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Soil and Water Evaluation using (SWAT) and (HRUs) in Wadi Al Ghuwair Basin

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***Abstract*— The study of water and soil in the water basin constitutes an entry point to deal with the hydrological reality, especially the ground recharge and collecting water flowing from the runoff through the construction of dams. There is great importance to study the soil and rocks in the watershed of Wadi Al –Ghuwair and in places where dams are built in particular. The importance of the study lies in the research on the basin topography, its girdle, the shapes and types of rocks and soils, the inclination and intensity of the slopes, and their impact on the hydrological reality. In order to achieve this goal, GIS, RS and SWAT technology were used, and the basin was divided into 32 sub-basins and 84 homogeneous HRS to facilitate their classification and study. It has found that there is severe groin in the basin, especially in the middle of it, where approximately 55% of the area of the basin constitutes areas with a slope of more than 20%. Also, dolomite rocks, sand and limestone formed 42% of the basin area, whereas the least percentage of marl and chalk was about 5%.**

***Index Terms*— Wadi Al –Ghuwair , SWAT, HRU, Soile, Water**

I. INTRODUCTION

Wadi Al-Ghuwair basin - one of the main basins within the northern Wadi Araba basin - is an important example and model for the subsidiary basins within the Dead Sea Canyon and Wadi Araba on the one hand, and the Shurah Mountains overlooking it on the other hand, within the similar geological and hydrological formations. A water basin described as a unit of water that results from the interaction of precipitation and the land surface, and the quantity and quality of water produced by the water basin is an indicator of the amount and intensity of rain and the nature of the water basin management[1]-[22]-[23].

Due to the remote nature of the Wadi Al-Ghuwair Basin and the inability to obtain accurate estimates of hydrological measurements, including surface runoff and sediments, it can use geographic information systems, remote sensing, and the SWAT water and soil assessment tool for the hydrological evaluation of this basin. The Wadi Al-Ghuwair basin receives varying amounts of precipitation in time and place due to the climate diversity and the dominance of four bioclimatic zones in the basin, which reflected in the hydrological situation in the basin. Severe erosion, erosion and transport processes prevail in the basin due to its terrain nature that increases the sedimentation at the feet of the mountains in the basin where the overflow alluvial fans are clearly formed.[2]-[3]-[4]-[16]-[25].

This study examines the hydrological response to changes in land use and land cover in the Wadi Al Ghuwair Basin. This helps us understand the changes in land use and its relationship with the flow of waterways, and thus identify the means that maximize the utilization of available water resources and increase the ability of decision-makers, planners, farmers and researchers to formulate sound policies to reduce negative future impacts and create alternatives [8]-[11]-[17]-[21].

The basin divided into small homogeneous units, Hydrologic Response Units (HRU), and the HRU concept is able to maintain the homogeneity of the physical characteristics of the hydrological basin (Flu gel, 1995), and local or regional hydrological models used in different climatic ranges. HRU was determined on the basis of a set of determinants and characteristics related to Slop, Aspect, Elevation, Vegetation type, Soil type, and Precipitation distribution. Each HRU has homogeneous hydrological properties. The difference in the dynamics of hydrological processes within one HRU is small compared to different HRUs [7]-[15].

II. PROCEDURE

A. Study Area

The Wadi Al-Ghuwair Basin is considered part of the northern Wadi Araba basin, and it is located between longitudes 35°39´15´´ E and 35 ° 18´W, and between latitudes 30 °45´45´N and 30 °31´30´S. It also covers an area of 324 km² and its circumference is 134 km. Its height is 1631 m, while it goes down to 196 m below sea level. Fig.1 shows the location of the Wadi Al-Ghuwair basin within the northern Wadi Araba basin, as well as its location within the borders of the Hashemite Kingdom of Jordan[6].

The Wadi Al-Ghuwair basin was identified and its details studied. Several maps were made of the basin's tendency, topography, direction, and network of waterways, and the basin was divided into 32 sub-basins and 84 water response units.

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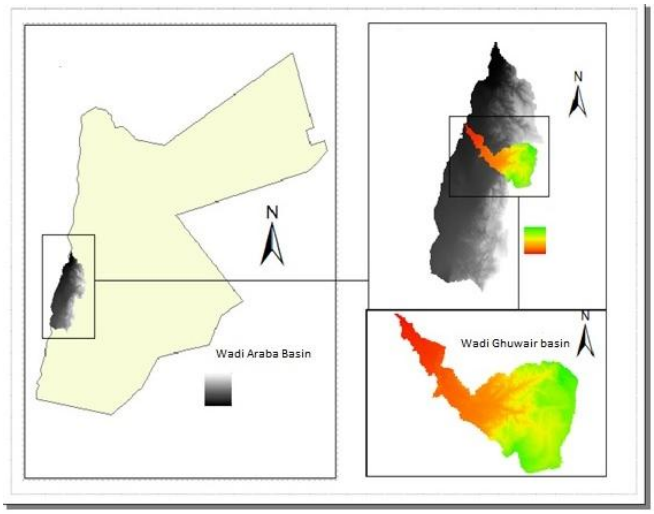

Fig.1 the location of the study area

III. METHODOLOGY OF THE STUDY

The Wadi Al-Ghuwair basin was divided into HRU fields to study the hydrological characteristics, atmospheric elements, soil properties, vegetation cover, land uses, slope and geology in each Hydrologic Response Unit, through the use of geographic information system in hydrological applications, and SWAT technology to study and evaluate soil and hydrology properties in the basin in addition to ENVI. . Also, a set of maps were extracted, such as soil maps, terrain maps, elevations, waterways, directional maps, inclination and sub-basins within the Wadi Al-Ghuwair basin[5].

Also done:

1- Analyzing the outputs of geographic information systems (GIS) and remote sensing (RS) after dividing the Wadi Al-Ghuwair basin into homogeneous units (HRU) in order to study the properties, tendency and geology of soil, land use, vegetation cover and rangelands in each unit.

2- Analyzing the digital elevations model (DEM) in order to analyze the water network and analyze HRU to find out the opportunities for expansion in the construction of dams and pits and the volume of water that can be collected[20].

The use of SWAT in order to create a model that simulates the hydrology and water quality for each field (HRU) in the sub-water basin that was selected, and simulates the flow, sedimentation and changes that occur in the watercourse, and by analyzing all the (HRU) in the basin, the model reflects the state of the various fields and gives a holistic picture. About the aquarium [3]-[4]-[12]-[14].

IV. RESULTS AND DISCUSSION

A. The effect of topography and slope on the hydrology of the basin

The topographic map of Wadi Al-Ghuwair basin shows the great diversity in the topography of the area despite the small area it covers. This characteristic state of Wadi al-Ghuwair can be generalized to most of the valleys that form the Sharah mountain range, which ends in Wadi Araba, the Jordan Valley and the Dead Sea. The topography of the water basin greatly influences the hydrological and biological processes, and the spatial distribution of topographic characteristics can be used as a measure of the spatial change of the hydrological and biological processes. Geographic information systems store, analyze and process topographic data as basic data for the analysis of water resources and biosphere. Through DEM, the basin topography was analyzed Fig. 2. [17]-[18]. The topography of the basin also affects the flow processes, ground recharge and the distribution of vegetation, and there is great importance for the slope in terms of angle and direction, in the velocity of flow, recharge capabilities, quantities and rates of evaporation, as it increases if the direction of slope is to the south and vice versa if the slope is to the north in the shadow area where The rates of evaporation and solar radiation are lower Fig 3. This helps in predicting surface saturation areas and areas with increased erosion and precipitation rates, as well as predicting the potential solar radiation distribution in the basin [15].

The rise in the sea level also affects the elements of the climate, so the temperature decreases at a rate of 0.6 ° C per 100 meters in altitude [8], the soil temperature decreases, the solar radiation increases, the amount of rain, relative humidity and wind speed increase, and the forms of precipitation sometimes change from rain to snow. These changes greatly affect the vegetation cover, as some forests spread in the eastern part of the Wadi Al-Ghuwair Basin, in addition to the spread of shrubs that reduce the speed of runoff as well as its probability, and this increases the opportunity for groundwater recharge. After the occurrence of runoff and the arrival of the flood waters to the Wadi Araba region, where the inclination angle of the slopes decreases in Fig.4 , the water's ability to carry suspended materials such as boulders, gravel, and silt begins to recede according to the decrease in the angle of inclination and thus the speed of the flow, and the flood fans begin to form at the feet of the mountains in Wadi al-Ghuwair. Here, the possibility of ground recharge increases, but in return, temperatures rise a lot, which leads to an increase in evaporation processes[24].

The steep slope of the terrain façade poses a great challenge to the ground recharge operations, as the areas where the slope of the slopes exceeds 40 ° represents more than a quarter of the area of the Wadi Al-Ghuwair Basin. The following observations can be summed up that constitute some facts about the Wadi Al-Ghuwair Basin:

1- The slopes are concentrated within the tilt range 10-30 ° in the eastern part of the basin most of the time to cover the area that forms the eastern highlands of the basin, which tends in the directions of the west, north and south, while the western region of the basin prevails - up to Wadi Araba - the slight slope that ranges from In most cases, its slope is 0-10 °, the flow velocity decreases, sedimentation processes begin, and flood fans are formed within a distance of less than two-thirds of the length of the stream.

2- The slopes are concentrated within the slope of 20 ° - 90 ° in the eastern part of the basin, while most of the western half of the basin is within a slope of 0-10 °.

3- The area whose slope is greater than 10 ° constitutes more than three quarters of the area of the Wadi Al-Ghuwair Basin and more than 55% of its area within the slope of a degree of inclination of more than 20 °, and more than a quarter of the area of the basin within a slope of slope greater than 40 °. The proportions and areas are shown in the table (1).

4- The gradual decline begins from the eastern part of the

basin at an altitude of 1633 m, to reach its lowest point in the basin at a height of 196 m below sea level, forming the difference between the highest and lowest area of the basin 1829 m and within the basin area estimated at 324 km².
5- The number of sub-basins within the Wadi Al-Ghuwair Basin is 32 as shown in the Fig.5.
6- The number of HRU units in Wadi Al Ghuwair Basin is 84 units that contain homogeneous characteristics in terms of soil, land use, land cover and gradient slope.
7- There is weakness in vegetation cover in general in the basin with a slight spread of forests, scattered trees and shrubs in the eastern high areas of the basin, as well as trees and shrubs spread in the waterways.
8- The relationship between molar severity and branch pond area is an inverse relationship
The following results have resulted from the previous facts:
1- An increase in the flow and velocity of water flow resulting from precipitation.
2- There is a great depth in the main and secondary waterways.
3- The increase in erosion, erosion, erosion and soil degradation processes.
4- Decrease in the percentage of vegetation cover.

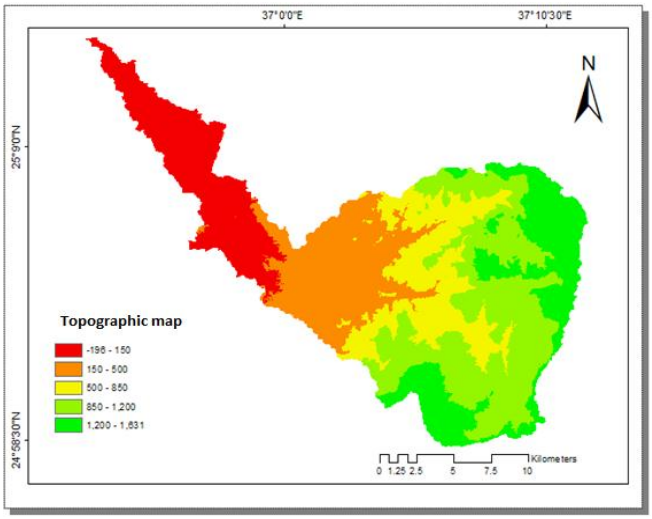

Fig .2 Topographic map of Wadi Al-Ghuwair Basin, researcher's work based on (USGS)

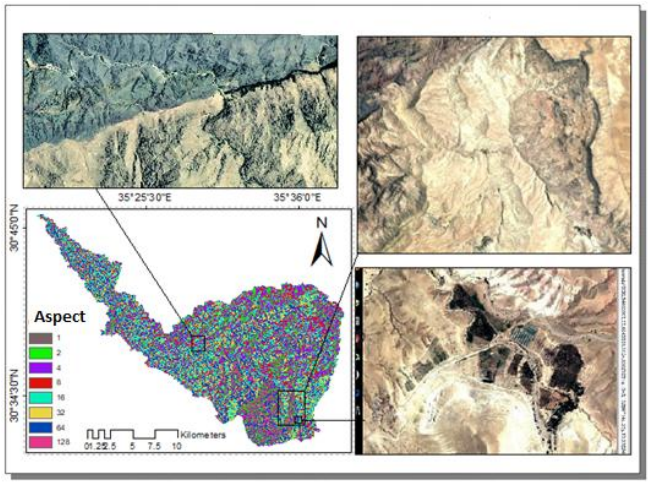

Fig .3 Map of aspects in the Wadi Al Ghuwair Basin and the corresponding Google earth

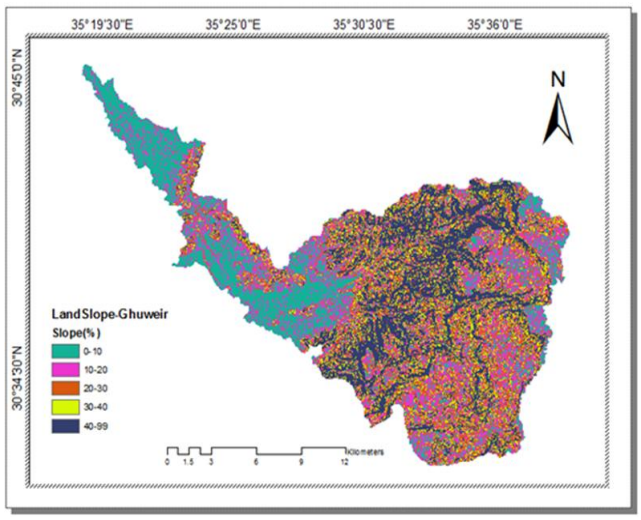

Fig .4 The slope ratio in the Wadi Al-Ghuwair Basin, based on (USGS).

Table.1 The angle of slope and the area of land covered within the periods shown and its percentage in the Wadi Al Ghuwair Basin (USGS)

Incline angle	Area km²	%
0 -10°	73.5	22.7
10°--20°	72.5	22.4
20°-30°	54.3	16.7
30°-40°	39.7	12.3
40°-90°	83.9	25.9

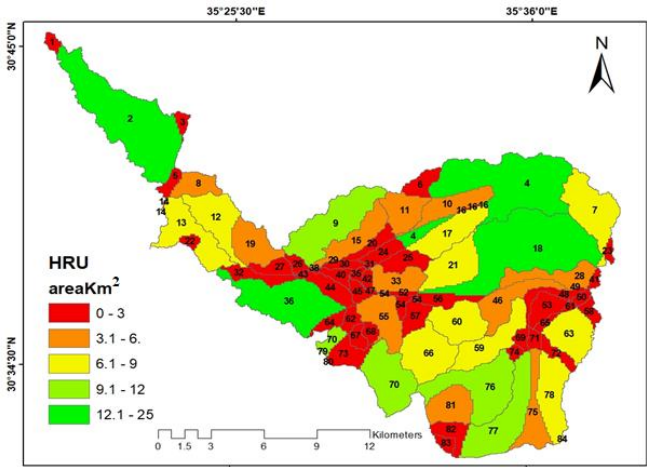

Fig.5 Sub-basins and HRU in Wadi Al-Ghuwair Basin

B. The effect of different soils and rocks of the basin on its hydrology

Soil is the decisive factor for hydrological processes such as runoff, permeability, porosity, flow below the surface, and providing water for plants, and the nature of the area's topography greatly affects the soil, so soil erosion and degradation increases as the height above sea level increases, and according to the direction and angle of slope of the surfaces. The Wadi Al-Ghuwair Basin is characterized by a great variation in elevation within a relatively small area, and there is a direct relationship between the increase in height. and the increase in the amount of rainfall with the erosion

and degradation of the soil, and this leads to the exposure of the mother rock in the mountainous regions. Soil erosion is also directly proportional to the inclination of slopes, the increase in slope inclination of the slopes leads to an increase in the flow of water flowing due to precipitation, thus increasing its kinetic energy, increasing its ability to erode and carrying larger masses of rock crumbs, and its capacity decreases as the angle of inclination of the slopes decreases and thus the speed of flow and energy Kinematic. To the Wadi Araba region, where the sedimentation process begins according to the mass of the transported materials, the larger and the smaller, and the soil erosion increases in the slopes where the vegetation cover is reduced from trees and shrubs. The soil is thick in flat and low-slope areas, and thus it is less exposed to the processes of erosion and soil degradation, but is more vulnerable to sedimentation and the formation of fans[9]-[10].

The soil of the Xerochrept variety is spread at altitudes higher than 1000 m from the eastern parts of the basin, and it is a soft, cracked loamy soil that is easily crumbled and elastic. Its size increases in winter to saturate it with water and decreases in size in the summer due to its drought and high clay content. As for the types of soils and rocks prevailing in the Wadi Al-Ghuwair Basin Fig. 6 and Table 2, the areas covered by each type of soil and rocks within the basin and its proportions are shown. Limeston, Marl, Chalk, Sand, Gravel are spread in the eastern highlands of the basin with soil types. Xerochrept Entic Chromexerert, the presence of soils of the Camborthid variety with soils and rocks of the Marl, Silt, Loam type is noted in the northeastern part of the basin in the Dana region, and Sand tone, Dolomite [13]-[19], Limestone, Granite, Marl, Chalk, Sand and Gravel rocks also prevail in The middle of the basin is homogeneous within the soil distribution of the class Camborthid and Torriothe. These areas are characterized by severe slopes that expose them to erosion processes resulting from precipitation, as well as the lower part in which the materials resulting from the erosion processes and transported down the basin are deposited in the broad valleys and in the flood fans. Sandstone, Dolomite, and Limestone rocks cover 137 km² of the basin area, with a rate of more than 42%, followed by Sand, Gravel with an area of 68 km², and a ratio of 21%, followed by granitic rocks with an area of 34 km² at a rate of 11%. The rest of the soils and rocks, such as Limestone, Marl, Chalk, Chert-Limestone, Sand- Limestone, Sandstone, Dolomite, Loam and Silt cover the remaining percentage, with about a quarter of the basin area.

Table 2. Types of soils and rocks in the Wadi Al-Ghuwair Basin

Code	Type of rock	Area km²	Area%
4	Sandstone, Dolomite, Limestone	34	10.6
9	Chert-Limestone	35	10.8
1	Sand, , Gravel	69	21.2
2	Limestone, Sand, Chert-Limestone	8	2.6
5	Dolomite, Sand, Limestone	137	42.2
8	Silt, Loam, Marl	31	9.6
7	Marl, Chalk, Limestone	17	5.2

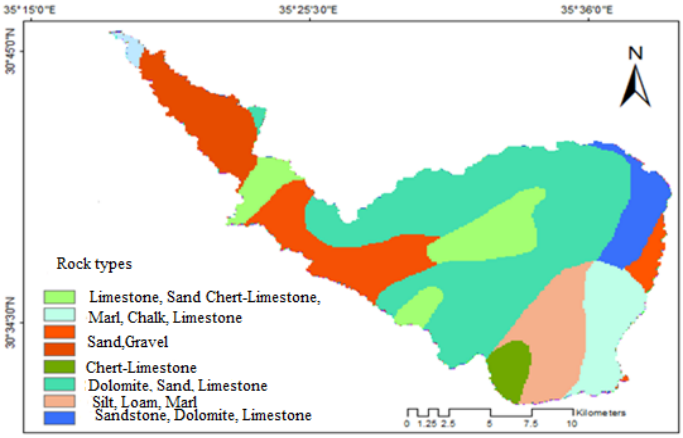

Fig.6 Rocks distribution in Wadi Al-Ghuwair Basin

B. The effect of basin hydrology on land use and land cover

Different forces influence land use and land cover change, such as human and climate impacts[17]-[18]. The type of vegetation cover determines a number of components of the hydrological cycle such as irrigation demand, water requirements, actual water consumption, evaporation, runoff, leaching and erosion. The vegetation map also includes a number of plant varieties that spread in the basin, and these classifications are combined with field verification. The arid lands in the Wadi Al-Ghuwair Basin constitute an area of about 324km², with a ratio of approximately two thirds, and cover 46 km², with a ratio of more than 14% of the deposited materials transported by the water flowing from high areas through waterways that are exposed to erosion processes due to rain and snow. Forests are spread in the northeastern parts of the basin, specifically the Dana area, within an area of 26 km², at a rate of 8%. The sand is deposited in waterways in valleys with an area of 14 km.

The Wadi Al-Ghuwair Basin is exposed to hydrological processes that start with snow and rain, in particular on the heights that form the eastern part of the basin, which has a height of 1650 m. This percentage is also the vegetation cover from the trees of the Dana forests, as well as the shrubs spread in the basin, and some of them were cultivated by the Ministry of Agriculture to benefit from them as pastures, as well as due to the nature of the loose soil that facilitates the ground recharge, as well as the springs spread over heights of more than 1000 m approximately.

In the event of heavy rainfall, runoff forms rapidly, as the area whose slope exceeds 20 ° represents 55% of the basin area, and this increases the processes of erosion, runoff and soil degradation, reaching the base rocks through the basin and to Wadi Araba where the angle of inclination in that area decreases and eliminates Running water from its load of boulders, rocks, sand and silt according to the gradient of the water's kinetic energy decrease.

V. Conclusion

The Wadi Al-Ghuwair Basin represents a similar condition to many of the water basins located within the front of the Shura Mountains, overlooking Wadi Araba and the Dead Sea, and the results of this study can be projected on these basins. Despite the small area of the basin, which is approximately 324 km², it contains a great diversity of terrain and a

difference in climatic conditions resulting in a clear variation in the hydrological processes and vegetation cover in kind and distribution. In addition to the distribution of the erosion processes that occur in the eastern part of the basin and the sedimentation processes in the western part of it. Therefore, GIS, remote sensing and SWAT techniques were used to evaluate hydrological processes and their interaction with the land and vegetation covers. Therefore, the basin was divided into 32 sub-basins and 84 homogeneous water response units that clarify and demonstrate this interaction in order to facilitate study and evaluation and thus help in making decisions related to the hydrological and developmental situation in the region. By looking at the topographic map of the basin, the steep slope of the terrain façades, which increases the chances of runoff and the occurrence of floods, and poses a challenge to the ground recharge.

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