Plant Archives Vol. 21, No. 2, 2021 pp. 154-163 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2021.v21.no2.026

APPLICATION OF HYDROLOGICAL MODELS IN A SMALL AGRICULTURAL CATCHMENT FOR WATER MANAGEMENT: CASE STUDY ON WADI EL-RAML WATERSHED-NORTH WESTERN COAST OF EGYPT

M.A.I. Abdalla[1*], M.K. Abd El-Wahab[2], M.A. Tawfik[2] and I.M.M. Khater[1]
[1] Soil and Water Conservation Department, Desert Research Center, 11753, Cairo, Egypt
[2] Agricultural Engineering Department, Faculty of Agriculture, Zagazig University, 45511 Zagazig, Egypt
*Corresponding author Email: DrMohamedDRC@gmail.com

(Date of Receiving-03-02-2021; Date of Acceptance-13-04-2021)

ABSTRACT

North Western Coast of Egypt as a semi-arid region suffers from lack of rainfall most of the year except during rainfall events during the winter season which may even culminate with flash floods that causes acceleration of soil erosion and water losses resulting in degradation of the cultivation lands and consequently the agri-food productivity. This region Suffer lack of water reservoirs and terraces construction. Hydrological models are very useful tools for simulating the effect of natural processes and management practices on soil and water resources. Hence, the aim of study is calibrating and validating hydrological models KINEROS2(K2), ARCSWAT, to select the appropriate model and applying it to establish water and Soil conservation strategies such as terraces construction and building reservoirs. A yearly data set was used consisting of weather data, water content measurements and Gerlesh trough technique. Satellite image Digital elevation model (DEM), Land Cover classifications and soil map were used as layers input in models. The Nash–Sutcliffe coefficient (NSE) and coefficient of determination (R^2) were used to evaluate model's performance. The results reveal that the K2 are better than ARCSWAT, with acceptable NSE and R^2 values, where the NSE, R^2 were 0.86, 0.84 fork 2 and NSE, R^2 were 0.55, 0.47 for ARCSWAT respectively. The K2 model was applied in sub-catchment where the estimated result of surface runoff was ranged from 21.92 to 169.695 $m^3\ ha^{-1}\ year^{-1}$. Hence, it is recommended that a reservoir can be constructed inside field approximately about 200 $m^3\ ha^{-1}\ y^{-1}$ for using as Supplementary irrigation during dry period and the result indicated to areas with a high risk of soil loss that ranged from 38.88 to 3,860 kg. ha^{-1}. $year^{-1}$.

***Keywords*:** Hydrological Modeling, KINEROS2, ARCSWAT, water management, soil conservation.

INTRODUCTION

Most arid-semi arid regions suffer from aridity conditions most of the year except during infrequent rainfall events which may even culminate in flash floods. Recently, there has been an increased interest in the damage caused by natural hazards and flash floods (Abdulrazzak *et al.*, 2019; Nguyen *et al.*, 2016). Water-induced soil erosion is a main factor of land degradation in many parts of the world (Quang, 2016). Soil erosion hazard is problem in the northern west coast of Egypt and lead to reducing the soil quality and increasing the degradation of soil resources (Mohamed *et al.*, 2013) furthermore, climate change is intensifying the existing risks, particularly in regions where water scarcity is already a concern. Thus, Agricultural water management benefit from understanding the risks and proposed adaptation strategies (Iglesias and Garrote, 2015). The water resources management generally includes catchment systems management, water storage, water abstraction and return-flow management, Integrated management techniques (Nyam *et al.*, 2020). The food security and agricultural production are highly dependent on the water availability. Improving agricultural water management and its quality is the main key to sustainable and agriculture productivity (Sivasankar *et al.*, 2020). Agricultural watershed in the North Western Coast, farmers looking for increasing their cultivated land to be irrigated by the highest possible extent in rainfall period without taking into consideration storing the excessive water for dry period because of the lack of reservoirs, farmer's past experience and local knowledge (DRC, 2010).

The above-mentioned challenges are directly or indirectly water-and soil-related, especially in terms of collecting, storing rainwater and know when and where it falls, and being able to sustainably preserve and use available soil resources (Nicol *et al.*, 2015). In this regard, meeting current and future global food needs to upgrade the agriculture by adopting cost-effective strategies for managing rainwater and soil at a small-scale farmer level(Rockström and Falkenmark, 2015). Rainwater harvesting management is the one of practices for restore degraded lands and decrease the exposure to climate variability and change (Ali *et al.*, 2016; Nicol *et al.*, 2015; Pachauri *et al.*, 2014). Thus, traditional, modern technologies and practices for collecting, storing, using rainfall for rainfed and off-season irrigated agriculture and the sustainable management of soils with the goal of improving soil conservation have gained worldwide interesting (de Trincheria Gomez *et al*., 2018). These set of technologies range from collecting and storing rainwater (i.e. earth dams, groundwater dams, on-farm ponds, road, rock and roof catchment systems), conserving and maximizing soil moisture (i.e. mulching, digging pits, terraces, trenches.), and off-season small-scale rainwater irrigation systems (i.e. rainwater harvesting (reservoirs) (Trincheria *et al*., 2016).

The coastal zone of Egypt has become the major site for extensive, diverse economic activities and one of the promising and strategic regions for future sustainable rainfed development and this, in turn, depends principally on the availability of water resources(Omran and Negm, 2018). As a strategic view, the development of the coastal zone of Egypt is essential because it has obtained the most promising land for agricultural expansion(Negm and Abu-hashim, 2019; Omran and Negm, 2018). The area has 218 wadis occupied by olive and fig trees and rainfed crops and natural vegetation (El-Sadek and Mohamed, 2017).

The primary concern of water resource management is the appropriate study and planning, for this reason hydrological models are used to understand the functioning of watersheds (El Harche *et al*., 2021). Watershed hydrology models are important in addressing the impact of many problems including soil erosion and runoff related to water resources assessment and development (Dwarakish and Ganasri, 2015). (KINEROS2 and SWAT) hydrological models address water flows as well as sediment yield, and infiltration in addition to, several environmental problems. The comparison of the performance of different models according to the processes that describe, require different types of data and parameters (Abdelwahab *et al*., 2018).

Firstly, The Kinematic runoff and erosion Model, KINEROS2 (Goodrich *et al*., 2012) which is a physics-based model was used for modeling runoff, average transmission losses and water stored in the soil during a single rainfall event. KINEROS2 model in general performed well for all rain events having different intensities, ranging from light to very heavy (Saran *et al*., 2021; Tajbakhsh *et al*., 2018).

Secondly, SWAT model operating on a daily time-step basis (Al-Mahasneh *et al*., 2018), has proven its effectiveness over the years in several studies and widely applied for runoff and water quality modeling under changed scenarios, is a promising model and has been widely used to understand water quantity and quality issues over a wide range of watershed scales and environmental conditions (Al-Mahasneh *et al*., 2018; Chen *et al*., 2018; Yang *et al*., 2016; Yu *et al*., 2018).

In light of above, the study aims to assess the performance of KINEROS2 and ARCSWAT models with GIS interface by compare simulated results with measured data under Egyptian conditions and making sure that the models work properly, select the appropriate model and apply in the assessment and the management of water resources, to establish water and Soil conservation strategies.

MATERIALS AND METHODS

The site

Wadi El-Raml watershed, covering an area of 20,388 ha and the stream length is 26.24 km (Khalifa and Beshay, 2015), It is located at west of Marsa Matrouh in the north-western coastal region of Egypt (*lat*. 31 15 41 N: *long*. 27 09 40 E.) as shown in Fig. (1). The climate of watershed is sub-humid, which are dry from May to September and humid from October to March. The study area is characterized by a temperate Mediterranean climate by short rainy season (Nov.-Feb.). The mean precipitation recorded about 128.82 mm/year. The soil texture in the Wadi El Raml area is classified as sandy loam.

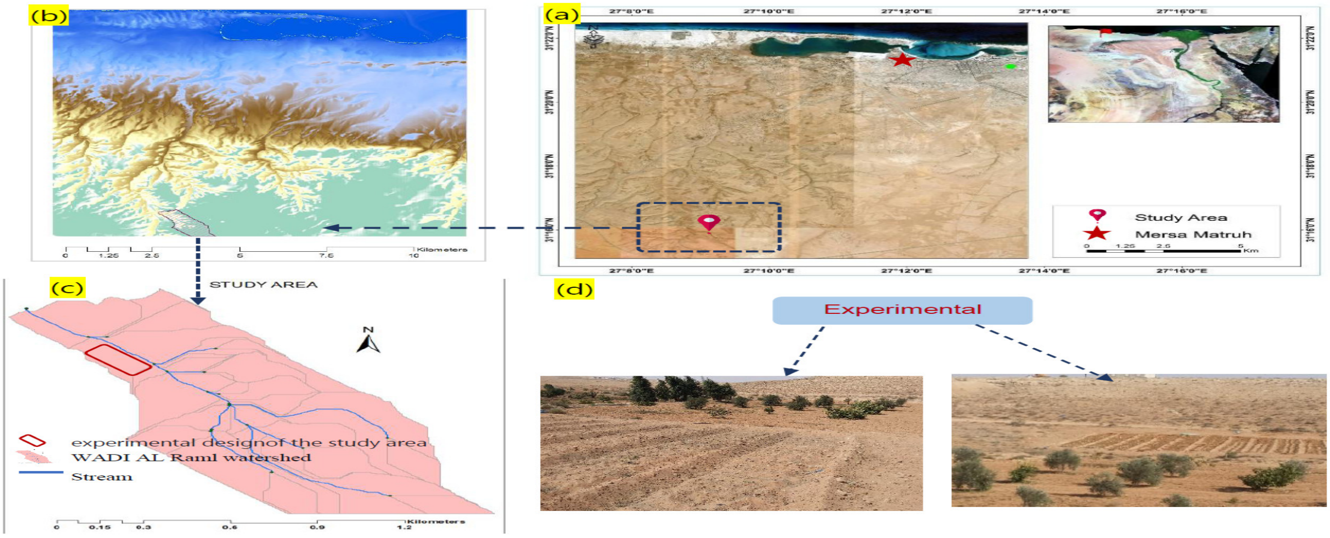

Fig. 1 : a) North-western coastal region of Egypt, with indication of Marsa Matrouh area; b) schematic view of the catchment of Wadi El Raml Watershed Basin; c) schematic view of the sub catchment of Wadi El Raml Watershed Basin; d) photos of experimental design of the study area.

The monitoring system and Sources of Data

The meteorological station

The data used in this study obtained from monitoring devices specifically installed in the Study area. The weather station consists of a rain gauge; a hygrometer; a sonic anemometer; and a radiation sensor. It is supported by a GPRS modem- Em50G for remote connection is presented in Table (1).

Soil water content

Soil water storage was calculated fora hole was drilled by a hand auger and thus a specifically designed PVC tube was installed down to 70 cm depth. This installation depth will allow to monitor the water content in study area by Diviner 2000 device that consists of a probe and hand-held data logging display unit. More details about the measuring devices used in this study is presented in Table (1).

Table 1 : The specifications of measuring devices used in this study.

Devices	Parameters	Usage	Measuring	Accuracy
The meteorological station (DECAGON Company, Em50G – 5G0F5292, U S A)	P (mm)	Rain gauge, which is used to record the rain	0-100 mm	0.2 mm
	SR (W/m²)	Radiation sensor, to measure the solar radiation during the day	0-1500 w/m^2	± 5%
	w (m/s)	Sonic anemometer for measuring the speed and direction of wind	0-100 m/s	± 0.3 %
	T °C	Hygrometer for measuring the temperature	0- 50 ^{o}	± 3%
	RH %	Hygrometer for measuring the relative humidity of the air	0.8 - 100 %	± 3 %
Diviner 2000 (Sentek Pty Ltd -ACN 007 916 672, Australia)	SWC %	Probe and hand-held data logging display unit.	0.0– 100 %	±3%

Measuring runoff volume and soil losses

Gerlesh trough technique was placed at the down-slope edge of different places in experimental site to collect the amount of surface runoff water and soil loss (Morgan, 2009)as shown in Fig. (2). Runoff and soil loss for every effective rainstorm were determined volumetrically per unit area, and soil loss was determined after dried it on 105ºC. Soil loss rate estimated by dividing sediment weight per unit area.

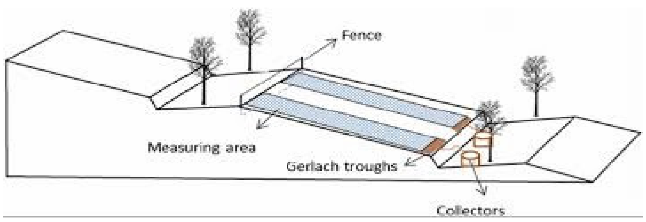

Fig. 2 : Schematic view of Measuring runoff volume and soil losses by Gerlesh trough method

Satellite image and Land Cover classifications

Satellite image was performed in ArcGIS 10. Hydrological models need four sets of input data to operate and describe the catchment area, which are the digital elevation model (DEM), soil, land use/land cover (LULC) and precipitations. A 30 m Digital Elevation Model (DEM) see Fig. (3a), The model uses the DEM to generate information related to the topographic characteristics of the watershed: elevation, water shed boundary, flow path, sub-basin area, slope, and channels elevation. LULC of Wadi El Raml water shed was set up using Lands at 5 TM scenes (30 × 30-meter resolution) see fig.(3b), where LULC map consists of Four classes, including forest, agricultural land, grassland, and bare land. The soil map of Wadi El Raml watershed is categorized into one major soil groupings: Yk22-1/2ab FAOSOIL see fig. (3b).

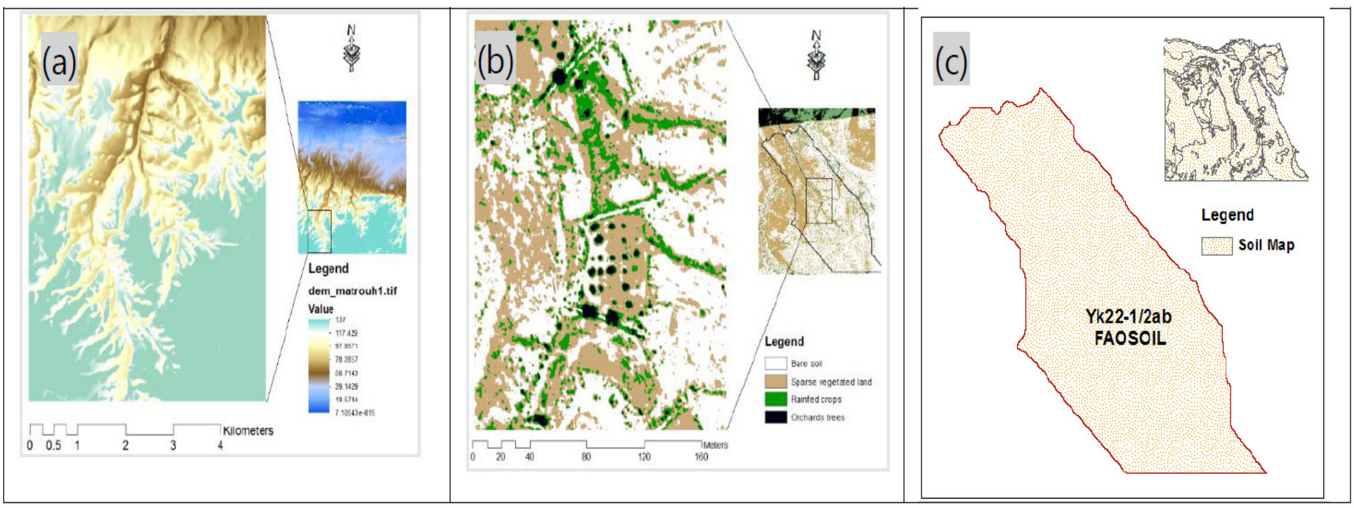

Fig. 3 : schematic view of a) Digital elevation model b) land use/land cover classification map c) soil map of Wadi El Raml Watershed Basin

The hydrological models

The Kinematic Runoff and Erosion Model, KINEROS2

KINEROS2(K2) is an event-oriented, distributed, physically-based model developed to simulate the runoff response in basins having predominantly overland flow and sediment transport (Semmens *et al.*, 2008). The form of the K2 model that we used in this study is part of the Automated Geospatial Watershed Assessment (AGWA) interface (Miller *et al.*, 2007). A geographic information system (GIS) user interface for K2, AGWA tool, and facilitates parameterization of the model. It was developed by

Environmental Protection Agency (EPA), the Agricultural Research Service of the United States Department of Agriculture (USDA).AGWA is designed to provide qualitative estimates of runoff and erosion in relation to landscape changes.

In this model, the watershed is represented by subdividing the area into a series of one-dimensional surface flows and channel elements using topographic information, in order to allow for a good understanding of watershed response to land use changes and land cover management. The utilization of a GIS further provides a means of relating model results to other spatial information. K2 first calculates the infiltration capacity when rainfall rate less than infiltration rate using the Smith-Parlange model (Parlange *et al.*, 1982). The model also calculates the sediment transport which is given by mass-balance equation similar to that for kinematic water flow.

Soil and Water Assessment Tool, SWAT

Soil and Water Assessment Tool (SWAT) is a physically based, distributed, continuous-time model that operates on a daily time scale. Physical processes associated with water movement, sediment movement, crop growth, nutrient cycling, etc. (Neitsch *et al.*, 2011). The original SWAT model is a long-term yield model. However, a daily simulation time step. In a previous study the sub-daily and even the sub-hourly modeling capacities of the ARCSWAT hydrological model was developed to allow simulations of flow with any time steps less than a day. Therefore, we can use the developed model ARCSWAT to compare with Kineros2 model in this study. The developed version of SWAT was named ARCSWAT to perform event-based flood simulation on a sub-daily timescale. The results simulated by the sub-daily ARCSWAT model indicated reliable performances, with NSE values varying from 0.67 to 0.95 (Yu *et al.*, 2018).

The model calculates for each cell, the flows and direction of water accumulation according to topography depicted by digital elevation model. The computation grid is the Hydrologic Response Unit (HRU), which is a spatial combination of soil type, land cover and slope class in each sub-basin. The volume of surface runoff is predicted using the soil conservation service (SCS) curve number (CN). Erosion and sediment yield are estimated for each HRU using (modified universal soil loss equation) MUSLE model (Williams, 1975).

Table (2) Summarized the characteristics of the two models and highlighted their advantages and limitations.

Table 2 : Comparison between KINEROS2 and ARC-SWAT models

Model	KINEROS2	ARCSWAT
Suitability	- Agricultural and urbanized basins - Small Watershed	-Agricultural basins - Cultivation practices
Surface runoff equation	-Hortonian flow - Kinematics equation	SCS equation
Operations	Describe the processes of interception, infiltration, runoff, erosion Used to determine the impact of developments in the watershed	Predict the effects of land management on water Predict the effects of sediment and chemical resources on agricultural yields in large basins
Input	-Topography (DEM) - Soil type - Land cover - Precipitation data	- Topography (DEM) - Soil type - Land cover - Meteorological data (temperature, humidity, wind and precipitation)
Output	- Runoff m3 -Sediment yield kg/ha - Infiltration m3/ha - Peak flow rate m^3/s - Maximum sediment flow rate kg/s	- Evapotranspiration (mm) - Percolation (mm) - Surface runoff (mm) - Transmission losses (mm) - Water yield (mm) - Sediment yields (t/ha)
Advantages	Reduced time of use, Simple, Estimates runoff and erosion/landscape change, Useful for running scenarios	Simulates nutrient, sediment and pesticide transfers to the drainage system and to aquifers

Model performance evaluation

- Nash–Sutcliffe coefficient (NSE):

NSE is used to estimate the model's performance in predicting sediment loads and flow rate. Whenever The models performance efficiency value is more than0.65, the model performance can be considered as satisfactory (Gehbrehiwot and Kozlov, 2019; Ghimire *et al.*, 2020; Memarian *et al.*, 2013; Nash and Sutcliffe, 1970; Safari *et al.*, 2012). NSE can be computed as following formula:

$$NSE = 1 - \frac{\sum_{i-1}^{n}(Q_{abs} - Q_{sim})^2}{\sum_{i-1}^{n}(Q_{abs} - Q^{-})^2}$$

Where NSE is Nash-Sutcliffe coefficient; Q_{sim} is simulated flow (m^3/s); Q_{obs} is Observed flow (m^3/s); Q^{-} is Average of observed flow (m^3/s).

- The coefficient of determination (R^2):

R^2represents the degree of collinearity between observed and simulated data. A value of R^2 closer to 1 indicates that descriptions of the predicted values are almost equal to the observed values. On Contrarily, a value of 0 signifies no correlation between observed and simulated values(Gehbrehiwot and Kozlov, 2019). R^2 can be estimated as follows:

$$R^2 = \frac{\left\{\sum_{i-1}^{n}\left(Q_{sim} - Q_s^-\right)\left(Q_{abs} - Q_s^-\right)\right\}^2}{\sum_{i-1}^{n}\left(Q_{sim} - Q_s^-\right)^2 \sum_{i-1}^{n}\left(Q_{abs} - Q_s^-\right)^2}$$

where R^2 is coefficient of determination; Q_{sim} is simulated flow (m^3/s); Q_s- is average of simulated flow (m^3/s); Q_{obs} is observed flow (m^3 /s); Q_o- is average of observed flow (m^3/s).

RESULTS AND DISCUSSION

The obtained results will be discussed under the following items:

Rainfall observed data

The Figures (4,5)indicate some selected rainfall events more than 10 mm, duration and intensities that generate runoff and sediment yield. This data recorded by the meteorological station through the period from October 2018 to 30 March 2020. The total rainfall recorded in the winter season 2018-2019 about 192.6 mm as illustrated in Fig. (4), and in the season 2019-2020 was about 112.6 mm as illustrated in Fig. (5).

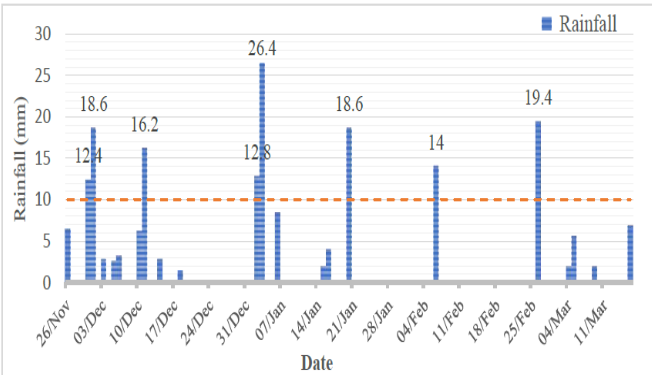

Fig. 4 : The rainfall data recorded in the first season 2018-2019.

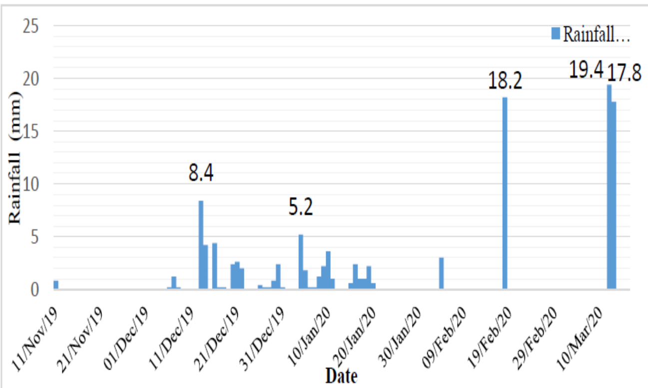

Fig. 5 : The rainfall data recorded in the second season 2019-2020.

Calibration and validation analysis

The comparison between the simulated and measured data in terms of runoff and sediment yield for daily simulate using the K2 and ARCSWAT. Afterwards, it is possible to select the appropriate model for suitable the present study.

Calibration analysis of hydrological models (K2, ARC SWAT) were carried out using the data of six storm events in the winter season 2018-2019 and using the data of three storm events in the winter season 2019-2020 for validation. The runoff and sediment yield simulations were used for comparison between the simulated and measured data. The Nash-Sutcliffe Efficiency (NSE) and the coefficient of determination (R^2) were used to evaluate the performance of the models where it is satisfactory more than 0.65 as mentioned in the previous work (Gehbrehiwot and Kozlov, 2019).

The obtained results from the comparison between the simulated and measured data showed that the NSE and R^2 were 0.87 and 0.88, respectively for K2 hydrological model and the NSE and R^2 were 0.55 and 0.47, respectively for ARCSWAT hydrological model in terms of surface runoff simulation. Hence, the results of K2 showed that there is a good agreement between simulated and measured values for the all-storm events except just event (4) that showed the highest deviation from measured values as depicted in Fig. (6). As a result, the performance of the K2 hydrological model was more than 0.65thusthe K2 model proved to be more efficient for simulating runoff, sediment yield and water infiltrating.

The comparison between the simulated and measured data in terms of sediment yield was carried outto increase the accuracy of calibration and making sure that the models work properly. The obtained results showed that the NSE and R^2 were 0.84 and 0.86, respectively for K2 hydrological model, while the NSE and R^2 were 0.52 and 0.45, respectively for ARCSWAT hydrological model as illustrated in Fig. (7). practically, ARCSWAT model seems to overestimate the values of daily runoff and sediment yield during model calibration. Therefore, the ARCSWAT model was less efficient in the simulation. The comparison of the simulated runoff and sediment yields during the calibration showed that K2 model predictions was better performance than ARCSWAT.

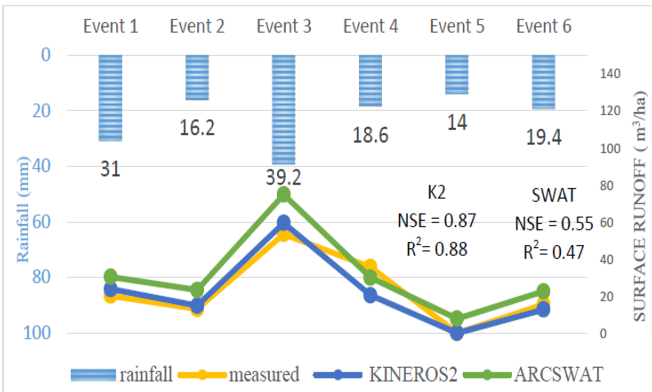

Fig. 6 : The comparison between simulated and measured data in terms of runoff (m^3/ha) for six storm events using the K2 and ARCSWAT-EVENT.

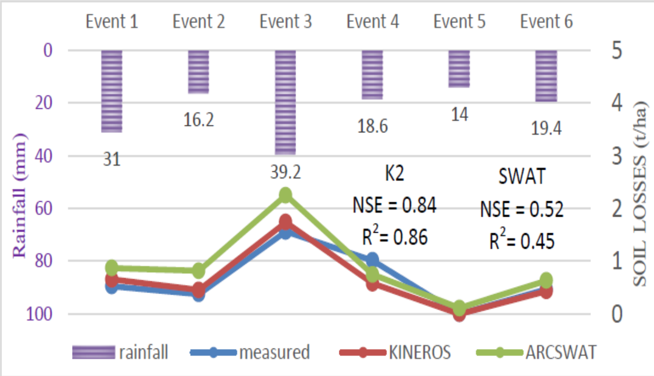

Fig. 7 : The comparison between simulated and measured data in terms of sediment yield (t/ha) for six storm events using the K2 and ARCSWAT-EVENT.

The validation was done according to the second season 2019-2020 that consist of three storm events. Fig. (8) shows that the K2 hydrological model appeared good precision regarding the surface runoff simulation, where NSE and R^2 were 0.80 and0.90,respectively and showed a reduction in ARCSWAT hydrological model performance for surface runoff simulation as NSE and R^2 were 0.43 and 0.49respectively. Fig. (9) shows that the K2 hydrological model appeared very stable for sediment yield simulation as NSE and R^2 were 0.91 and 0.93,respectively but a reduction shown in ARCSWAT hydrological model performance for sediment yield simulation as NSE and R^2 were 0.40 and 0.56, respectively.

Fig. 8 : The comparison between simulated and measured data in terms of runoff (m^3/ha) for six storm events using K2 and ARCSWAT-EVENT model.

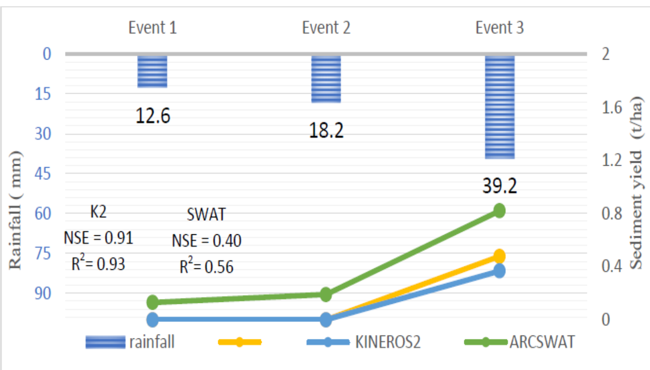

Fig. 9 : The comparison between simulated and measured data in terms of sediment yield (t/ha) for six storm events using K2 and ARCSWAT model.

The obtained results after calibration and validation indicated that the performance efficiency of K2 model and the simulated data were close to the field reality and therefore, it is effectively used for simulating runoff, sediment yield and water infiltrating in the soil. Hence, the K2 model proves a functional coupling for integrated soil and water resource management with sustainable use at the level of Wadi El Raml watershed.

In this purpose, the modelling methodology was used in this study to quantify the volumes of surface runoff that can be stored in reservoirs. Additionally, the quantify infiltrated water stored in the soil which would be available for crops during the spring – summer seasons and quantify the volumes of sediment yield.

Applying the obtained results by k2 hydrological model on Wadi El Raml watershed.

The GIS-based model (K2) was applied in the sub-catchment of Wadi El Raml watershed, North Western Coast of Egypt for soil and water resource management and developing conservation strategies such as terraces construction for reduction of soil erosion and building reservoirs for storing the excessive rain water. Hence, based on obtained results from the application of the K2 hydrological model, the volume of surface runoff was about 560 m^3. $year^{-1}$ in experimental site that takes ID32 with total area 4.2 ha as shown in Fig. (10).Therefore, the experimental site needs three reservoirs. Hence, it is recommended that each reservoir can be constructed inside field approximately capacity of 200 m^3 ha^{-1} y^{-1} and use it during the dry season as supplementary irrigation source, where the volume of water in sub-catchment of Wadi El Raml ranged from 21.92 to 169.695 m^3 ha^{-1} $year^{-1}$ as shown in table (4), Fig. (10). In addition to the K2 model concentrated focused on identifying areas with a high risk of soil loss and the obtained results indicated that the sediment yield was ranged from 38.88 to 3,860 kg ha^{-1} $year^{-1}$ as shown in Table (4),Fig. (10). The K2 hydrological model was applied on large scale of Wadi El Raml watershed to simulate sediment yield that affect agricultural productivity, food security and environmental quality. The obtained results of the application indicated that the sediment yield for the basins ranged from 7.27 to 2,532 kg ha^{-1}, and ranged from 10.09 to 1,418.21 for stream (channels) due to a single event that recorded 31 mm in duration of 3.5 hours in the winter season as shown in Fig. (11). Therefore, the priority should be given to reduce or control the rate of soil erosion by means of soil and water conservation planning include terracing, pitting, conservation tillage practices, commonly implemented to control soil erosion and increasing the infiltration. In the meantime, the erosion hazard in expected and will be increase in future in the investigated area thus, the appropriate land-use planning is needed such as suitable cropping pattern for agricultural land and constructing terraces.

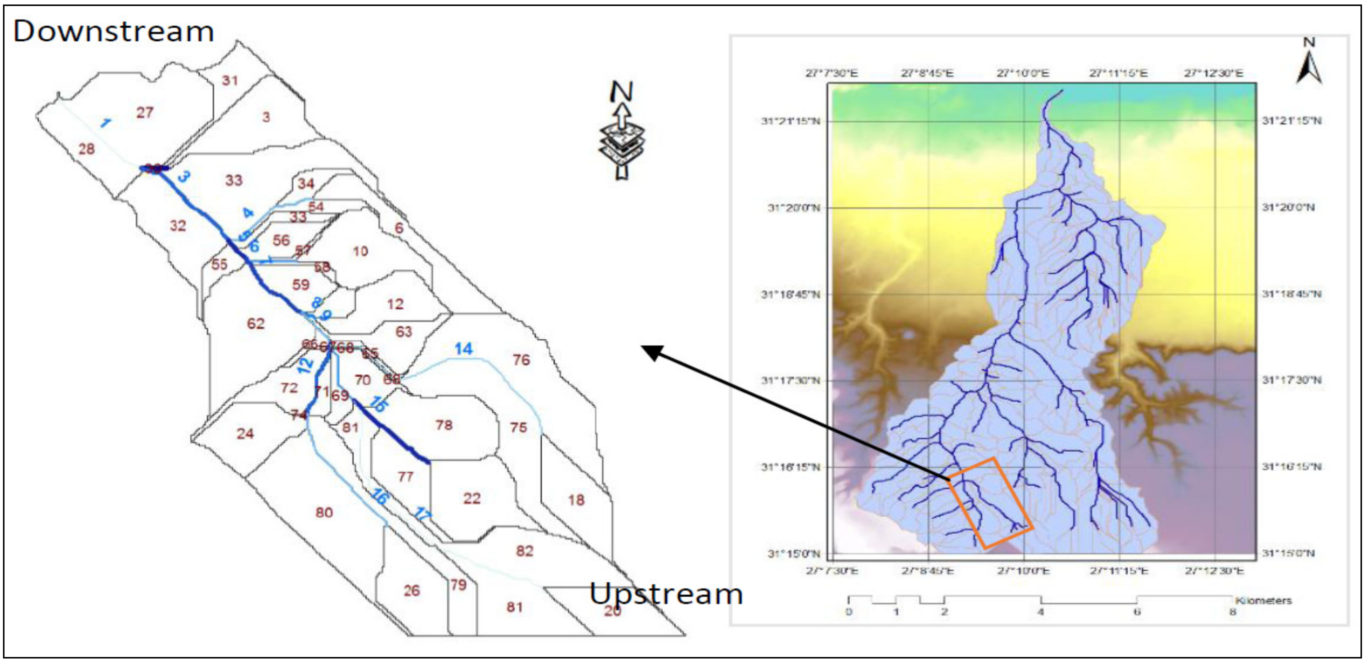

Fig. 10 : schematic view a) Wadi El Raml Watershed Basin; b) sub-catchment of Wadi El Raml Watershed Basin shows the Object ID.

Table 4: Analysis simulated sediment yield, runoff and infiltration for sub-catchment of Wadi El Raml watershed.

Object ID	basin Area (ha)	Infiltration (mm)	Runoff (m^3. ha^{-1}. $Year^{-1}$)	Sediment yield (kg. ha^{-1})
3	4.29	118.99	45.73	646.96
10	4.19	117.51	61.66	993.14
12	3.16	117.60	60.59	1,087.37
20	3.17	121.26	21.92	38.88
22	4.69	118.22	54.06	574.76
24	3.47	116.04	76.93	887.44
26	3.76	120.93	25.43	73.73
27	7.32	113.96	98.73	2,867.17
28	2.66	110.86	131.06	3,646.09
31	2.12	112.21	146.78	1,293.68
32	4.28	110.89	130.95	3,864.53
33	7.83	115.84	79.95	1,623.53
34	0.86	107.12	169.70	3,859.95
54	0.89	107.84	162.78	3,093.16
56	1.55	113.95	99.14	2,502.12
59	1.84	109.70	142.59	3,833.39
62	6.95	115.94	78.70	1,834.99
63	2.82	120.28	33.21	735.94
65	0.30	107.37	167.56	3,268.35
66	0.31	107.27	168.68	3,004.30
69	0.64	108.92	151.83	2,456.58
70	1.72	111.15	127.65	3,460.57
72	2.43	112.27	116.34	2,578.76
75	5.93	111.83	120.34	2,176.03
76	8.14	117.35	63.63	174.94
77	2.74	113.45	104.29	1,660.06
78	4.85	115.81	80.42	1,411.31
79	3.74	115.00	87.41	549.03
80	8.05	118.17	54.99	407.14
81	5.02	114.84	90.46	259.55
82	6.14	115.88	79.41	226.71

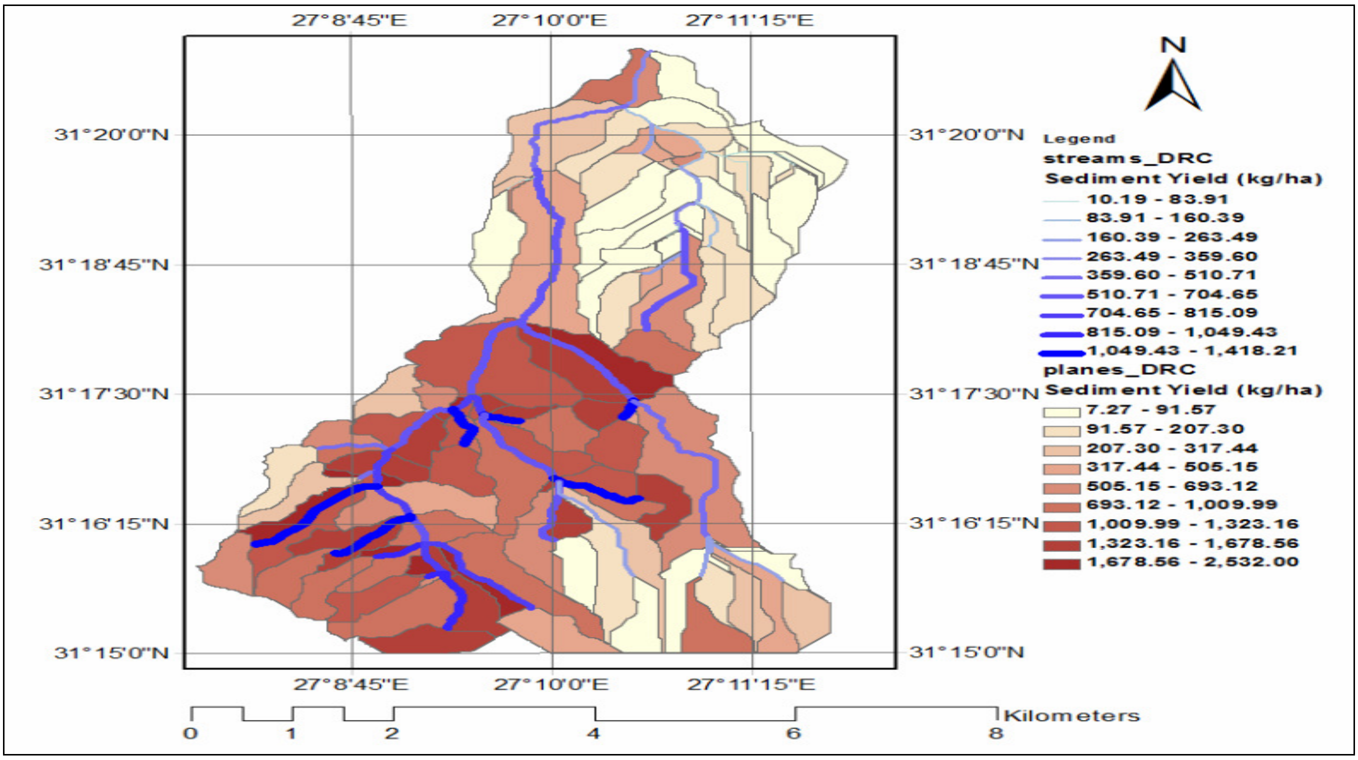

Fig. 11 : Schematic view of the Kineros2 model output for Wadi El Raml Watershed.

CONCLUSION

The north western Coastal zone of Egypt is considered as a semi-arid region that suffers from flash floods, climate variability and change which causes acceleration of soil erosion and water losses resulting in degradation of the cultivation lands, and consequently the agri-food productivity. The major problem in this region that the farmers in this region are looking for increasing their cultivated land to be irrigated by the highest possible extent in rainfall period without taking into consideration the either the soil erosion or storing the excessive water for dry season because of the lack of reservoirs, terraces construction and local knowledge. Thus, it is necessary to adopt a new modeling methodology to simulate and predict flash flood and soil losses. Hence, this work aims to calibrate and validate two hydrological models of KINEROS2 (K2) and the modified Soil and Water Assessment Tool (ARCSWAT) to select the appropriate model and was applying it to establish water and Soil conservation strategies. The obtained results revealed the followings:

- The K2 model proved to be more efficient performance than ARCSWAT by giving acceptable values of 0.86 and 0.84 for NSE and R^2, respectively.
- TheK2 was applied on one of sub-catchments of Wadi El Raml watershed wherein, the results indicated that the experimental site needs three reservoirs to receive the excessive water of run-off, where each reservoir can be constructed inside field with approximate capacity of 200 $m^3.ha^{-1}.y^{-1}$. Additionally, the experimental site exposed a high risk of soil loss about 3.860 $kg.ha^{-1}.year^{-1}$ that can be avoided by constructing terraces on the main stream.
- The K2 hydrological model was applied on the large-scale of Wadi El Raml watershed to simulate sediment yield that ranged from 7.27 to 2.532 kg. ha^{-1} during a single event.
- Hence, the outcomes of this work can be recommended to the researchers for establishing soil and water conservation planning based on the obtained results on large-scale of Wadi El Raml watershed in future, especially it is has vast covering area of 20.388 ha.

Ultimately, it is recommended to integrate the satellite images with the hydrological model of K2 which will be very helpful to detect the environmental changes and their impact on the watershed and develop better options for sustainable development of land and water resources.

REFERENCES

Abdelwahab, O.; Ricci, G.; De Girolamo, A. and Gentile, F. (2018). Modelling soil erosion in a Mediterranean watershed: Comparison between SWAT and AnnAGNPS models. *Environmental research,* 166: 363-376.

Abdulrazzak, M.; Elfeki, A.; Kamis, A.; Kassab, M.; Alamri, N.; Chaabani, A. and Noor, K. (2019). Flash flood risk assessment in urban arid environment: case study of Taibah and Islamic universities' campuses, Medina, Kingdom of Saudi Arabia. *Geomatics, Natural Hazards and Risk,* 10: 780-796.

Al-Mahasneh, L.; Ziadat, F.; Srinivasan, R. and Shatanawi, K. (2018). Adapting SWAT model for the evaluation of water harvesting systems in an arid environment: a case from Jordan.

Ali, Z.I.; Lajili, L. and Zairi, M. (2016). Rainfall-runoff modeling for predictive infiltration and recharge areas for water management in semi-arid basin: a case study from Saadine watershed, Tunisia. *Arabian Journal of Geosciences,* 9: 19.

Chen, Y.; Marek, G.W.; Marek, T.; Brauer, D.K. and Srinivasan, R. (2018). Improving SWAT auto-irrigation functions for simulating agricultural irrigation management using long-term lysimeter field data. *Environmental modelling & software,* 99: 25-38.

de Trincheria Gomez, J.; Dawit, D.; Famba, S.; Leal Filho, W.; Malesu, M.; Mussera, P.V.; Ngigi, S.; Niquice, C.; Nyawasha, R. and Oduor, A. (2018). Using Rainwater for Off-Season Small-Scale Irrigation in Arid and Semi-arid Areas of Sub-Saharan Africa: Key Working Principles and Best Practices. *In* "Rainwater-Smart Agriculture in Arid and Semi-Arid Areas", pp. 9-36. Springer.

DRC, D.R.C. (2010). Development of Northwestern coastal wadies. *Progressive report DRC publications, EGYPT.*

Dwarakish, G. and Ganasri, B. (2015). Impact of land use change on hydrological systems: A review of current modeling approaches. *Cogent Geoscience,* 1: 1115691.

El-Sadek, A.N. and Mohamed, A.H. (2017). Simulation of the Effect of Land Cover Change on Water Balance and Sediment Yield of Wadi El Raml in the North Western Coast, Egypt. 38: 940-955.

El-Harche, S.; Chikhaoui, M.; Naimi, M.; Choukri, F. and Chaaou, A. (2021). Comparative analysis between KINEROS2 and SWAT for hydrological modeling: A case study from Tleta Watershed in Morocco. *International Journal of Environment, Agriculture and Biotechnology,* 6: 1.

Gehbrehiwot, A. and Kozlov, D. (2019). GIUH-Nash based runoff prediction for Debarwa catchment in Eritrea. *In* "E3S Web of Conferences", 97, pp. 05001. EDP Sciences.

Ghimire, U.; Agarwal, A.; Shrestha, N.K.; Daggupati, P.; Srinivasan, G. and Than, H.H. (2020). Applicability of lumped hydrological models in a data-constrained river basin of Asia. *Journal of Hydrologic Engineering,* 25: 05020018.

Goodrich, D.; Burns, I.; Unkrich, C.; Semmens, D.J.; Guertin, D.; Hernandez, M.; Yatheendradas, S.; Kennedy, J.R. and Levick, L.R. (2012). KINEROS2/AGWA: model use, calibration, and validation. *Transactions of the ASABE,* 55: 1561-1574.

Iglesias, A. and Garrote, L. (2015). Adaptation strategies for agricultural water management under climate change in Europe. *Agricultural water management,* 155: 113-124.

Khalifa, M.; and Beshay, N.F. (2015). Soil classification and potentiality assessment for some rainfed areas at West of Matrouh, Northwestern Coast of Egypt. *Soil Tillage Res,* 94: 425-440.

Memarian, H.; Balasundram, S.K.; Talib, J.B.; Teh Boon Sung, C.; Mohd Sood, A. and Abbaspour, K.C. (2013). KINEROS2 application for land use/cover change impact analysis at the H ulu L angat B asin, M alaysia. *Water and Environment Journal,* 27: 549-560.

Miller, S.N.; Semmens, D.J.; Goodrich, D.C.; Hernandez, M.; Miller, R.C.; Kepner, W.G. and Guertin, D.P. (2007). The automated geospatial watershed assessment tool. *Environmental Modelling & Software,* 22: 365-377.

Mohamed, E.; Schütt, B. and Belal, A. (2013). Assessmentof environmental hazards in the north western coast-Egypt using RS and GIS. *The Egyptian Journal of Remote Sensing and Space Science,* 16: 219-229.

Morgan, R.P.C. (2009). "Soil erosion and conservation," John Wiley & Sons.

Nash, J.E. and Sutcliffe, J.V. (1970). River flow forecasting through conceptual models part I—A discussion of principles. *Journal of hydrology,* 10: 282-290.

Negm, A.M. and Abu-hashim, M. (2019). Sustainability of Agricultural Environment in Egypt: Part II: Soil-Water-Plant Nexus.

Neitsch, S.L.; Arnold, J.G.; Kiniry, J.R. and Williams, J.R. (2011). "Soil and water assessment tool theoretical documentation version 2009." Texas Water Resources Institute.

Nguyen, H.Q.; Degener, J. and Kappas, M. (2016). Flash flooding predictionin regions of northern Vietnam using the KINEROS2 model. *Hydrology Research,* 47: 1038-1052.

Nicol, A.; Langan, S.; Victor, M. and Gonsalves, J. (2015). "Water-smart agriculture in East Africa," IWMI.

Nyam, Y.; Kotir, J.; Jordaan, A.; Ogundeji, A. and Turton, A. (2020). Drivers of change in sustainable water management and agricultural development in South Africa: a participatory approach. *Sustainable Water Resources Management,* 6: 1-20.

Omran, E.-S.E. and Negm, A.M. (2018). Adaptive management zones of Egyptian coastal lakes. *In* "Egyptian Coastal Lakes and Wetlands: Part I", pp. 37-60. Springer.

Pachauri, R.K.; Allen, M.R.; Barros, V.R.; Broome, J.; Cramer, W.; Christ, R.; Church, J.A.; Clarke, L.; Dahe, Q. and Dasgupta, P. (2014). "Climate change 2014: synthesis report. Contribution of Working Groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change," Ipcc.

Parlange, J.-Y.; Lisle, I.; Braddock, R. and Smith, R. (1982). The three-parameter infiltrationequation. *Soil Science,* 133: 337-341.

Quang, N.H. (2016). Modelling Soil Erosion, Flash Flood Prediction and Evapotranspiration in Northern Vietnam, Ph. D. Thesis, Georg-August Universität Göttingen, Göttingen, Germany.

Rockström, J. and Falkenmark, M. (2015). Agriculture: Increase water harvesting in Africa. *Nature News,* 519: 283.

Safari, A.; De Smedt, F. and Moreda, F. (2012). WetSpa model application in the distributed model intercomparison project (DMIP2). *Journal of Hydrology,* 418: 78-89.

Saran, S.; Sterk, G.; Aggarwal, S. and Dadhwal, V. (2021). Coupling Remote Sensing and GIS with KINEROS2 Model for Spatially Distributed Runoff Modeling in a Himalayan Watershed. *Journal of the Indian Society of Remote Sensing*, 1-19.

Semmens, D.; Goodrich, D.; Unkrich, C.; Smith, R.; Woolhiser, D. and Miller, S. (2008). KINEROS2 and the AGWA modeling framework. Chapter 5: In Hydrological Modelling in Arid and Semi-Arid Areas (H. Wheater, S. Sorooshian, and KD Sharma, Eds.). pp. 49-69. Cambridge University Press ,London.

Sivasankar, S.; Heng, L.K. and Kang, S.-Y. (2020). Agriculture: Improving Crop Production.

Tajbakhsh, S.; Memarian, H.; Sobhani, M. and Aghakhani Afshar, A. (2018). Kinematic runoff and erosion model efficiency assessment for hydrological simulation of semi-arid watersheds. *Global Journal of Environmental Science and Management,* 4: 127-140.

Trincheria, J.; Adhiambi, S.; Bila, S.; Cuamba, B.; Dawit, D.; Leal, W. and Wuta, M. (2016). Fostering the use of rainwater for small-scale irrigation in sub-saharan Africa. AFRHINET.

Williams, J.R. (1975). Sediment-yield prediction with universal equation using runoff energy factor. *Present and prospective technology for predicting sediment yields and sources,* 40: 244-252.

Yang, X.; Liu, Q.; He, Y.; Luo, X. and Zhang, X. (2016). Comparison of daily and sub-daily SWAT models for daily streamflow simulation in the Upper Huai River Basin of China. *Stochastic environmental research and risk assessment,* 30: 959-972.

Yu, D.; Xie, P.; Dong, X.; Hu, X.; Liu, J.; Li ,Y.; Peng, T.; Ma, H.; Wang, K. and Xu, S. (2018). Improvement of the SWAT model for event-based flood simulation on a sub-daily timescale. *Hydrology and Earth System Sciences,* 22: 5001-5019.