

بسم الله الرحمن الرحيم

**DEVELOPMENT OF RAINFALL-RUN OFF *ESTIMATION*
COMPUTER-AIDED MODELS FOR DESIGN OF WATER
HARVESTING IN WADI SYSTEMS: CASE STUDY, WADI ABU
FARGA - GEDAREF AREA - EASTERN SUDAN**

بناء نموذج حاسوبي لتقدير الجريان السطحي للمساعدة في مشاريع تصميم
حصاد المياه من الأودية - حالة وادي أبو فارغة - منطقة القضايف - شرق
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فليُنظر الإنسان إلى طعامه (24) أنا صببنا الماء (23)
صبا (25) ثم شققنا الأرض شقا (26) فأنبتنا فيها حبا
(27) وعنبا وقضبا (28) وزيتونا ونخلا (29) وحدائق
غلبا (30) وفاكهة وأبا (31) متاعا لكم ولأنعامكم (32)
..... عبس

صدق الله العظيم

DEDICATION

The researcher dedicates this effort to his:

Beloved mother. Dear **friend and father ... supportive and dear wife..**
precious and beautiful daughters, sons..
Kind and warm grand mother, grand father, brothers and sisters.

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ABBREVIATIONS

A	Area
A	The drainage area in km ² ;
ABS:	Agricultural Bank of Sudan
AE:	Agricultural Engineering
AMC:	Antecedent Moisture conditions
ARC:	Agricultural Research Corporation
ARS:	Agricultural Research Service
A _w	Available water
BAW:	Bank of Animal Wealth
B _c	Bulk density
BRAC:	Breakeven Risk Aversion Coefficient
Ca	Calcium ion
CA:	Cultivated Area
CBS:	Centre Bank of Sudan
CDF:	Cumulative Distribution Function
CED:	Conservation Engineering Division
CN	Curve number
CN:	Curve Number
DC	Area corrected depth
DR	Design depth
E _c	Electrical conductivity
E _o	Evaporation
FAO:	Food and Agriculture Organization of the United Nations
F _c	Field capacity
M	Rank number
MFC:	Mechanized Farming Corporation
Mg	Magnesium ion
MIWR:	Ministry of Irrigation & Water Resources
MOA :	Ministry of Agricultural
Na	Sodium ion
NPV:	Net Present Value
NRCS:	Natural Resources Conservation Service

P	Probability of occurrence
P	Rain fall
PDF:	Probability Density Function
PH	Hydrogen ion concentration
PWP	Permanent wilting Point
Q	Run off rate
Q_{peak}	The peak discharge in m^3/s
REM:	Runoff Estimation Model
RF:	Rain fall
RFWH	Rain fall water harvesting systems
RFWH	Rain fall water harvesting system
RMSE:	Root mean Square Error
RWH:	Rain Water Harvesting
SAR	Sodium absorption ratio
SCS:	Soil Conservation Services
SD:	Sudanese Dinar (Currency)
SMD:	Soil Moisture Deficit
SP	Sodium percent
SUST:	Sudan University of Science & Technology
T	Return period
TINs:	Triangulated Irregular Networks
TR:	Technical Release
TYESP:	The Three-Year Economic Salvation Program
USDA:	United States Department of Agriculture
WLD:	Wide Level Disk
WMO:	World Meteorological Organization
μ_y	Mean
σ_y	Standard deviation

ABSTRACT

Water is one of the limiting factors to food production and socio-economic development in arid and semi-arid areas. One method to improve livelihoods of farmers in areas of mechanized rain fed agriculture is to adopt water harvesting techniques. Usually , there is in adequate data to design water harvesting projects in engaged wadis. In designing water harvesting or a drainage project, it is essential to quantify the peak runoff rate, for designing the cross-sections of main drainage canals, culverts, and siphons or the capacity of pumping stations. Consequently, this study reviews all constraints hindering design and implementation of water harvesting system with examples. It gives particular attention to determining aspects of hydrological design parameters such as expected rain fall and rain off rates from a watershed. Hence, this study, discusses the rainfall frequency approaches and presents a software package that involves performing a statistical analysis of the recorded rainfall data using different forms of probability of rain fall distributions (Normal, Log-Normal, Weibul, California, Gumbel, Exponential) and then making an estimate for the desired design return period. Using certain rainfall-runoff relationships (Rational method, Curve Number method and Soil Moisture Balance), then this design rainfall is converted into a design runoff; the runoff is thus considered indirectly.

These models were applied to the Abu Farga watersheds in Gedaref State. The effectiveness of the estimation methods for ungauged basins was tested, verified, and validated by comparing the model simulations to observed data using descriptive performance model statistics.

The statistics showed that for small areas use of Rational method is more preferred while for large areas it is advised to use the empirical method and SCS – Curve Number method. It is found that there is uncertainty in hydrologic estimates by the various methods used. It is thus, advisable to produce estimate by more than one method and take the most conservative result.

Application of the procedure in Wadi Abu Farga reveals the possibility of constructing small scale water harvesting reservoir to store water to be used for supplementary irrigation.

Keywords: frequency, analysis, rainfall, distribution, probability, Runoff farming; rain fed farming; water harvesting;

خلاصة البحث

الماء هو احد العوامل التي تحدد الإنتاج الغذائي والتنمية الاجتماعية الاقتصادية في المناطق الجافة وشبه الجافة وانه احد الطرق لتحسين سبل كسب العيش للذين يعيشون في هذه المناطق مثلاً (الزراعة الآلية المطرية) هو تطبيق تقنيات حصاد المياه في الوديان غير المقاس تصرفاتها التي تحد من تصميم وتطبيق نظم حصاد المياه مع توضيح كافه الأمثلة .

وينصب الاهتمام في البحث بشكل خاص علي مقاييس التصميم الهيدرولوجي وذلك علي النحو المتوقع من هطول الأمطار ونسبة انسيابها او جريانها في المساقط المائية .

وعند تصميم حصاد المياه او مشروع الصرف فأنه من الضروري تحديد معدل الحد الاعلي للانسياب وذلك لتصميم الأقسام الأخرى المتقاطعة لقنوات التصريف الرئيسية مثل الجداول والقنوات والسايفونات وقدرة محطات الضخ حيث ان هنالك علاقة بين درجة الحد إلا علي للانسياب وتكرار هطول الأمطار .

وتقدم هذه الدراسة طرقاً مختلفة لتقدير معدلات هطول الأمطار والانسياب وذلك نسبة للموقع الجغرافي للمنطقة ومناقشة تكرار هطول الأمطار كما تستعرض إدخال نظم المعلومات الي التصميم وتحليل بيانات هطول الأمطار وتوزيعها إحصائياً وذلك وفقاً للاحتمالات المختلفة لبيانات هطول الأمطار ومعدلاتها

Normal , Loy normal, Werbut, Gamma, Gumbel,) Exponer or

(pareto,distribotion) ومن ثم إعداد التقديرات المطلوبة للتصميم المطلوب الفترة المحددة وباستخدام احدي العلاقات بين معدل هطول الأمطار ومعدل الانسياب او الجريان وهي الطريقة المنطقية او طريقة المنحي الرقمي او مقياس درجة رطوبة التربة ومن ثم تحويل معدل هطول الأمطار الي تصميم انسيابي وهكذا ينظر إلي الانسياب بشكل غير مباشر .

لقد تم تطبيق هذه النماذج علي المياه الجارية بوادي ابوفارغه بولاية القضارف والنتائج المتحصل عليها من التجارب الفعلية أثبتت فعاليتها طرق التقديرات للأحواض التي لم يتم قياسها وذلك بمقارنة نتائج المرصودة والبيانات الإحصائية للنموذج المطلوب كما إن البيانات الإحصائية أوضحت انه بالنسبة للمساحات المحدودة او الصغيرة من الأراضي فانه الطريقة المنطقية هي الأفضل . وبالنسبة للمساحات الكبيرة فانه ينصح باستخدام المعادلات التجريبية ويفضل استخدام طريقه منحي رقم المنحي.

في المناطق الحضرية ولقد تم التوصل الي انه لايمكن الحصول علي نتائج دقيقه في التقديرات الهيدرولوجيه بطريقه واحده ويفضل الحصول علي التقديرات المطلوبة باستخدام أكثر من طريقه واحدة النتيجة او النتائج الأكثر تحفظاً . والنتائج المتحصل عليها من تطبيق التمازج علي وادي ابوفارغه أكدت إمكانية بناء خزان بحجم صغير لحصاد المياه واستخدامها في منطقة الوادي لعمليات الري الإضافي او التكميلي وتخزينها