Meteorology Department).

Plotting the relative humidity values over the years on a graph in Figure 8 can provide a visual representation of the trends and fluctuations. And notes that there are discrepancies in relative humidity values between increasing and decreasing in the study years for the average annual increase in relative humidity of about 0.22% over 43 years. Analyzing such data usually involves looking for patterns, trends, or anomalies. Inconsistencies and fluctuations in annual data are affected by various factors, including changes in climate, specific weather events, or changes in local or regional conditions [35]. The average relative humidity over 43 years was about 46.00%. Which is the central point around which relative humidity values cluster? The standard deviation was 3.17, measuring how much individual values deviate from the mean. A higher standard deviation indicates greater variance in the data. With a standard deviation of 3.17, most individual relative humidity values fall within about 3.17 percentage points above or below the average of 46.00%. In other words, most values are likely 42.83% to 49.17% [36].
When the air's relative humidity is high like these values (48.83, 49.41, 50.25, 50.33, 52, 52.08, and 50.48) for the years (1982, 1988, 1992, 2003,2015, and 2019), it means the air is near saturation with water vapour. In such conditions, the air has a reduced capacity to accept more water vapour. This leads to a decrease in the rate of evapotranspiration. When the air is humid, the gradient of vapour pressure between the leaf interior (where humidity is high) and the external air is lower, which slows down the transpiration rate. Similarly, evaporation from soil or water surfaces is less efficient under high humidity conditions [37]. Conversely, low relative humidity, like these years (1984, 1987, 2000, 2008, 2013, and 2021) with values (41.25, 38.81, 40.25, 42.58, 44.75, 44.36), indicates that the air is dry and can absorb more water vapour. This creates a higher vapour pressure deficit, the difference between the amount of moisture in the air and how much it can hold when it's saturated. A higher vapour pressure deficit enhances the rate of evapotranspiration. Dry air can take up water vapor more readily from the soil, water bodies, and plant leaves, thus increasing evaporation and transpiration rates [38]. Plants often respond to high humidity by closing their stomata, the pores in their leaves, to reduce water loss. This is a protective mechanism to conserve water. In low humidity conditions, stomata are generally more open, assuming sufficient water availability, and allowing more transpiration [39]

Conclusion

This review presents that the relationship between relative humidity and evapotranspiration is inversely proportional.

Higher humidity typically reduces evapotranspiration rates, while lower humidity can increase them, assuming other factors like temperature and solar radiation are conducive. this relationship is essential in fields like agriculture, hydrology, and climate science, as it helps predict water demand, irrigation requirements, and ecological dynamics. Temperature changes have a direct and complex relationship with evaporation rates. Understanding this relationship is crucial for water resources management, especially in the context of climate change and its potential impact on hydrological cycles.

REFERENCES

[1]. Mitchell T, Hulme M. Predicting regional climate change: Living with uncertainty. Prog. Phys. Geogr. Earth Environ. 1999; 23: 57–78. DOI: 10.1191/030913399672023346

[2]. [2] Amblar Francés P, Casado Calle M, Pastor Saavedra A, Ramos Calzado P, Rodríguez Camino E, Guía de Escenarios Regionalized de Cambio Climático Sobre España a Partir de los Resultados del IPCC-AR5; AEMET: Madrid, Spain, 2017; p. 102. DOI: 10.31978/014-17-010-8

[3]. [3] Huntington TG. Evidence for intensification of the global water cycle: review and synthesis. J Hydrol. 2006; 319: 1(4) 83-95. DOI: 10.1016/j.jhydrol.2005.07.003

[4]. [4] Houghton R A, Hackler J L. Changes in terrestrial carbon storage in the United 376 States. I: The roles of agriculture and forestry Global Ecol. Biogeography. 2000; 9: 125-377

[5]. [5] Chaouche K, Neppel L, Dieulin C, Pujol N, Ladouche B, Martin E, Salas D and Caballero Y. Analyses of precipitation, temperature and evapotranspiration in a French Mediterranean region in the context of climate change. Comptes Rendus Geoscience. 2010; 342(3):234-243. doi.org/10.1016/j.crte.2010.02.001

[6]. [6] Xiang K, Li Y, Horton R, Feng H. Similarity and difference of potential evapotranspiration and reference crop evapotranspiration—A review. Agric. Water Manag. 2020; 232: 106043. doi.org/10.1016/j.agwat.2020.106043

[7]. [7] Montoro A, Mañas F, López-Urrea, R. Transpiration and evaporation of grapevine, two components related to irrigation strategy. Agric. Water Manag. 2016; 177: 193–200. doi.org/10.1016/j.agwat.2016.07.005

[8]. [8] Seneviratne S, Lu¨ thi D, Litschi M & Scha¨r C. Land–atmosphere coupling and climate change in Europe. Nature. 2006; 443: 205–209. DOI: 10.1038/nature05095

[9]. [9] Gharsallah O, Facchi A, Gandolfi C. Comparison of six evapotranspiration models for a surface irrigated maize agroecosystem in Northern Italy. Agric. Water Manag. 2013; 130: 119–130. doi.org/10.1016/j.agwat.2013.08.009

[10]. [10] Prenger J, Fynn R, Hansen R. A comparison of four evapotranspiration models in a greenhouse environment. Trans. ASAE 2002; 45: 1779. DOI: 10.13031/2013.11429

[11]. [11] Zhang Z, Li X, Liu L, Wang Y, Li Y. Influence of mulched drip irrigation on landscape-scale evapotranspiration from farmland in an arid area. Agric. Water Manag. 2020; 230: 105953. DOI: 10.1016/j.agwat.2019.105953

[12]. [12] Allen R, Pereira L, Raes D, Smith M. Crop evapotranspiration. Guidelines for computing crop water requirements. FAO Irrigation and Drainage., FAO, Rome 1998; Paper no. 56. FAO, Rome, 300, D05109.

[13]. [13] Ramírez D, Yactayo W, Rolando J, Quiroz, R. Correction to: Preliminary Evidence of Nocturnal Transpiration and Stomatal Conductance in Potato and their Interaction with Drought and Yield. Am. Potato J. 2017; 95: 139–143. DOI: 10.1007/s12230-017-9618-9

[14]. [14] Helfer F, Lemckert C, Zhang H. Impacts of climate change on temperature and evaporation from a large reservoir in Australia. J. Hydrol. 2012; 475: 365–378. doi.org/10.1016/j.jhydrol.2012.10.008

[15]. [15] Herman M, Nejadhashemi A, Abouali M, Hernandez-Suarez J, Daneshvar F, Zhang Z, Anderson M, Sadeghi A, Hain C, Sharifi A. Evaluating the role of evapotranspiration remote sensing data in improving hydrological modeling predictability. J. Hydrol. 2018; 556: 39–49. doi.org/10.5194/hess-2023-200

[16]. [16] Yilmaz A and Imteaz M 2011. Impact of climate change on runoff in the upper part of the Euphrates basin. Hydrology. Sci. J., 2011; 56 (7): pp. 1265-1279. doi.org/10.1080/02626667.2011.609173

[17]. [17] Oishi A, Oren R, Stoy P. Estimating components of forest evapotranspiration: A footprint approach for scaling sap flux measurements. Agric. For. Meteorol. 2008; 148: 1719–1732. DOI: 10.1016/j.agrformet.2008.06.013

[18]. [18] Akram M Abdulrahman. An analytical study of the climatic elements in Bazian region Sulaymaniyah for the period from 1985 - 2022 and its impact on the planting dates of some crops. Kirkuk University Journal for Agricultural Sciences, 2023; 14(3): 399-412. doi: 10.58928/ku23.14339

[19]. [19] Akram M Abdulrahman & Jawhar H Khalid, Zana M Majeed and Aso K Taib. influence of temperature rises over 48 years on Sulaymaniyah agroecosystem structure and nematode distribution using GIS application. Soil Science and Agricultural Engineering. Zagazig J. Agric. Res. 2021; 48. (1). DOI: 10.21608/zjar.2021.165676

[20]. [20] Akram M AbdulRahman1 Jawhar H Khalid. Influence of climate changes (Winds, vapor pressure) on Sulaimaniyah Governorate, stricture, and sustainable Agroecosystem. Kufa Journal For Agricultural Sciences. 2019; 11(2):43-53

[21]. [21] Mackay D, Ah D, Ewers B, Gower S, Burrows S, Samanta S, Davis K. Effects of aggregated classifications of forest composition on estimates of evapotranspiration in a northern Wisconsin forest. Glob. Chang. Biol. 2002; 8: 1253–1265. DOI: 10.1046/j.1365-2486.2002.00554.x

[22]. [22] Gu L, Hu Z, Yao J, Sun G. Actual and Reference Evapotranspiration in a Cornfield in the Zhangye Oasis,

Northwestern China. Water 2017; 9: 499. doi.org/10.3390/w9070499
[23]. [23] Christopher T, Goodburn J. The Effects of Spatial Patterns on the Accuracy of Forest Vegetation Simulator (FVS) Estimates of Forest Canopy Cover. West. J. Appl. For. 2008; 23: 5–11. DOI: 10.1093/wjaf/23.1.5
[24]. [24] Javadian M, Behrangi A, Smith W, Fisher J. Global Trends in Evapotranspiration Dominated by Increases across Large Cropland Regions. Remote Sens. 2020; 12: 1221. doi.org/10.3390/rs12071221
[25]. [25] Guo Y, Song C, Zhang J, Wang, L, Sun L. Influence of wetland reclamation on land-surface energy exchange and evapotranspiration in the Sanjiang plain, Northeast China. Agric. For. Meteorol. 2021; 296: 108214. doi.org/10.1016/j.agrformet.2020.108214
[26]. [26] Zhang K, Kimball J, Running, S. A review of remote sensing based actual evapotranspiration estimation. Wiley Interdiscip. Rev. Water. 2016; 3: 834–853. DOI: 10.1002/wat2.1168
[27]. [27] Akram M Abdulrahman & Aladdin Yüksel. Effect of Some Agroecosystems Management Applications on Plant Flowering and Root-Knot Nematodes Activates Using Some Soil Improvements in Greenhouses. B.A.E.R. 2019; 3 (2): 142-151
[28]. [28] Yan C, Zhao W, Wang Y, Yang Q, Zhang Q, Qiu G. Effects of forest evapotranspiration on soil water budget and energy flux partitioning in a subalpine valley of China. Agric. For. Meteorol. 2017; 246: 207–217. DOI: 10.1016/j.agrformet.2017.07.002
[29]. [29] Wang K, Dickinson, R, A review of global terrestrial evapotranspiration: Observation, modeling, climatology, and climatic variability. Rev. Geophys. 2012; 50. doi.org/10.1029/2011RG000373.
[30]. [30] Shi Z, Xu L, Yang X, Guo H, Dong L, Song A, Zhang X, Shan N. Trends in reference evapotranspiration and its attribution over the past 50 years in the Loess Plateau, China: Implications for ecological projects and agricultural production. Stoch. Environ. Res. Risk A. 2017; 31: 257–273. DOI: 10.1007/s00477-015-1203-5
[31]. [31] Acharya N, Shrivastava N, Panigrahi B, Mohanty U. Development of an artificial neural network based multi-model ensemble to estimate the northeast monsoon rainfall over south peninsular India: An application of extreme learning machine. Clim. Dyn. 2014; 43: 1303–1310. DOI: 10.1007/s00382-013-1942-2
[32]. [32] Wang Y, Liu Y, Jin J. Contrast Effects of Vegetation Cover Change on Evapotranspiration during a Revegetation Period in the Poyang Lake Basin, China. Forests 2018; 9, 217. doi.org/10.3390/f9040217
[33]. [33] De Dios V, Roy J, Ferrio J, Alday j, Landais D, Milcu A, Gessler A. Processes driving nocturnal transpiration and implications for estimating land evapotranspiration. Sci. Rep. UK 2015; 5: 1–8. doi.org/doi:10.1038/srep10975
[34].]34] Han Y, Zhang, L, Wang C, Yuan J, Wei H. Dynamic characteristics and influencing factors of actual evapotranspiration in cold wetland. South North. Water Transf. Water Sci. Technol. 2018; 16: 28–34. doi.org/10.3390/w14050700
[35]. [35] Bultot F, Dupriez G, Gellens D, 1988. Estimated annual regime of energy balance components, evapotranspiration and soil moisture for a drainage basin in case of a CO2 doubling. Climate Change. 1988; 12: 39–56. doi.org/10.1177/030913339501900
[36]. [36] Snyder R.L. Daily Reference Evapotranspiration (Eto) Calculator. Department of Land, Air and Water Resources, University of California. Davis, California. 2000
[37]. [37] Clark, D. (1998) " CropWat for Windows user Guide, University of Southampton, version. 1998; 4(2):13 October.
[38]. [38] Airman D, Houter G. Influence of radiation and humidity on transpiration: Implications for calcium levels in tomato leaves. J. Hortic. Sci. 1990; 65: 245–253. DOI:10.1080/00221589.1990.11516053
[39]. [39] Tanny J. Microclimate and evapotranspiration of crops covered by agricultural screens: A review. Biosyst. Eng. 2013; 114: 26–43. doi.org/10.1016/j.biosystemseng.2012.10.008..

تأثير تغير بعض عناصر مناخ مدينة السليمانية خلال 43 سنة على معدلات التبخر- النتح من الفترة 1979-2022، العراق

أكرم محي الدين عبد الرحمن[1] جوهر حمه لاو خالد[2] هيوا بايز شريف [1] أسو كمال طيب[2] ليلى عمر[2]

[1]. مديرية الابحاث الزراعية في محافظة السليمانية, وزارة الزراعة والموارد المائية, العراق
[2]. مديرية الانواء الجوية والرصد الزلزالي في محافظة السليمانية, وزارة النقل, العراق

الخلاصة

بيانات الأرصاد الجوية اليومية عن التبخر، ودرجة الحرارة، والرطوبة النسبية، وسرعة الرياح، وهطول الأمطار لتحليل البيانات باستخدام معادلة ***Penman-Monteith (PM)*** الموحدة لقيمة التبخر المرجعية للمظلة القصيرة، في ظل الظروف الحالية، ويعتبر شهر يونيو هو الأكثر تغيرًا مقارنة وبقية الأشهر خلال فترة الدراسة حيث انخفضت معدلات التبخر بمعدل 3.75 ملم. وتظهر مستويات التبخر تقلبات موسمية، كما يتضح من معدلات التبخر السنوية. خلال الأشهر الباردة والمطرية، وتحديداً من أكتوبر إلى مارس، لوحظ اتجاه تنازلي في معدلات التبخر طوال فترة الدراسة. على العكس من ذلك، في الأشهر الأكثر دفئًا (أبريل حتى سبتمبر)، أعلى إشعاع سنوي في عام 2021، 17.5 (ميجا جول م-2 يوم-1)، يمثل زيادة عن عام 1982 البالغ 15.5 (ميجا جول م-2 يوم-1). وعلى مدار 43 عامًا، يبلغ متوسط المعدل السنوي للتغير الإشعاعي حوالي 0.0263 وحدة، مما يشير إلى زيادة تدريجية. وعلى مدار 43 عامًا (1979-2022)، تراوح معدل التبخر والنتح من 3.68 ملم إلى 4.4 ملم، ويزداد بسبب ارتفاع درجات الحرارة والإشعاع الشمسي. تؤدي سرعات الرياح المرتفعة عمومًا إلى زيادة التبخر بسبب عمليات التبخر والنتح المعززة. وعند مقارنة التغيرات في سرعة الرياح خلال سنوات الدراسة تبين أن سرعة الرياح زادت بمعدل عام لجميع سنوات الدراسة بلغ 1.4 (م.ثانية-1) وتباين التغير بين كل سنة والسنة

التالية بين الزيادة والنقصان عن المعدل العام لهذه التغيرات. تظهر بيانات هطول الأمطار من 1979-2022 تقلبات سنوية ملحوظة. شهدت الثمانينيات وأوائل العقد الأول من القرن الحادي والعشرين انخفاضًا في هطول الأمطار، في حين شهدت التسعينيات وأواخر العقد الأول من القرن الحادي والعشرين كميات أعلى، مع انخفاض مرة أخرى في عشرينيات القرن الحادي والعشرين. متوسط الزيادة السنوية 0.22% ومتوسط القيمة 46.00%. يشير الانحراف المعياري البالغ 3.17 إلى أن معظم القيم تقع ضمن 42.83% إلى 49.17%. تشير سنوات الرطوبة النسبية العالية (على سبيل المثال، 1982، 1988، 1992، 2003، 2015، 2019) إلى هواء قريب من التشبع، مما يؤدي إلى انخفاض معدلات التبخر والنتح بسبب انخفاض تدرجات ضغط البخار وكفاءة النتح. وعلى العكس من ذلك، فإن سنوات الرطوبة المنخفضة (على سبيل المثال، 1984، 1987، 2000، 2008، 2013، 2021) تظهر قدرة أعلى للهواء على امتصاص بخار الماء.

الكلمات المفتاحية: التبخر نتح، الرطوبة النسبية، هطول الأمطار، درجة الحرارة، سرعة الرياح.