Iraqi Journal of Agricultural Sciences –2026:57(8):2339-2350
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/gt254v14

Evaluation of the Effect Between Rainfall and Soil Moisture in Iraq

Sara Ali Muter *[1], Yaseen Kadhim Al-Timimi [2], Monim Hakeem Al-Jiboori [3]
*[1, 2, 3] Department of Atmospheric Science, College of Science, Mustansiriyah University, Baghdad, Iraq.

ABSTRACT

Soil moisture data improves the accuracy of remotely sensed surface soil moisture evaluations, as water resources, agriculture, climate, and ecosystems are impacted by land-atmosphere interactions. This study aimed to examine the retrieved soil moisture data and its correlation with rainfall to analyze the regional interdependence between the two variables. Both soil moisture measurements from Google Earth Engine and rainfall records from ground-based stations were analyzed from the year 2000 to 2021. It was observed that the relationship between soil moisture and rainfall follows a polynomial function and that there is a strong positive correlation between the two, with a Pearson r value of 0.86, which suggests that soil moisture increases with rainfall. Additionally, the relationship was found to be climate dependent, with stronger correlations in humid and temperate regions, and weaker correlations in arid and cold climates. Regions in the north and central parts of the country, where rainfall was abundant, showed a stronger correlation as compared to the desert and arid regions with less rainfall, which showed weak or no significant correlation. Furthermore, it was discovered that during periods of heavy rainfall, there is an increase in the rate of groundwater recharge and surface water flow, which are vital for the conservation of local water resources. These outcomes emphasize the need to focus on the complex relationship between soil moisture and rainfall for efficient water resource management, particularly in areas of diverse vegetation and climates.

Key words: Correlation, GEE, Iraq, Rainfall, Soil moisture, Satellite observations.

Received: 18/4/2025, Accepted: 13/7/2025, Published: 31/8/2026

INTRODUCTION

Soil moisture content is regarded as a key factor in environmental agriculture, hydrology, and climate change studies. Soil moisture at depths of one to two meters, plays a crucial role for the interaction between the Earth and the atmosphere. Therefore, monitoring and assessment of the spatial and temporal variations in soil moisture content are essential (Abdul-Jabbar, & Abdulkareem, 2021). The relationship between soil moisture and rainfall represents a critical aspect of the hydrological cycle. This interaction becomes particularly important in the context of global climate change, which is characterized by heightened variability in both the frequency and intensity of rainfall events (Abdulraheem, et al. 2023). Soil moisture is the amount of water in the soil compared to the amount of dry solid particles, shown as a percentage. In hydrology and the water cycle on land, soil moisture is an important state variable (Al-Taai, & Hadi, 2018). Soil moisture is utilized in weather forecasting, climate variability, agricultural productivity, water resource management, drought prediction, flood area mapping, and ecosystem health monitoring (Abhilash & Rana 2023) .Soil moisture assess at several scales, from in situ observations to satellite footprints that are about 40 km wide, and at different times (Clemente et al. 2020). Alongside satellite radiometers, radar scatter meters are used to retrieve soil moisture. However, each of these technologies can only partially satisfy the requirements for high spatial and temporal resolution (Irfan, et al.

Iraqi Journal of Agricultural Sciences –2026:57(8):2339-2350
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/gt254v14

2020). Over the past ten years, many research have looked at how rainfall affects soil moisture around the world. It used NASA's SMAP and TRMM datasets to look at the relationship between soil moisture and rainfall around the world. The results showed that there were larger associations in dry and sparsely vegetated areas than in wet and densely vegetated areas. The results show that the kind of ecosystem and climate has a big effect on the link between soil moisture and rainfall, especially in dry areas (Sehler, et al. 2019). (Zhang et al. 2020) looked at how soil moisture changes in the Pisha sandstone area of China, which is prone to erosion. Their research showed that rain is the main cause of soil moisture. It has a big effect on the top layers of soil (up to 50 cm), but not so much on the deeper layers. The ground grows wetter when it rains, but the way the water is spread out vertically doesn't change. This shows how important rain is for fixing up land .(Irfan et al. 2020) used a system of integrated observations to directly collect data and quantify things. Two stations were put up in different sites to study the connection between rainfall and soil moisture in peatlands in South Sumatra. The statistical study indicated a strong linear relationship between rainfall and soil moisture, with correlation coefficients of 0.78 and 0.64 (Irimia, et al. 2023). (Panayan and Mamta 2023) looked explored the link between rainfall and soil moisture in the area by using remote sensing products to detect soil moisture and the Climate Hazard Group Infrared Rainfall with Station Data (CHIRPS), which delivers worldwide rainfall data at a 5 km resolution. We looked at the results statistically and saw that there was a weak to moderate correlation between soil moisture and rainfall in the research areas we chose to observe. (Dai et al. 2022) used a soil moisture sensor on the Qinghai-Tibet Plateau in 2015 and 2016 to study how soil moisture levels varied in alpine meadows and shrub habitats. The results showed that the surface soil (0–20 cm) and medium soil (40–60 cm) immediately altered when it rained, but the deeper soil (80–100 cm) took longer to respond. There was a positive link between soil moisture and rain and a negative link between soil moisture and air temperature (Das, et al. 2023). These studies show that satellite images can be used to accurately measure soil moisture at a lot of different times and places. You can find patterns and trends that might be linked to variations in temperature, rainfall, or other weather factors by keeping a watch on soil moisture over time (Muhammad, & Al-Dabbas, 2022). It utilise satellite images and other remote sensing methods to keep an eye on soil moisture across large areas and long periods of time. Scientists may be able to gain a better picture of how soil moisture changes over time and what that means for the ecosystem and water supplies by combining data from remote sensing with observations and models made on the ground. Soil moisture in Iraq is very important for stopping desertification, protecting farming, and lessening the effects of climate change. To make sure that resources last, it's important to find and deal with the things that change the moisture in the soil. Climate change, less water, and people doing things that aren't good for the environment are all making Iraq's soil drier. When the temperature goes up, more water evaporates, which makes it hard for the soil to stay moist. This problem gets worse when there is a drought or rain that comes and goes, especially in the dry central and southern parts (Kazemi, et al. 2024). The purpose of this study is to find out how soil moisture changes and behaves throughout months and years, as well as how rain affects soil moisture in all parts of Iraq. It also looks at how well Google Earth Engine (GEE) can be used to anticipate the amount of moisture in the surface soil and keep an eye on how it changes over time and space in Iraq.

MATERIALS AND METHODS

Study area: The Republic of Iraq is the main focus of the study's geographical area. Iraq is in the southwestern part of Asia, at the subtropical latitudes of the northern hemisphere. Its climate is influenced by tropical high-pressure systems during the summer months . Iraq lies between the equator (29.5°) and mid-latitudes (37.5°), spanning longitudes from 38.45° to 48.45° east of the Greenwich Meridian. It shares land borders with six other countries: Iran, Jordan, Kuwait,

Iraqi Journal of Agricultural Sciences –2026:57(8):2339-2350
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/gt254v14

Saudi Arabia, Syria, and Turkey. Iraq has a Mediterranean climate, ranging from semi-arid (highlands) to arid (lowlands), with dry and hot summers and cool winters (Abhilash, & Rana, 2023). Iraq's climate is characterized as a continental and subtropical system, featuring four distinct seasons. In Iraq, in the winter, the minimum temperatures in the north can be below zero, and in the summer, the maximum temperatures in the south can be over 45°C (Zhang, et al. 2020). Rainfall occurs seasonally from November to May, with an overall average annual rainfall of 150 mm in the south and 900 mm in the northeast. The annual mean wind speed in Iraq is approximately 3.6 m/s (. The primary bodies of water influencing Iraq are the Arabian Gulf and the Mediterranean Sea, which significantly affect its climate and thermal characteristics. Iraq has a varied terrain that includes plains, hills, and mountains. It is also home to a wide variety of soil types (Amani, et al. 2020).

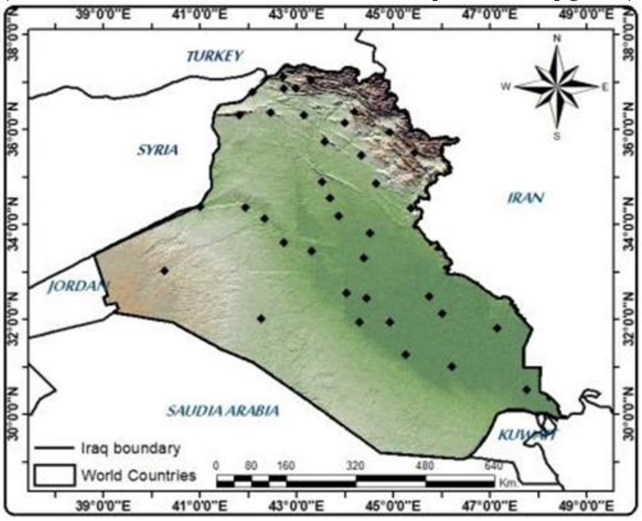

Figure 1. The study area includes the location of meteorological stations throughout Iraq

Data: Historical records of rainfall for the period 2000-2021 were acquired from the Iraqi Meteorological Organization & Seismology. These data were collected from 38 stations located in different regions of Iraq; see (Figure 1) and (Table 1). Soil moisture data were acquired from Google Earth Engine (GEE). Soil moisture data were used from the GLDAS NOAH (Global Land Data Assimilation System - Noah Model) dataset provided by NASA. These data were derived from the SoilMoi0_10cm_inst layer measuring soil moisture at 0-10 cm depth. They are exhibited as one picture with a resolution of 0.25 degrees for each month from 2000 to 2021.

Google Earth Engine: GEE, a powerful geospatial processing tool, over a cloud-based computing network. It fixes the huge IT challenges that come up when you have to use a lot of equipment to work with geographical data (Sazib et al., 2020). People who utilise GEE can design algorithms that automatically produce data products or apps that let users interact with them (Mimeau et al., 2021). This feature makes it possible for people who don't know much about web programming or application design to use the platform's resources (Velastegui et al., 2023). The cloud is a single high-performance computing environment that makes it easy to store, process, and analyse spatial data. It lets scientists, researchers, and enthusiasts work with datasets that help them understand how the surface of the Earth changes over time (Taminimia et al., 2020). Using Google's computing power to deal with big problems in society, like deforestation, drought, disaster relief, disease control, food security, water resources management, climate monitoring, and environmental monitoring and protection (Clemente et al., 2020), research could be done all over the world at different spatial and temporal resolutions. GEE provides access to a rich database of more than 40 years of historical and contemporary global satellite images, the necessary tools for data assessment, and the power to process and extract data from these vast resources (Dai et al., 2022).

Iraqi Journal of Agricultural Sciences –2026:57(8):2339-2350
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/gt254v14

Table 1. Details of Geographic coordinates for study area

Station No.	Station Name	Latitude (Degree)	Longitude (Degree)	Station No.	Station Name	Latitude (Degree)	Longitude (Degree)
1	Emadiah	37.05	43.29	20	Kanaqin	34.18	45.26
2	Sumeel	36.86	42.85	21	Samaraa	34.11	43.53
3	Rabiah	36.48	42.06	22	Haditha	34.04	42.22
4	Tel-Afer	36.22	42.29	23	Al-Khalis	33.5	44.32
5	Sinjar	36.19	41.5	24	Heet	33.38	43.45
6	Ducan	36.12	44.92	25	Ramadi	33.27	43.9
7	Zakho	37.08	42.41	26	Baghdad	33.14	44.14
8	Duhook	36.52	43	27	Rutbah	33.02	40.17
9	Salahaddin	36.37	44.13	28	Karbalaa	32.37	44.01
10	Mosul	36.19	43.09	29	Kut	32.3	45.49
11	Erbeel	36.09	44	30	Hella	32.27	44.27
12	Makhmoor	35.45	43.36	31	Kut-Al-Hai	32.1	46.03
13	Sulaimaniya	35.33	45.27	32	Nukaib	32.02	42.15
14	Kirkuk	35.28	44.24	33	Najaf	32.01	44.2
15	Baiji	34.56	43.29	34	Diwaniya	31.59	44.59
16	Tuz	34.53	44.39	35	Amarah	31.51	47.1
17	Tikrit	34.34	43.42	36	Semawa	31.18	45.16
18	Ana	34.28	41.57	37	Nasiriya	31.05	46.14
19	Al-Kaem	34.23	41.01	38	Basra	30.34	47.47

Methodology: It used correlation and regression to see if there is a connection between rainfall and soil moisture in Iraq from 2000 to 2021. It performed the Pearson correlation test to see how total rainfall and soil moisture were connected (James, et al. 2023). This number tells you how strong and in what direction a linear relationship is between two things. The Pearson correlation coefficient, which can be between -1 and 1, tells you how strong and what direction a link is. A score of 1 means a perfect positive correlation, -1 means a perfect negative correlation, and 0 means there is no linear relationship. Values close to 1 reflect a strong correlation, while values near 0 indicate a weak or non-existent relationship (Gao, et al. 2022).This coefficient is commonly used in data analysis to identify relationships between variables is computed using equ.(1). ArcMap was employed to examine the spatial and temporal aspects of the rainfall and soil moisture data, while Origin was utilized to calculate the correlation and evaluate the relationship between the two variables (James, et al. 2023).

$$r = \frac{\sum_{i-1}^{x}(Xi-Y)(Yi-Y)}{(n-1)SxSy} \text{........ (1)}$$

$\bar{X}$ is arithmetic mean of the data x1, x2, xn
$\bar{Y}$ is arithmetic mean of the data y1, y2, yn
Sx is the standard deviation of the data x1, x2, xn
Sy is the standard deviation of the data y1, y2, yn

The relationship is polynomial in representing the relationship between rainfall and soil moisture may not be constant but rather depends on the previous saturation level of soil or seasonal conditions (Faizi&Alvi, 2023). This is the general expression and it can also expressed as;

$$f(x) = a_n X^n + a_{n-1} X^{n-1} + \cdots . + a_1 x + a_0 \text{.... (2)}$$

RESULTS AND DISCUSSION

Analysis of soil moisture and rainfall in Iraq: The temporal distribution of mean monthly rainfall and soil moisture was studied for Iraq. The results, presented in (Figure 2), indicate seasonal variation in soil moisture levels. During the wet months, average soil moisture demonstrated an upward trend, with levels in the wet season (October to April) considerably exceeding those in the dry season (May to September) across all study sites. The northern regions recorded the highest rainfall, with amounts decreasing toward the south. Additionally, rainfall was most abundant during the winter months (December, January, and February), while summer months experienced minimal rainfall. (Figure 2) displays two time-series graphs illustrating the trend of rainfall and soil moisture, depicting soil moisture (in kg/m³) over a specific period. The above graph represents rainfall (in mm). The data exhibits a clear seasonal pattern, with peaks corresponding to periods of heavy rainfall, likely occurring during the main rainy season or winter, and troughs representing dry seasons. This cyclical behavior reflects the

Iraqi Journal of Agricultural Sciences –2026:57(8):2339-2350
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/gt254v14

region's climatic characteristics. Higher soil moisture values are observed immediately following periods of increased rainfall, indicating the soil's capacity to absorb water. On the other hand, a slow drop in soil moisture following the rain shows things like evaporation and water moving into deeper layers of soil. This shows that the amount of moisture in the soil changes with the seasons because the weather changes. The most moisture is between 25 and 28 kg/m³, and the least is between 9 and 12 kg/m³. This huge gap shows that the amount of moisture changes a lot throughout the year. Climate change, new farming methods, or other environmental variables could have caused these alterations. Farmers can better manage water by planning irrigation if they know about these changes. It could be helpful to look at this data in more detail, perhaps by looking at long-term patterns or comparing different time periods, to get a clearer idea of what has changed. Rain and soil moisture are directly related and change over time. After it rains, the ground gets a lot wetter, but after the rain stops, it gets drier. This shows how water moves in and out of the ground. The short period between the peaks of rainfall and the soil moisture response could be because of how the top layers of soil soak up and hold water. The cyclical pattern in both graphs shows how much soil moisture depends on rain that falls in different seasons. This connection is very important for figuring out how changes in the climate influences the balance of water in the soil. It also provides valuable insights for developing predictive models to manage water resources, mitigate drought effects, and optimize agricultural practices.

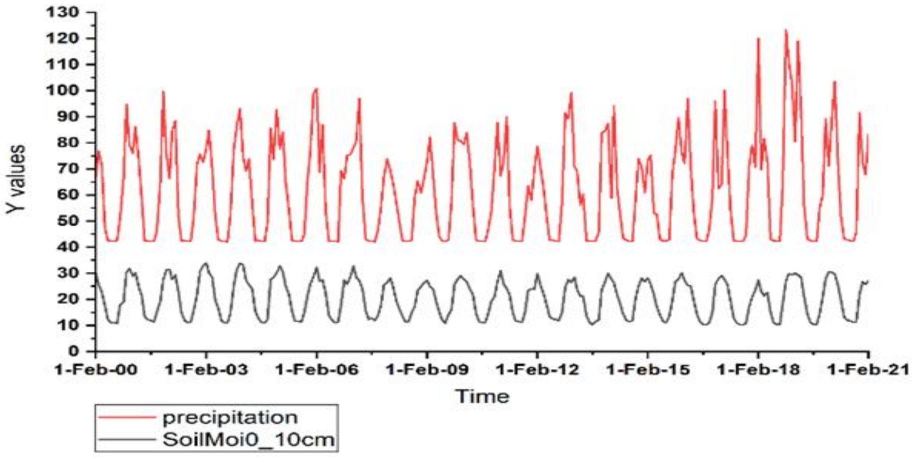

Figure 2. Temporal pattern of monthly rainfall and soil moisture in Iraq

The total amount of rain that falls in a year is called the annual rainfall. Based on the statistical analysis of annual rainfall presented in (Figure 5), it was found that rainfall amounts and intensities are irregular, with peak rainfall recorded in 2006 and 2019, while the lowest levels were observed in 2008 and 2021. During these years, Iraq experienced its driest season in 42 years, characterized by record-low rainfall. (Figure 3) presents a comparison between soil moisture and rainfall over several years. In general, it can be seen that there are some periods where there is a clear correlation between soil moisture and rainfall. For example, around 2003, both variables increased, and in recent years, values have decreased similarly. For example, rainfall increased significantly from 2016 to 2017, as well as from 2018 to 2019. We also find that soil moisture follows a nearly identical pattern to rainfall, with a tiny lag in reaction after rainfall. This lag is common since soil takes time to absorb water after rain. Soil moisture levels rise dramatically following periods of heavy rainfall. In some cases, there is a clear difference between rainfall and soil moisture. For example, between 2007 and 2013, soil moisture increased although rainfall decreased, which could imply other variables other than rainfall, such as soil quality, water management, or other climatic conditions (evaporation). From 2017 to 2020, we noticed oscillations in rainfall and a general decline in soil moisture, which could signal a dry time or

Iraqi Journal of Agricultural Sciences –2026:57(8):2339-2350
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/gt254v14

other factors affecting the soil's ability to retain moisture. The graphic illustrates that the relationship between rainfall and soil moisture is not necessarily linear or direct, implying that other conditions influence soil moisture. Some things that could cause this conclusion to be uncertain are temperature, wind, and evaporation. Soil moisture and rainfall can tell us how water is used in farming, such as for irrigation and groundwater. The ground stays pretty wet even when it hasn't rained much yet. This could be because of good water management techniques like irrigation. This approach helps us look into how different objects interact and change in more detail. The graph shows essential information about the long-term relationship between soil moisture and rainfall. To really get this, though, we need to look at other things, see how they change the moisture in the soil, and then use that information to build smart strategies for farming and managing water supplies.

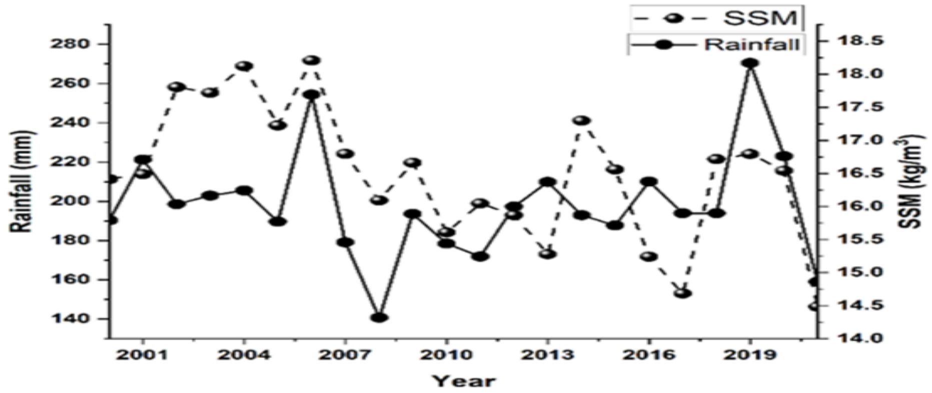

Figure 3. Temporal pattern of soil moisture and rainfall (2000-2021).

(Figure 4) shows how wet the earth is in different places in Iraq. Some stations, like Emadiyah and Rabiah, show higher levels of soil moisture than others. This could be because of good climatic conditions, like more rain, and where the stations are located. Other stations in the south, such as Basrah and Nasiriya, have less moisture in the soil. This could be because it doesn't rain often there or because the soil is soil and doesn't hold water well. Central regions, like Baghdad and Karbala, have intermediate levels, reflecting transitional conditions. This climatic variation helps explain the observed decline in soil moisture. Soil moisture levels may also be related to soil type, vegetation cover, and water management practices in each area. For example, agricultural areas that rely on irrigation may have higher moisture levels than areas that rely on rain alone. This spatial variation highlights the influence of climatic, topographic, and land-use factors. The findings emphasize the need for region-specific strategies to manage natural resources and address environmental challenges, particularly in areas with lower values that may require targeted interventions.

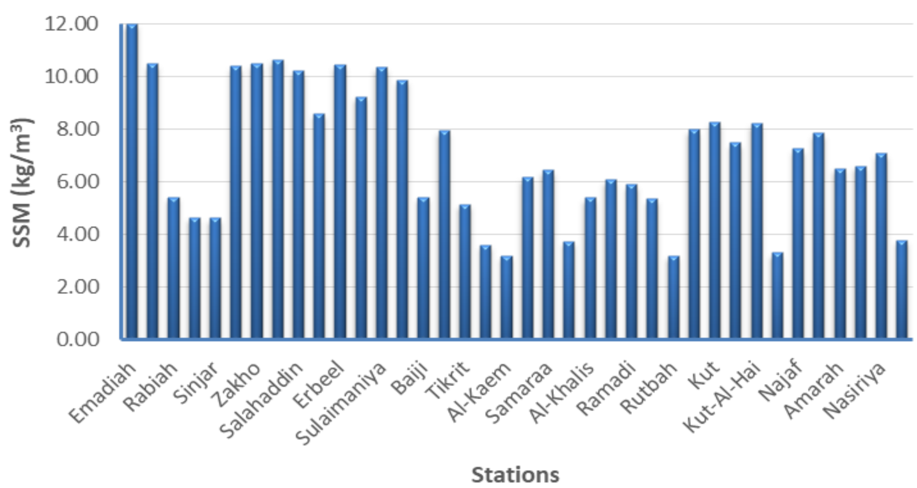

Figure 4. Bar chart of soil moisture values across various stations in Iraq

Iraqi Journal of Agricultural Sciences –2026:57(8):2339-2350
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/gt254v14

The relationship between rainfall and Soil moisture: The spatial pattern of soil moisture and rainfall can be analyzed in (Figure 5), which illustrates the relationship between rainfall and surface soil moisture. It reveals a linear relationship between rainfall and soil moisture, highlighting the general trend of this association. (Figure 5B) represents a gradient map showing the spatial distribution of soil moisture across the country. The northern and northeastern regions show higher levels of soil moisture (up to 23.54), which makes sense as these regions benefit from mountainous terrain and higher rainfall. This could be related to mountain rains, or intensive agricultural. The southern and southwestern regions of Iraq show lower soil moisture, which may be expected given the dry climate there, the absence of sustainable water sources, and their reliance on seasonal rains. The central region shows a marked decrease in soil moisture (14.44–15.55). This indicates an area that may be particularly affected by climate change or soil quality. The map supports the observations of the previous figure about differences between regions. The northern regions, such as Emadiyah and Rabiah, which appeared in the graph with higher moisture levels, are also shown here in darker colors, reflecting higher levels of soil moisture. (Figure 5A) shows the distribution of rainfall in Iraq. The northern and northeastern regions of Iraq appear to receive the highest amounts of rainfall, which is consistent with the mountainous terrain and more humid climate. The southern and western regions (including the western desert) receive less rainfall, reflecting the desert and dry nature of those regions. When comparing this figure with the soil moisture figure in (Figure 5B), a clear correspondence can be observed between the regions that receive more rainfall and higher soil moisture. The northern regions with higher rainfall, such as Emadiyah and Rabiah, correspond to areas of high soil moisture. In contrast, the southern regions that receive less rainfall correspond to lower soil moisture levels, as shown in the soil moisture map. (Figure 4) shows differences in soil moisture levels across specific stations, and these differences can be linked to rainfall. The regions that showed high values in the graph (such as the north) receive higher amounts of rainfall, as shown in this map. The downward trend line in the graph is reflected in this map, as rainfall gradually decreases from north to south, which explains the gradual decrease in soil moisture shown in the graph. Other factors besides rainfall may affect soil moisture, such as soil quality, slope, and agricultural activities. But there is a clear link between how much rain falls and how wet the soil is in Iraq. This figure confirms a direct relationship between the amount of rainfall and soil moisture levels in the region.

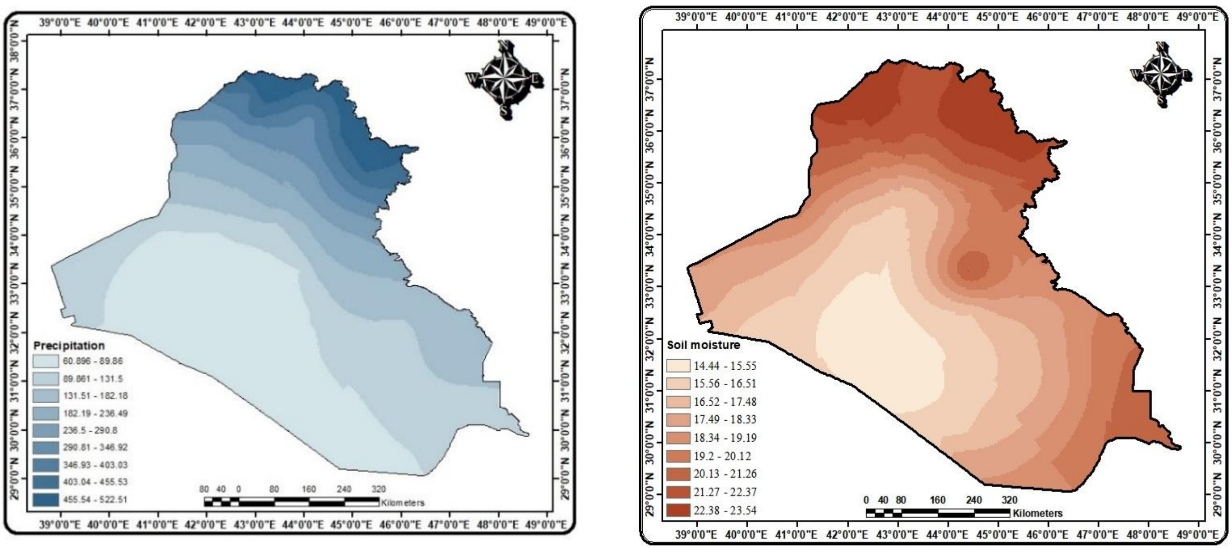

Figure 5. Spatial Pattern of (A): Rainfall and (B) Soil moisture for (2000-2021). Plot spatial distribution of soil moisture and rainfall

Iraqi Journal of Agricultural Sciences –2026:57(8):2339-2350
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/gt254v14

The scatter plot in (Figure 6) demonstrates a Pearson's correlation coefficient (0.86) and the coefficient of determination (0.74) show that there is a strong positive correlation between rainfall (mm) and soil moisture (kg/m³). This suggests that 74.1% of the variability in soil moisture is explained by rainfall, highlighting rainfall as a primary driver of soil moisture dynamics. This means that increasing rainfall leads to increasing soil moisture. The regression line confirms that higher rainfall results in increased soil moisture, reflecting the natural replenishment of soil water content. While this relationship is significant, the remaining variability may be influenced by factors such as soil type, vegetation, evaporation, and infiltration. These findings are critical for hydrological modeling, agricultural water management, and predicting drought or waterlogging scenarios. Understanding this relationship enables better planning and decision-making in managing soil-water resources, especially in regions reliant on rainfall for sustaining soil moisture levels. Despite the clear general trend, there is some dispersion in the data. This suggests that there are some exceptions where higher rainfall did not lead to a similar increase in soil moisture. This could be due to other factors such as soil type and quality, evaporation, or climatic conditions. It makes reasonable that there is a link between rainfall and soil moisture since rain adds water to the soil, which makes it wetter. You may use this connection to figure out how much moisture is in the soil based on how much rain fell. This is helpful for planning farming and managing water resources. Therefore, it may be beneficial to consider these factors when applying this model in real-life situations. This kind of study can help make water management plans better, especially in places where farming depends on rain. This study can help us guess how wet the soil will be based on how much rain is expected.

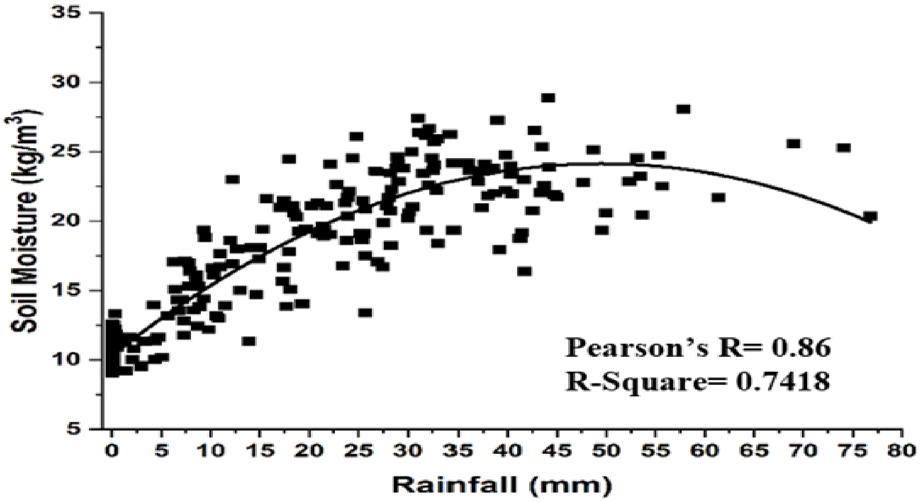

Figure 6. Correlation of rainfall with soil moisture

The spatial variation of the correlation is shown in (Figure 7), which reflects the climatic and geographical distribution in Iraq. The northern and central regions, which receive more rainfall, have stronger correlations, while the desert and arid regions with less rainfall have weak or insignificant correlations. Furthermore, high evaporation rates in southern and western regions, due to high temperatures, can lead to more rapid moisture loss, thereby reducing the impact of rainfall on soil moisture content. Soil type and depth have a considerable impact on the rainfall-soil moisture connection. For example, clay or loamy soils in central regions may explain the strong correlation, whereas sandy or dry soils in the southwest may explain the low correlation. (Figure 7) depicts the distribution of Pearson correlation coefficients between rainfall and soil moisture content across Iraq. Iraq's topography has a direct impact on rainfall patterns, as evidenced by the rainfall-soil relationship. The graphic illustrates how natural factors (topography and soil) and climate influence the relationship between the two variables. The regions with

Iraqi Journal of Agricultural Sciences –2026:57(8):2339-2350
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/gt254v14

correlation coefficients between 0.6 and 0.7 show the strongest positive association between rainfall and soil moisture. These places are primarily located in the northeast, where soil moisture responds strongly to fluctuations in rainfall. This can be ascribed to the soil features of certain places, such as their propensity to store large amounts of water or to have consistent rainfall throughout the year. This can occur because geographical features, such as mountains, can increase rainfall and improve soil quality. Western places with arid topography, like Anbar, on the other hand, have correlation coefficients between 0.2 and 0.4, which means that the variables are only weakly or moderately related. This could be due to a shortage of water resources and rainfall, which causes low soil moisture. Soil can vary in type, such as sandy soils that lose moisture quickly, or environmental factors, like high temperatures that cause faster evaporation. Western regions exhibit correlation coefficients near to zero. These findings suggest a weak or nonexistent correlation between rainfall and soil moisture content. Low yearly rainfall, high soil permeability, and the need to use other sources of moisture, such as irrigation, are some of the other things that could affect these places. The central and southern regions show a progressive shift in relationships based on soil type and land use, with alluvial plains affected by river systems like the Tigris and Euphrates, resulting in a mix of loam and clay soils. Clay soils in alluvial plains can explain the average values (0.3 - 0.5), as they hold moisture yet are sensitive to rainfall variations. It can be said that the various types of soil in Iraq have a significant impact on how strongly environmental factors interact with one another. Areas with clay soils and hilly topography have a strong association, but sandy and arid areas do not.

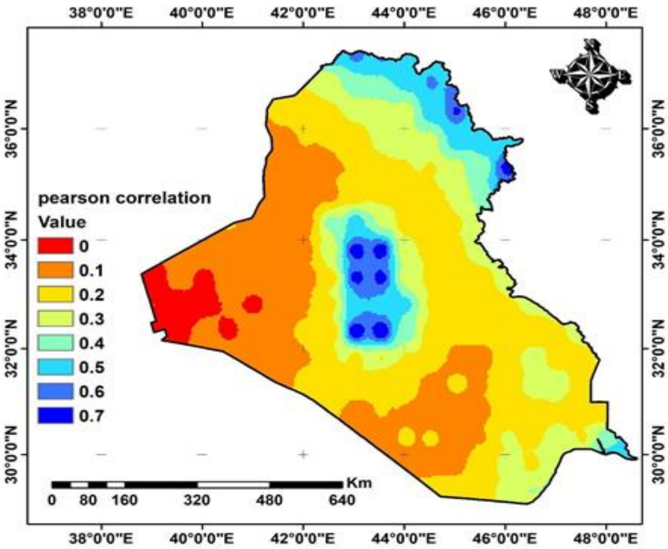

Figure 7. Spatial distribution of the Pearson correlation coefficient between rainfall and soil moisture content in Iraq

This study examines the interrelationship between climate and natural resources in Iraq over time. It stresses the importance of using these maps for long-term planning of land and water use.

CONCLUSION

Using satellite data from 2000 to 2021, this study examined the relationship between rainfall and soil moisture in Iraq. The data indicate a substantial positive correlation between soil moisture and rainfall, with a Pearson correlation coefficient of 0.86. The Earth gets wetter when it rains. This changes a lot depending on where you are. Climate regimes also have an effect on the correlation. It is stronger in places that are humid and moderate, and weaker in places that are dry and frigid. The northern and centre areas, which get more rain, are better connected. There aren't many connections in the desert and dry areas because they don't get much rain. We can better manage water supplies, plan farming activities, and predict droughts by learning more about how water moves in

P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/gt254v14

the area being examined. This kind of study can help us learn more about how water flows in a certain location. It can use this information to plan agricultural, manage water, and predict droughts. The results demonstrate that rain has a big effect on how wet the soil is, but it's not the only thing that does. Land cover, climate, weather, and hydrological processes, especially evapotranspiration, all play a role. The amount and frequency of rain have a big effect on how water moves, is distributed, and is available in the soil, which in turn affects how ecosystems work. There are seasonal patterns, like how the average amount of moisture in the soil is larger during wet seasons than during dry ones. There is also a monthly change, with the amount of moisture in the soil going down in the summer and up in the winter. According to research, the average annual soil moisture was highest in 2003 and lowest in 2021. This work shows how to use data from remote sensing to look at rainfall and soil moisture. The results will assist people understand how the amount of water in the soil changes in different weather conditions.

ACKNOWLEDGEMENT

The authors are grateful to Mustansiriyah University for providing scientic support to accomplishing this research.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

AUTHOR/S DECLARATION

We confirm that all Figures and Tables in the manuscript are original to us. Additionally, any Figures and images that do not belong to us have been incorporated with the required permissions for re-publication, which are included with the manuscript.

Ethical Clearance and Animal welfare: This study does not involve any experiments on human participants or live animals.

Funds: This research received no specific grant from any funding agency in the public, commercial, or non-profit sectors

AUTHOR'S CONTRIBUTION STATEMENT

SA collected the data, analyzed, interpretation and drafting the MS, MH Conception, design, revision and proofreading, YK design, acquisition of data, revision and proofreading.

REFERENCES

Abdul-Jabbar, A. M., & Abdulkareem, A. K. (2021). Predicted the cumulative annual rainfall in Iraq using SDSM modal. Al-Mustansiriyah Journal of Science, 32(2), 11–17 https://doi.org/10.23851/mjs.v32i2.977

Abdulraheem, M. I., Zhang, W., Li, S., Moshayedi, A. J., Farooque, A. A., & Hu, J. (2023). Advancement of remote sensing for soil measurements and applications: A comprehensive review. Sustainability, 15(21), 15444. https://doi.org/10.3390/su152115444

Abhilash, P., & Rana, M. (2023). Analysing relationship between soil moisture and rainfall from remote sensing approach. Journal of Pharmacognosy and Phytochemistry, 12(3), 221–230.

Amani, M., Ghorbanian, A., Ahmadi, S. A., Kakooei, M., Moghimi, A., Mirmazloumi, S. M., Moghaddam, S. H. A., Mahdavi, S., Ghahremanloo, M., Parsian, S., et al. (2020). Google Earth Engine Cloud Computing Platform for Remote Sensing Big Data Applications: A Comprehensive Review. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 13, 5326-5350, https://ieeexplore.ieee.org/document/9184118

Al-Taai, O. T., & Hadi, S. H. (2018). Analysis of the monthly and annual change of soil moisture and evaporation in Iraq. Al-Mustansiriyah Journal of Science, 29(4). https://doi.org/10.23851/mjs.v29i4.151

Clemente, J. P., Fontanelli, G., Ovando, G. G., Roa, Y. L. B., Lapini, A., & Santi, E. (2020). Google Earth Engine: Application of algorithms for remote sensing of crops in Tuscany (Italy). The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XLII-3/W12, 291–296. 10.5194/isprs-archives-XLII-3-W12-2020-291-2020

Dai, L., Fu, R., Guo, X., Du, Y., Zhang, F., & Cao, G. (2022). Soil moisture variations in response to precipitation across different vegetation types on the northeastern Qinghai-Tibet Plateau. Frontiers in Plant Science, 13, 854152. https://doi.org/10.3389/fpls.2022.854152

Das, B. K., Jha, D. N., Sahu, S. K., Yadav, A. K., Raman, R. K., & Kartikeyan, M. (2023).

Concept of simple correlation and regression. In Concept building in fisheries data analysis. Springer. https://doi.org/10.1007/978-981-19-4411-6_8

Faizi, N., & Alvi, Y. (2023). Chapter 6. In Biostatistics manual for health research (pp. 109–126). Academic Press. https://doi.org/10.1016/B978-0-443-18550-2.00002-5

GAO, L., GAO, Q., Zhang, H., Li, X., Chaubell, M. J., Ebtehaj, A., Shen, L., & Wigneron, J. P. (2022). A deep neural network based SMAP soil moisture product. Remote Sensing of Environment, 277, 113059. https://doi.org/10.1016/j.rse.2022.113059

Irimia, O., Panaite-Lehadus, M., Tomozei, C., Mosnegutu, E., & Przydatek, G. (2023). Origin-destination traffic survey—Case study: Data analyse for Bacau municipality. Sustainability, 15(6), 4975. https://doi.org/10.3390/su15064975

Irfan, M., Setya, O. C., Virgo, F., Sutopo, A. M., & Sulaiman, I. I. (2020). Is there a correlation between rainfall and soil moisture on peatlands in South Sumatra? Journal of Physics: Conference Series, 1572, 012040. https://doi.org/10.1088/1742-6596/1572/1/012040

James, G., Witten, D., Hastie, T., Tibshirani, R., & Taylor, J. (2023). Linear regression. In An introduction to statistical learning. Springer. https://doi.org/10.1007/978-3-031-38747-0_3

Kazemi Garajeh, M., Haji, F., Tohidfar, M. et al. 2024. Spatiotemporal monitoring of climate change impacts on water resources using an integrated approach of remote sensing and Google Earth Engine. Sci Rep 14, 5469. https://doi.org/10.1038/s41598-024-56160-9

Mimeau, L., Tramblay, Y., Brocca, L., Massari, C., Camici, S., & Finaud-Guyot, P. (2021). Modeling the response of soil moisture to climate variability in the Mediterranean region. Hydrology and Earth System Sciences, 25, 653–669. https://doi.org/10.5194/hess-25-653-2021

Muhammad, S. A., & Al-Dabbas, M. (2022). Climatic water balance comparison for selected areas in the middle of Iraq. Iraqi Journal of Science, 63(10), 4328–4341. https://doi.org/10.24996/ijs.2022.63.10.19

Panayan, A., Mamta, R. (2023). Analysing relationship between soil moisture and rainfall from remote sensing approach. Journal of Pharmacognosy and Phytochemistry, 12(3), 221–230. https://www.phytojournal.com /

Sazib, N., Bolten, J., & Mladenova, I. (2020). Exploring spatiotemporal relations between soil moisture, precipitation, and streamflow for a large set of watersheds using Google Earth Engine. Water, 12(5), 1371. https://doi.org/10.3390/w12051371

Sehler, R., Li, J., Reager, J., & Ye, H. (2019). Investigating relationship between soil moisture and precipitation globally using remote sensing observations. Journal of Contemporary Water Research & Education, 168, 106–118. https://doi.org/10.1111/j.1936-704X.2019.03324.x

Tamiminia, H., Salehi, B., Mahdianpari, M., Quackenbush, L., Adeli, S., & Brisco, B. (2020). Google Earth Engine for geo-big data applications: A meta-analysis and systematic review. ISPRS Journal of Photogrammetry and Remote Sensing, 164, 152–170.

Velastegui-Montoya, A., Montalván-Burbano, N., Carrión-Mero, P., Rivera-Torres, H., Sadeck, L., & Adami, M. (2023). Google Earth Engine: A global analysis and future trends. Remote Sensing, 15(14), Article 3675. https://doi.org/10.3390/rs15143675

Zhang, P., Xiao, P., Yao, W., Liu, G., & Sun, W. (2020). Profile distribution of soil moisture response to precipitation on the Pisha sandstone hillslopes of China. Scientific Reports, 10(1), Article 9136. https://doi.org/10.1038/s41598-020-65829-w

Iraqi Journal of Agricultural Sciences –2026:57(8):2339-2350
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/gt254v14

تقييم التأثير بين هطول الأمطار ورطوبة التربة في العراق

ساره علي مطر [1]، ياسين كاظم التميمي [2] ، منعم حكيم الجبوري [3]
قسم علوم الجو، كلية العلوم، الجامعة المستنصرية، العراق.

المستخلص

تلعب رطوبة التربة دوراً حيوياً في تنظيم التفاعلات بين الأرض والغلاف الجوي، مما يترك تأثيرات كبيرة على الموارد المائية والزراعة والمناخ وديناميكيات النظم البيئية. تهدف هذه الدراسة إلى تقييم بيانات رطوبة التربة المستمدة من الاستشعار عن بُعد والتحقق من علاقتها بهطول الأمطار لاستكشاف التغير الإقليمي المشترك بين المتغيرين. يغطي التحليل الفترة من عام 2000 إلى 2021، باستخدام بيانات رطوبة التربة المستخرجة من منصة Google Earth Engine وبيانات الأمطار من محطات أرضية. تكشف النتائج عن علاقة متعددة الحدود وارتباط إيجابي قوي بين رطوبة التربة وهطول الأمطار، مع معامل بيرسون 0.86، حيث تزداد رطوبة التربة مع هطول الأمطار. يتأثر الارتباط أيضًا بالأنظمة المناخية، حيث يكون أقوى في المناطق الرطبة والمعتدلة، وأضعف في المناخات القاحلة والباردة. تتمتع المناطق الشمالية والوسطى، التي تتلقى المزيد من الأمطار، بارتباطات أقوى، في حين أن المناطق الصحراوية والجافة ذات الأمطار الأقل لها ارتباطات ضعيفة أو غير مهمة. علاوة على ذلك، تبيّن أن الأحداث المطرية الغزيرة تسهم في تعزيز إعادة تغذية المياه الجوفية وزيادة تدفق المياه السطحية، وهو أمر بالغ الأهمية لاستدامة الموارد المائية المحلية. تؤكد هذه النتائج على أهمية فهم الديناميكيات بين رطوبة التربة وهطول الأمطار لتحسين إدارة الموارد المائية، خصوصاً في المناطق ذات الظروف النباتية والمناخية المتباينة.

الكلمات المفتاحية: الارتباط، GEE، العراق، الامطار، رطوبة التربة، ملاحظات الأقمار الصناعية.