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WATER RESOURCES POTENTIALITY FOR SUSTAINABLE AGRICULTURE DEVELOPMENT IN SOUTH SINAI

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ABSTRACT

Recently, sustainable agriculture development and desert reclamation occupy the top priority on the political agenda of the Egyptian government. Sustainable agriculture development mainly relies on the balance between water resources and demands in a certain timeframe. For the study purpose, Wadi Watier basin was selected to determine the potential seasonal water resources, which should be balanced with the water demands in purpose of determine the agriculture development area with its spatial distribution. The rainfall data was analyzed to determine the probable seasonal rainfall depth over the Wadi for different return periods. Thereafter, storm-by-storm was simulated using the WMS model to determine the historical seasonal runoff volume and statistically analyzed to determine the runoff volume at a determined return period. Sequentially, the groundwater recharge rate was determined using the water balance of the Wadi systems. Three appropriate crop pattern options were studied to determine the agricultural water requirements, in the meantime, the domestic water demand was determined. As a result, the seasonal runoff volume was estimated at 154,000 m^3 at a return period of two years, distributed over 29 sub-catchments. The average natural groundwater recharge was estimated at 101,68 million m^3. Comparing the crop pattern options revealed that the olive has the lowest water requirement of 4735 m^3/acre/year, while the mango trees have a maximum of 6375 m^3/acre/year. Applying the water balance showed that 16,000 acres of mango trees, 22,000 acres of olive trees, or 18,000 acres of vegetation crops could be cultivated based on the crop pattern selection.

Keywords: Agriculture Development, Arid Areas, South Sinai, Wadi System, Water Resources.

إمكانيات الموارد المائية للتنمية الزراعية المستدامة فى جنوب سيناء

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الملخص

في الآونة الأخيرة، أخذت التنمية الزراعية المستدامة واستصلاح الصحراء الأولوية الأولى في الأجندة السياسية للحكومة المصرية. تعتمد التنمية الزراعية المستدامة بشكل أساسي على التوازن بين الموارد والاحتياجات المائية في إطار زمني معين. لغرض الدراسة، تم اختيار حوض وادي وتير لتحديد الموارد المائية الموسمية، والتي يجب أن تحقق التوازن المائى مع الاحتياجات المائية لتحديد المساحة الممكنة للتنمية الزراعية مع توزيعها المكاني. تم تحليل بيانات الأمطار لتحديد عمق الأمطار الموسمي المحتمل لفترات تكرارية مختلفة. بعد ذلك، تمت محاكاة العاصفة تلو الأخرى باستخدام نموذج WMS لتحديد حجم الجريان السطحي الموسمي السابق وتحليله إِحْصَائِيًّا لتحديد حجم الجريان السطحي في فترة عودة محددة. بالتتابع، تم تحديد معدل تغذية المياه الجوفية باستخدام الميزان المائي لأنظمة الوادي. تمت دراسة ثلاثة خيارات للتركيب المحصولي المناسب لتحديد الاحتياجات المائية للزراعة، وفي نفس الوقت، تم حساب الاحتياجات المائية المنزلية. ونتيجة لذلك، قدر حجم الجريان السطحي الموسمى 154000 م^3 لفترة عودة عامين، موزعة على 29 مستجمعا فرعياً. وقدر متوسط معدل الشحن الموسمى للمياه الجوفية بحوالي 101.68 مليون متر مكعب. أظهرت مقارنة خيارات التركيب المحصولي أن الزيتون هو أقل احتياج مائى سنوي بمقدار 4735 م^3/ فدان، في حين أن أشجار المانجو لها أقصى احتياج مائى بمقدار 6375 م3/ فدان. أظهر تطبيق الميزان المائي أن 16000 فدان من أشجار المانجو، أو 22000 فدان من أشجار الزيتون، أو 18000 فدان من محاصيل الحبوب يمكن زراعتها طبقاً لاختيار التركيب المحصولى للمنطقة.

الكلمات المفتاحية: التنمية الزراعية ، المناطق الجافة ، جنوب سيناء ، نظام الوادي ، الموارد المائية.

1. Introduction

According to the world's water resources assessment carried out by the United Nations; the core of sustainable development is the available water resources. In the meantime, water shortages coupled with rising water demand are a common concern for humanity, and it is predicted to get worse in the coming years. [1] cited in [2]. Many researchers have studied the particular challenge of proper water resources management, particularly for agricultural uses [3]–[10].

The arid and semi-arid regions have special attention because of the limitations on water resources. Mostly, the water resources are represented by surface, groundwater, or integration between them, while rainfall is rare and undependable.[11]. One of the arid areas is the Sinai Peninsula, which composes around 6% of the overall land of Egypt and has a significant portion of the Egyptian land. At the same time, it is becoming more and more obvious that, given Egypt's current population growth rate, the reclamation of more and more desert lands is crucial to solving the country's ongoing food shortage [12].

Despite the importance of the Sinai site and its urgent development needed for security, social, and economic considerations. However, the resources aren't managed in a sound economic matter. Regarding agriculture activities, the province is characterized by cultivating traditional crops such as barley and wheat as seasonal crops, and also the cultivation of palm trees and olive trees [13].

For the study purpose, Wadi Watier basin was selected. It is one of the main wadis in South Sinai and has numerous activities represented in agriculture, livestock, and tourism [14]. The study area suffers from water scarcity in the dry seasons and probable flash floods in the wet seasons. The Bedouin's nature is to move everywhere looking for water resources for livestock and engaging in agriculture near the available water sources. The water resources' sustainability enhances the Bedouins' settlement chances, which reflects a positive environmental, social, and economic impact on the study area [15].

The main water resources of the study area are contained in the rainfall, which recharges the groundwater storage and could be harvested as surface runoff. The recharge of groundwater occurs naturally through the infiltration losses into the soil where the water moves to the aquifer. However, natural recharge has varied due to population growth, rapid development, and climate change in recent decades, and these changes result in a lack of groundwater or land-surface inundation in many areas [16].

The fundamental concept of sustainable development has been accepted as one that will enable the world to develop its resources while protecting nonrenewable and finite resources and ensuring acceptable living conditions for future generations. Accordingly, integrated water resources management is essential to achieve sustainability by considering its four dimensions, which are [17]:

- ***The water resources*****:** considering the entire hydrological cycle.
- ***The water users*****:** all stakeholders and sectoral interests.
- ***The spatial dimension*****:** including the spatial distribution of water resources and uses.
- ***The temporal dimension*****:** taking into account that water resources vary over time.

Renewable groundwater has an active part in the hydrological cycle. In contrast, fossil groundwater could be consumed once, and it is not renewable. However, the availability of groundwater storage is critical in arid climates. Therefore, groundwater becomes available in two ways: either by artificial withdrawal (pumping) or natural seepage to the surface [17].

This study aims to allocate the potential water resources and determine the water demands for domestic and agricultural uses, which represent the major water needs. Also, it aims to identify a proper crop pattern and area of cultivation that achieves the water balance and sustainable development of the study area.

2. Materials and Methods

The rainfall, geology, and topographic data were collected and stored in a geodatabase using ArcGIS software. It was statistically processed and analyzed using ArcGIS and Excel programs to obtain the required information for the hydrological model. In the meantime, a literature review and field visits were carried out for the purpose of identifying the probable rainwater harvesting (RWH) sites that are important to subdivide the basin as well as identifying the proper crop pattern alternatives. Sequentially, the potential water resources and water demands were calculated to determine the possible agricultural land area that fit with the available water resources to achieve the water balance and the desired sustainable development. The general methodology of this research is presented in **Fig. 1**.

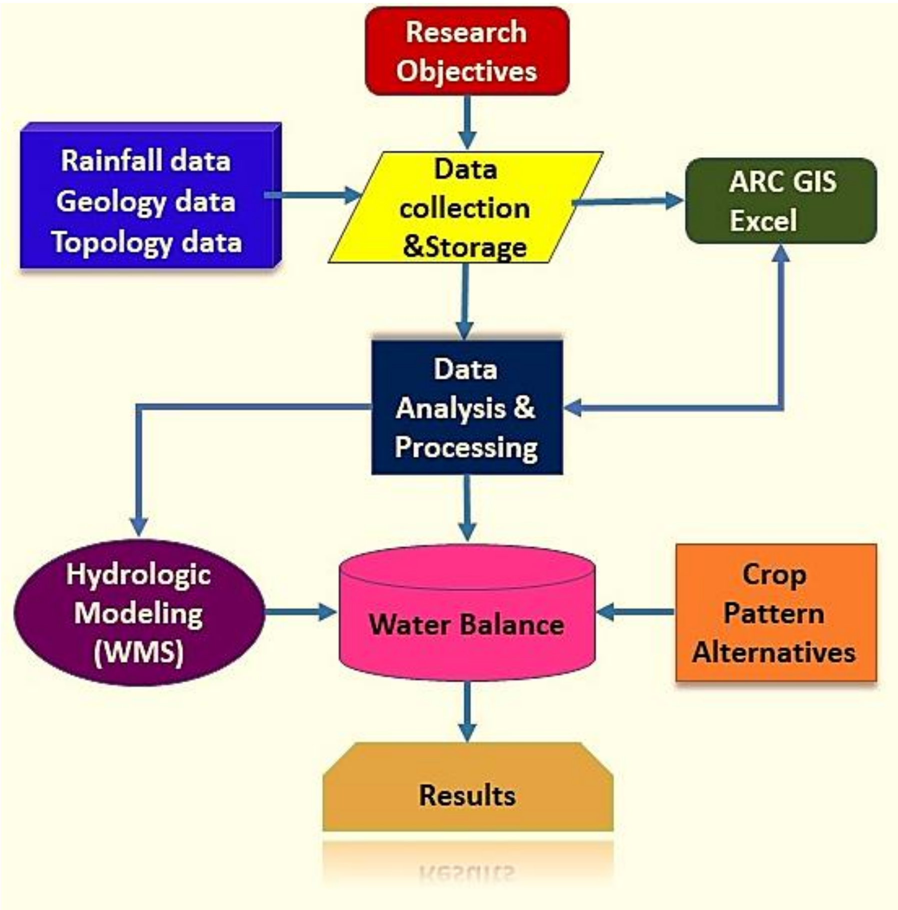


Fig. 1: General followed methodology.

2.1. Study Area

Wadi Watier is located in South Sinai governorate and contributes to an area of 3500 km^2. It has twelve check dams with a reservoir, which were newly constructed for the purpose of flash flood protection. In addition, two dams with artificial lakes, one underground tank for mixed uses, and one small dam for wadi bed cultivation were observed for the purpose of storage. Moreover, the four rural communities, or Bedouin settlements, as well as the crossing points with the existing international road passing through the wadi's main channel were taken into consideration when identifying the proposed RWH sites. The Wadi location and the existing structures are presented in **Fig. 2.**

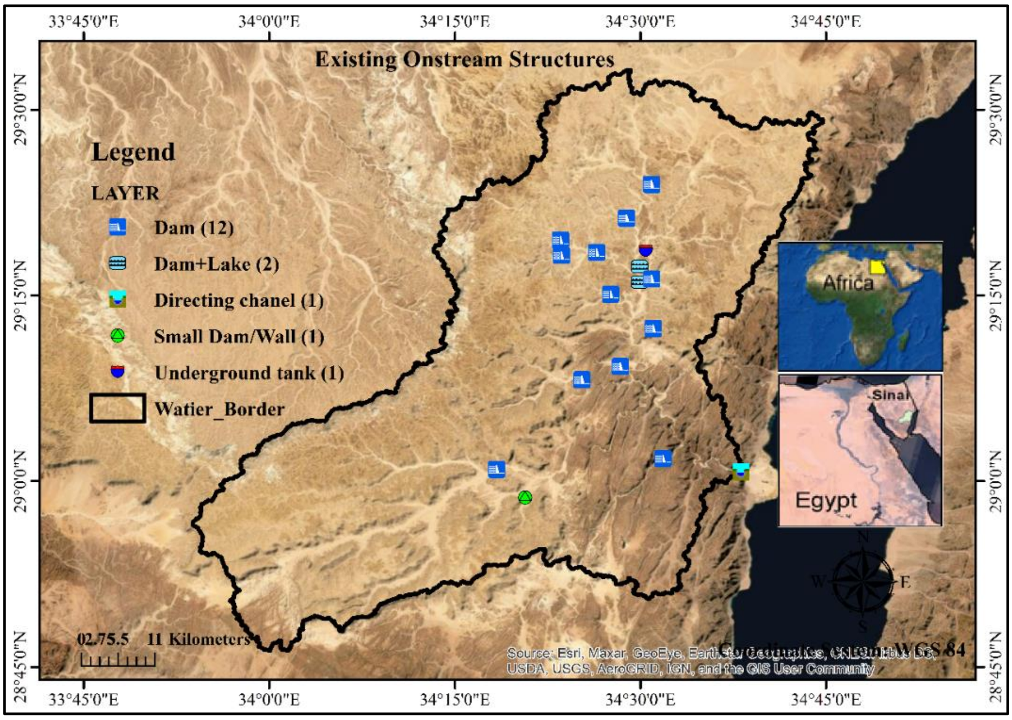


Fig. 2: layout and the existing structures in Wadi Watier Basin.

2.2. Data Collection and Storage

- All collected data was stored in a geodatabase using ArcGIS software as a raster or vector layer to be analyzed and presented.
- The metrology data were collected from five rainfall stations located within and around the Wadi, as well as one weather station in Nuweiba city. The historical rainfall records are between the years 2000 and 2016. The annual maximum recorded rainfall is 51 mm in Saint Catherine Station, while the average ranges between 5 and 7 mm.
- The topological data was obtained and stored as (DEM). Saint Catherine station records the highest elevation of 1646 m, while the lowest elevation is recorded at 44 m in Nuweiba city at the outlet of the Wadi.
- The geological data was obtained from Water Resources Research Institute (WRRI), which was created by the Japanese cooperation project in 1999.

2.3. Data Analysis and Modeling

2.3.1 Rainfall probability analysis

Using the following Equations (**1** and (2, the rainfall data were statistically analyzed to determine the likely seasonal rainfall depth in the study area at a specified return period [18]:

$$\mathrm{P}\ (\%) = \frac{\mathrm{m} - 0.375}{\mathrm{N} + 0.25} \times 100 \qquad (1)$$

$$\mathrm{Tyears} = \frac{1}{\mathrm{P}} \qquad (2)$$

Where:

P (%): Probability in % of the observation of the rank (m);

N = Total number of observations; T= Return period in years.

2.3.2 Hydrological modeling

The hydrological model is essentially required to determine the runoff volume that could be harvested at the wadies outlets as surface water resources. The HEC-1 model was selected to simulate the wadi and generate the runoff for the historical rainfall events. It is one of the WMS modules which simulates the wadi as a comprehensive and interconnected system [19]. The model was used in Jordan to mitigate the flashfloods that occur in Petra region [20]. Likewise, it was used in the study area to mitigate flash floods [14]. Moreover, it was used to select suitable RWH sites and alternatives in a case study in Lebanon [21].

The study area was delineated into 29 sub-wadies as presented in **Fig. 3** according to the locations of the existing artificial structures and some proposed outlets' locations which were selected at the Bedouins settlements and crossing points with the international road passing through the mainstream of Wadi Watier basin.

The SCS-Curve Number (CN) method was applied in the WMS model to estimate the losses due to infiltration. The CN values were obtained from WRRI for the different geological formations in the study area, and the average CN was estimated for each sub-wadi in Wadi Watier basin.

The effective area of each rainfall station over the whole basin was identified using the Thiessen polygon method and the result was that El-Sheikh Attia station, which is located in the middle, is the most effective station by 64% of the Wadi area. Storm-by-storm analysis was applied to determine the runoff volume at the sub-wadis' outlets. Due to the high infiltration rates of the wadi beds, which are sandy soil, rainfall values of less than 4 mm were neglected.

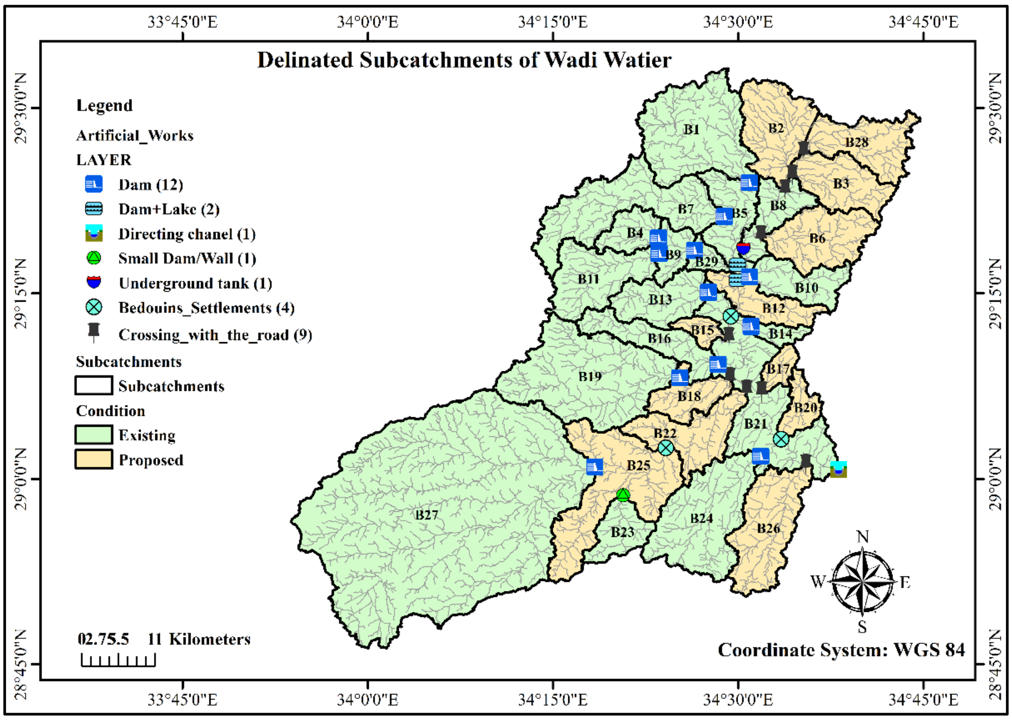


Fig. 3: Delineated Sub-catchments of Wadi Watier.

2.4. Water Resources of the study area

The water resources management should achieve a balance between water demand and supply. Hence, it is essential to define a specific return period to study the water balance. The return period is considered as 2 years for estimating the seasonal runoff while it is considered as 25 years for the natural groundwater recharging estimation [14].

The water resources in the wadi are limited to the groundwater, which is recharged naturally by the rainfall, and runoff. The resulting runoff volumes from the hydrological model were statistically analyzed to obtain the runoff volume for the designated return period.

Also, natural groundwater recharge is necessary as it represents the main water resource for different purposes. [22] cited that [23] estimated the infiltrated water reached the groundwater table through the wadi bed with 75% of the total infiltration losses, neglecting the evaporation during the flood event, based on an experimental reach in Wadi Tabalah in southwestern Saudi Arabia, which is similar to our case study.

2.5. Water Demands

2.5.1 Domestic water demand

The water demands of the study area are represented by domestic and agricultural uses. Domestic water demands (Qav) could be calculated using an equation based on population and per capita water consumption, Equation (3).

$$Q_{av} = Pop \times WC \ (m^3/d) \quad (3)$$

Where:

Pop = The total population in the region;

WC = Water Consumption (m^3/Capita/day).

The population was estimated for the next 25 years using Equation (4).

$$\mathrm{Pi} = \mathrm{P0}\,(1 + \frac{r}{100})^{(Ti - T0)} \quad (4)$$

Where:

P_i = Population in a future year (i); P_0 = Population of the current year (0); r = Population growth rate (%) which taken as 2.20% according to [24];

T_i = Future year (i); T_0 = Current year.

The average WC is 13.20 m^3/year. This means that the average WC is equal to 36 liters/capita/day. Therefore, Bedouins live under the water poverty line, which is identified as 500 m^3/year according to WHO [24]. In the current study, the WC was considered as 40 liters/capita/day to meet the increased water needs in the future.

2.5.2 The agriculture water Demands.

The agriculture water requirements depend on the climatic characteristics of the region, which include the relative humidity, evaporation rates, solar radiation, temperature, and wind speed in addition to the crop type cultivated in the area. Therefore, it is essential to identify suitable crop patterns for the study area to calculate the amount of agricultural water required for irrigation. The crop pattern alternatives were defined after the field visits and consultation with some farmers. Three crop pattern options and alternatives were presented in **Table 1**. The CROPWAT 8 model was used to calculate the irrigation water requirements. It is interactive and can determine the following:

- The potential evapotranspiration (ET_o) is based on climatic conditions.
- The crop water requirements per decade.
- The effective rainfall based on the given rainfall data; and
- The irrigation water requirements.

The CROPWAT 8 software employs the Penman-Monteith method for determining evapotranspiration (ETo). Penman-Monteith equation is:

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34 u_2)} \quad (5)$$

Where:

ET_o: reference evapotranspiration [mm day^{-1}],
R_n: net radiation at the crop surface [MJ m^{-2} day^{-1}],
G: soil heat flux density [MJ m^{-2} day^{-1}],
T: mean daily air temperature at 2 m height [°C],
u_2: wind speed at 2 m height [m s^{-1}],
e_s: saturation vapor pressure [kPa],
e_a: actual vapor pressure [kPa],
$e_s - e_a$: saturation vapor pressure deficit [kPa],
D: slope vapor pressure curve [kPa $°C^{-1}$],
g: psychometric constant [kPa $°C^{-1}$].

The entered data to the CROPWAT to calculate the ET_0 is tabulated in **Table 2**.

Table 1: Different crop pattern options and agriculture times

Month	Crops	Plant date	Harvest date	Plant period (day)	Land Preparing (day)	Total Period (day)
Option (1)						
October	Potato	1/10	2/2	125	5	130
February	Small Vegetables	7/2	5/5	90	5	95
May	Tomato					
June		10/5	26/9	135	5	140
Option (2)						
All over the year	Date Palms	1/10	30/9	365	0	365
All over the year	Mango	15/3	14/3	365	0	365
All over the year	Olive	1/3	28/2	365	0	365
Option (3) – Alternative (1)						
September	W Wheat	15/9	7/5	235	5	240
May	SORGHUM	12/5	10/9	120	5	125
Option (3) – Alternative (2)						
November	Barley	15/11	14/3	120	5	125
March	Small Vegetables	19/3	21/6	95	5	100
June	Sorghum	26/6	25/10	122	18	140
Option (3) – Alternative (2)						
October	Alfaalfa 1	1/10	13/5	225	10	235
May	Sorghum	23/5	24/9	125	5	130

Table 2: Metrological data entered to the CROPWAT model.

Month	Temperature °C			Humidity (%)	Wind Speed (km/d)	Sunshine (hours)	Average rain (mm)
	Max	AVG	Min				
January	25.25	16	8	43.75	390	8	2.60
February	26.5	16.5	8	37.75	370	10	0.60
March	35.25	22	14	43.75	350	12	2.00
April	37.5	23.5	12	42	330	12	0
May	42	25.5	13	39.25	310	14	0
June	40	29.5	24	46	280	14	0
July	41	32.5	27	49	290	14	0
August	41	32.75	27	51	300	13	0
September	38	32.25	28	45	320	12	0
October	32	24.75	19	48.75	340	11	1.1
November	31	22.5	13.5	45.75	360	10	1.60
December	25	18	11	37.5	380	8	0.50
Average	34.5	24.6	17.0	43.75	335	11.5	0.70

Source: (WRRI).

2.6. Water Balance of the Wadi

According to [17], the water balance is applied to the catchment. The catchment size increases by moving the outlet location downstream. In case of no surface runoff, the input precipitation P will equalize the evaporation E and the change in groundwater storage due to infiltration losses. Hence, the water balance of a drainage basin might be written as Equation (6):

$$\frac{\Delta s}{\Delta t} = (P - E) \times A - Q \qquad \textbf{(6)}$$

Where: ΔS/Δt, the change in the groundwater storage which is difficult to measure over a specific period.

3. Results and discussions

3.1. Rainfall-Runoff water volume

The runoff volume was determined for the 29 delineated catchments by applying the WMS simulation to 50 historical rainfall records in the five rainfall stations for precipitation values higher than 4 mm. The resulting runoff volumes were studied to calculate the total probable runoff generated from each sub-catchment in the Wadi. As shown in **Fig. 4**, the total synthetic rainfall volume was calculated for each sub-catchment and compiled to calculate the overall runoff for the Wadi. The maximum runoff is 3.65 million m^3 from a flash flood that occurred in the season 2000-2001 as a result of exposing most sub-catchments that were subjected to the flood.

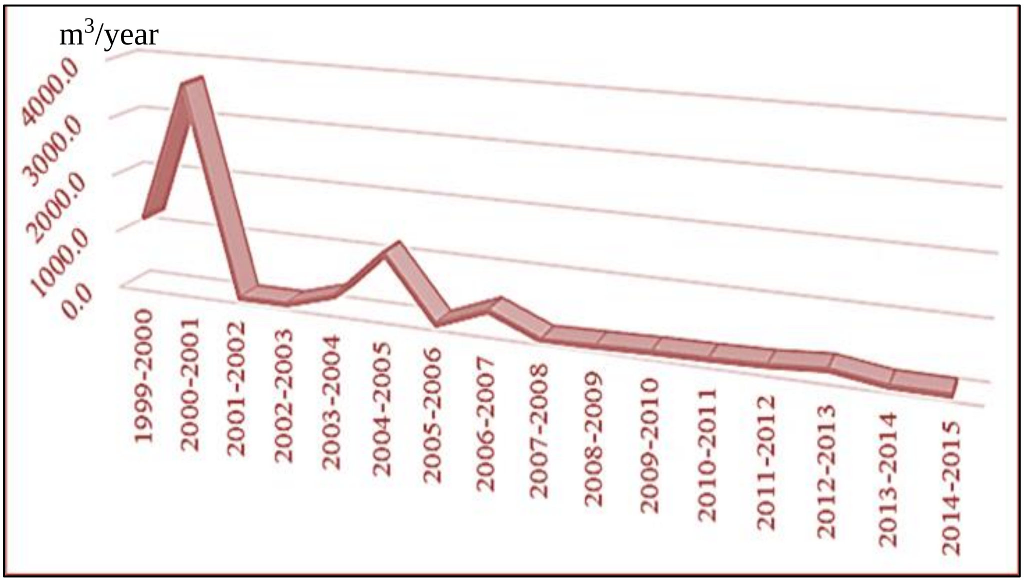


Fig. 4: Total synthetic runoff volume of Wadi Watier

The probability and return period analysis was carried out on the seasonal synthetic runoff for each sub-catchment in the Wadi to determine the runoff at the designated return period using equations (1) and (2). The total runoff volume for some return periods is presented in **Table 3**. Sustainable development requires a reliable water resource. Therefore, the proposed RWH structures should be designed for a small return period to achieve the sustainability and reliability of that source. Hence, the return period of two years was proposed for the purpose of applying the RWH techniques as a surface water resource with a total runoff volume of 154,000 m^3 per year distributed over all outlets' sites.

Table 3: Probability and return period analysis for the runoff Volume

Return period (years)	Probability (%)	Runoff water volume (million m^3)
T100	1.0	9.421
T50	2.0	6.910
T25	4.0	5.083
T5	20.0	0.993
T2	50.0	0.154

3.2. Natural Groundwater Recharge Rate

The groundwater is recharged naturally through infiltration during rainfall events. This amount of water represents the reliable groundwater resource in the studied wadi. The infiltration losses were estimated using the water balance Equation (**6**. Thereafter, the total synthetic infiltration was calculated as presented in **Fig. 5**.

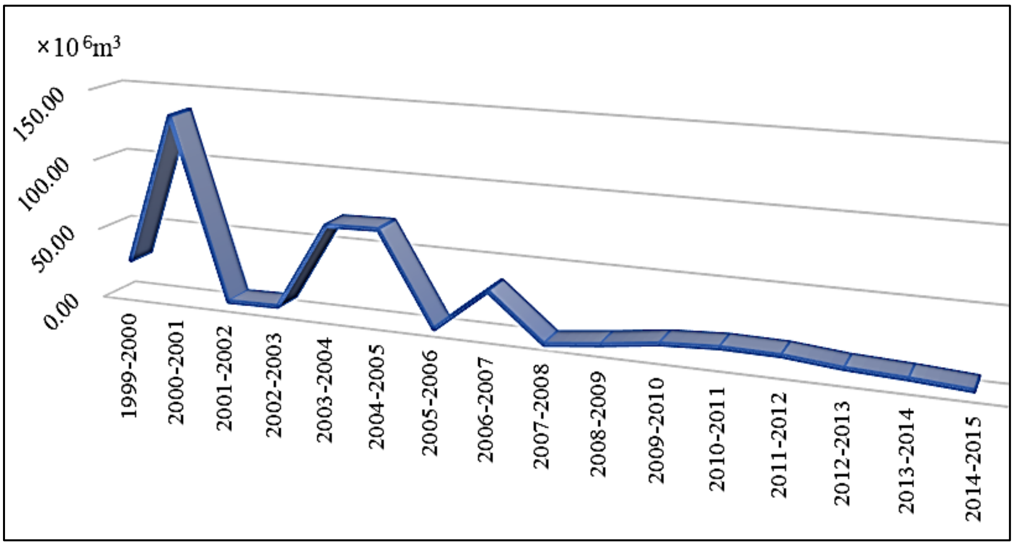


Fig. 5: Total Synthetic infiltration losses in Wadi Watier

The sustainability and reliability of the groundwater resource could be achieved over a return period of 25 years and the natural groundwater recharge could be estimated at 75% of the total infiltration losses [22].

Therefore, the probability and return period analysis was carried out to determine the infiltration losses for the designated return periods using equations (1) and (2). As shown in **Table 4**, the maximum groundwater recharge for a return period of 25 years is estimated at 147.558 million cubic meters over the wadi while the minimum is 17.80 million cubic meters per year. Therefore, the average recharging volume over the 25 years will be considered and estimated at 101.68 million cubic meters per year.

Table 4: Probability and return period analysis of the groundwater recharge.

Return period (years)	Probability (%)	Groundwater Recharge (million m^3)
T25	4.0	147.558
T5	20.0	58.015
T2	50.0	17.80
Average		101.68

3.3. Domestic Water Demand

The domestic water demands were calculated for the four official settlements in the study area based on the baseline population obtained from CAPMAS and the average water consumption stated before. The population was projected using equations (4) and (5) and used to calculate the average domestic water requirements over the next 25 years. The average water demands were estimated at 9077 m^3/year over the study period.

Table 5: Domestic water demand for Wadi Watier Villages

Village	2006	2010	2015	2020	2025	2030	2035	2040	2045
Althawra (m^3/d)	1	1	1	2	2	2	2	3	3
Alsheek Attia (m^3/d)	7	8	9	10	12	13	15	17	19
Ain Fourtaga (m^3/d)	1	1	1	1	1	2	2	2	2
Ain om Ahmed (m^3/d)	3	3	3	4	4	5	6	6	7
Sum (m^3/d)	12	13	15	17	19	22	25	28	31
Total (m^3/year)	4234	4729	5396	6137	6954	7900	8949	10121	11458

3.4. Agriculture Water Requirements

The annual crop water requirements were estimated for each crop pattern proposed for the study area. The adequate soil for cultivation practices is specified in the Wadi beds as it is classified as sandy soil [25]. In addition, the study area is an arid area that suffers from a water shortage; hence, modern irrigation systems are recommended. The crop water requirements (CWR) and irrigation water were calculated using the drip or sprinkler irrigation system with previously studied efficiency by the Water Management Research Institute (WMRI). As a result, the olive has the lowest water consumption, so it is one of the traditional agricultures in Sinai.

Table 6 presents the CWR and irrigation water for each crop.

Table 6: CWR and irrigation water required for Each crop pattern.

	Crops	CWR (mm)	Irrigation System	Irrigation Efficiency (%)	Irrigation water depth (mm)	Annual Irrigation water (m^3/Acr)
Crop Pattern (1) -Vegetation crops						
Scenario (1)	Potato	188.30	Drip	85% (WMRI)	222	930
	pepper	285.50			336	1411
	Tomato	697.60			821	3447
	Sum	1171.40			1378	5788
Crop Pattern (2) –Trees						
Alternative (1)	Date Plam	1222.10	Drip	85% (WMRI)	1438	6039
Alternative (2)	Mango	1290.20			1518	6375
Alternative (3)	Olive	958.20			1127	4735
Crop Pattern (3) – Grain crops						
Alternative (1)	W-Wheat	542.20	Sprinkler	75% (WMRI)	723	3036
	Sorghum	488.20			651	2734
	Sum	1030.40			1374	5770
Alternative (2)	Barley	157.80	Sprinkler	75% (WMRI)	210	884
	Pepper	428			571	2397
	Sorghum	406.30			542	2275
	Sum	992.10			1323	5556
Alternative (3)	Alfaalfa 1	453.70	Sprinkler	75% (WMRI)	605	2541
	Sorghum	488.80			652	2737
	Sum	942.50			1257	5278

3.5. Sustainable Agriculture Development

Sustainable agriculture development could be achieved in the case of the availability of water resources. Therefore, the water balance of the study area was applied using equation (6) to calculate the area for agriculture based on the water resources for each sub-catchment in the study area, see **Fig. 6.** As a result, the olive is the best crop pattern alternative and could be cultivated in the wadi beds with a total area of 22,000 acres distributed spatially over the sub-catchments according to the water resources as shown in **Fig. 7**.

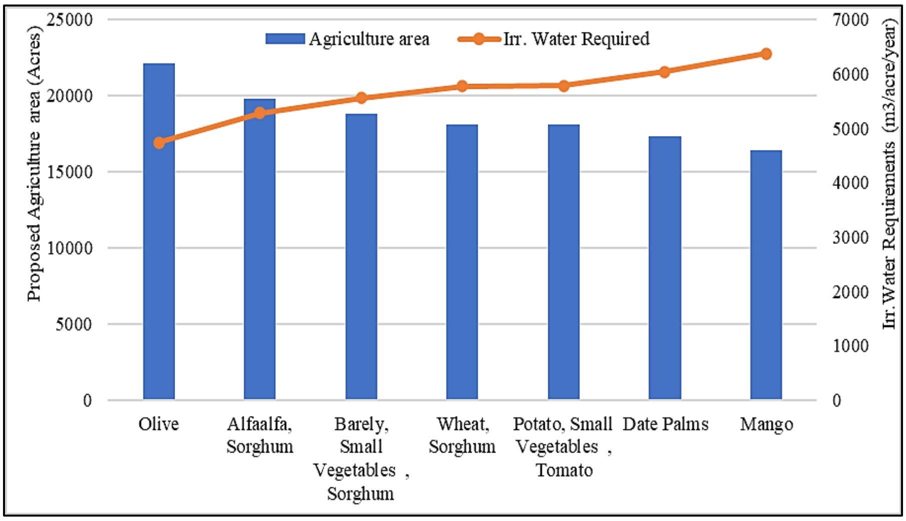
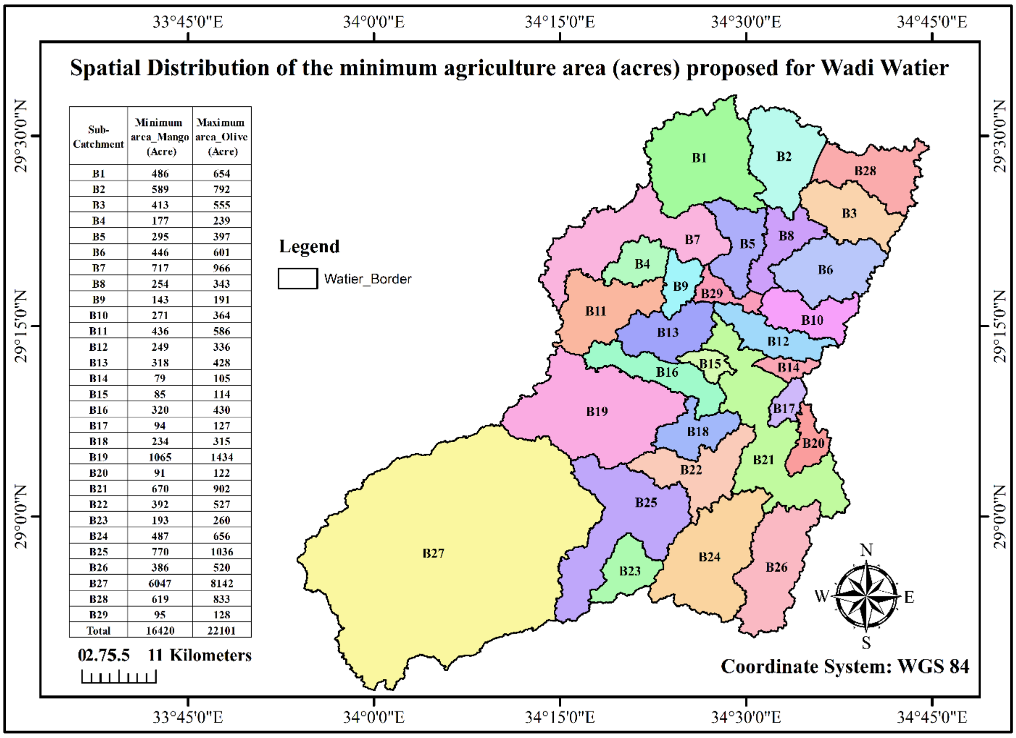


Fig. 6: Proposed cultivation area and irrigation water requirements



Sub-Catchment	Minimum area_Mango (Acre)	Maximum area_Olive (Acre)
B1	486	654
B2	589	792
B3	413	555
B4	177	239
B5	295	397
B6	446	601
B7	717	966
B8	254	343
B9	143	191
B10	271	364
B11	436	586
B12	249	336
B13	318	428
B14	79	105
B15	85	114
B16	320	430
B17	94	127
B18	234	315
B19	1065	1434
B20	91	122
B21	670	902
B22	392	527
B23	193	260
B24	487	656
B25	770	1036
B26	386	520
B27	6047	8142
B28	619	833
B29	95	128
Total	16420	22101

Fig. 7: Spatial distribution of the cultivation area over the sub-catchments

4. Conclusion

- This research aims to determine the potential water resources that achieve the sustainable agriculture development in Wadi Watier basin.
- The rainfall data was analyzed to determine the likely seasonal rainfall depth over the Wadi Watier basin during the study period.
- The WMS model was created and verified to determine the rainfall-runoff amount at each proposed RWH site.
- The groundwater recharge rate was determined using the water balance of the Wadi systems.

- For the purpose of calculating the agriculture development area, three appropriate crop pattern options were studied to determine the agriculture water requirements. In the meantime, the domestic water demand was determined.
- The runoff volume resulting from the hydrological model is 154,000 m^3/year at a return period of two years, distributed over the sub-catchments of the wadi. It could be harvested at the specified sites for domestic or agricultural uses using an appropriate RWH technique.
- The natural groundwater recharge rate was estimated at 101,68 million cubic meters per year, which recharges the groundwater through the wadi beds.
- The comparison between crop pattern options revealed that the olive has the lowest water requirement of 4735 m^3/acre/year, while the mango trees have the maximum water requirement of 6375 m^3/acre/year.
- Applying the water balance equation between the water requirements (domestic and agriculture) and the water resources of the wadi, it was found that from 16,000 acres of mango to 22,000 acres of olive could be developed for agricultural uses based on the crop selection.

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