DEDICATION

To my parents

To my husband

To my family, sisters and brother

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ABBREVIATIONS AND ACRONYMS

γ	=	Psychometric constant (kPa ºC-1).
Δ	=	Slope of vapour pressure curve (kPa ºC-1).
Abu VI	=	Abu sita
Abu XX	=	Abu Shreen
ADE	=	Assistant Division Engineer
A R C	=	Agricultural Research Corporation
ABS	=	Agricultural Bank of Sudan
BRAC	=	Breakeven Risk Aversion Coefficient
C	=	Cost of irrigation
C Ri	=	Capillary rise from the ground water table on day i
CWR	=	Crop water requirement
C W S I	=	Crop water satis faction index
CDF	=	Cumulative Distribution Function
CWPFM	=	Crop Water Production Function Model
D	=	Root depth.
Dr, i	=	Root zone depletion at the end of day i
Dr, i-1	=	Water content in the root zone at the end of the previous day i-1
Dt	=	Is the time step
DP	=	Dynamic programming
ETa	=	Actual evapotranspiration
ETC	=	evapotranspiration
ETc	=	Adual crop evapotranspiration
ETc	=	Corp evapotranspiration
ETc adj	=	Actual evapotranspiration on day
ETci	=	Corp evapotranspiration on day i
ETi	=	Crop water use at time i
ETm	=	Maximum evapotranspiration
ETo	=	Reference evapotranspiration . mm/day
ea	=	Actual vapour pressure (kPa)
es	=	Saturation vapour pressure (kPa)
es-ea	=	Saturation vapour pressure deficit (kPa)
ET	=	Evapotranspiration.
ETa	=	Actual evapotranspiration.
ETc	=	Crop evapotranspiration. mm/day

FOP	=	Field out let pipes
Fc	=	Field capacity
FOP	=	Field outlet pipes
Fsl	=	Full supply level
F*N	=	The optimal policy decision
FAO	=	Food and Agriculture Organization of the United Nations
fed	=	Feddan; 1 feddan = 0.42 ha
G	=	Soil heat flux density (MJ m^{-2} day^{-1}).
g	=	Sychoment constant
GC	=	Ground water contribution
GDDS	=	Growing Degree Days
Global AEZ	=	Global Agro ecological Zones.
GRS	=	Gunied Research Station.
HRS	=	Hydraulic Research Station
Hawasha	=	Individual Farm size in Gezira Scheme = 5 feddans
I	=	Irrigation
ISM	=	Irrigation Scheduling model
IWR	=	Irrigation requirements
Kc	=	Crop coefficient
KF	=	Crop factor
Ks	=	Is the coefficient of soil water stress
Ks	=	Crop coefficient
Ky	=	Kield Resporiple Foators
Ky (An)	=	Weigh factor which reflect varying crop sensitity to moisture stress at time period
Ky	=	Crop response factor.
In	=	Net irrigation depth in day i
Ii	=	Irrigation at time i
MB	=	Mega byte
MHz	=	Megahertz
MOI	=	Ministry of irrigation
N	=	Number of stage
Nimra	=	Area of 90 Feddans
NPV	=	Net Present Value
NSS	=	Night Storage System
P	=	Depletion factor
P	=	Precipitation
P	=	Cash value

PWP	=	Permanent witting point
PDF	=	Probability Density Function
Q	=	Soil water flux
R	=	Runoff
RAW	=	Readily available Water
RD	=	Root depth
Ri	=	Rainfall at time
Ro	=	Runoff
RAM	=	Randomize Auxiliary Memory
Rn	=	Net radiation at the crop surface (MJ m^{-2} day^{-1}).
SGB	=	Sudan Gezira Boarder
SMD	=	Soil moisture Deficit
Sn	=	Aurrent state of stage n
Sw	=	Soil Water
SWD	=	Soil water deficit at ti
SD	=	Sudanese Dinar (Currency)
SPSS	=	Statistical package for social science
T	=	Mean daily air temperature at 2 m height, (ºC).
T	=	Air temperature
T A M	=	Total available moisture
T.D.R	=	Time Domain Reflect tometry
TYESP	=	Three-Year Economic Salvation Program
U	=	Wind speed at 2 m height
U_2	=	Wind speed at 2m height (ms-1)
WPET	=	Witting point and evapotranspiration
WT-i	=	Initial and final soil water storage in the root zone in on the time step
WUE	=	Water use efficiency
Ya	=	Actual yield
Ym	=	Maximum yield
Yn	=	Decision available for stage n
Yn^x	=	Optimum value of x n
Y_a	=	Actual yield
Zr	=	Root zone depth

ABSTRACT

The northern parts of Sudan face high water scarcity due to aridity and desertification but excess water is often applied to the main irrigated crops. This over-irrigation contributes to aggravate water scarcity problems. Improved water saving irrigation is therefore required, mainly through appropriate irrigation scheduling. Consequently, a two-step (simulation and dynamic programming) approach has been introduced in this study to solve the complex problem of optimal water scheduling for single crop at a farm level operating under flexible water delivery system. The complexity of a real-world situation is represented by incorporating in the optimization model the nature of irrigation water supply and rain fall and the dynamic nature of crop growth. A linear, dated, and additive crop water production function of Doorenbos and Kassam (1979) was incorporated with financial benefits as a useful tool to evaluate alternative irrigation management scenarios. Knowledge of the crop behavior to varying levels of water use through crop growth stages is vital for making rational decisions based on the most economical use of limited water.

The developed irrigation scheduling model consists of a database management interfest, a water balance simulation base and dynamic programming. It performs irrigation scheduling under various management options for single crop in a single field. This single crop model tries to find the best allocation of the available water in time in order to maximize the total expected yield of a given crop. It uses several sub- models that interface with each other and with the dynamic programming (DP) to generate the optimal tradeoff between irrigation levels.

The model is developed under Excel spreadsheet environment and employ mouse-driven approach. It is base on utilizes of a daily water balance approach and uses climatological, crop and soil data as input.

The dynamic programming model (DP) allocates a given amount of water optimally over the different growth stages to maximize the yield per hectare for a given crop, accounting for the sensitivity of the crop growth stages to water stress the model was applied to schedule cotton crop in tayba block of Gezira

The model was verified by testing it against field data and FAO CROPWAT model. The model-predict seasonal number of irrigation water use and total volume of applied water comparison the DP model and CROPWAT gave significant different. Due non consideration of variation of crop water need with various crop growth stage

The developed irrigation scheduling simulation model was explored to simulate improved irrigation scheduling alternatives. Several irrigation strategies were analyzed, including a variety of climatic demand conditions (irrigation at wet and dry periods, at high medium and low crop evapotranspiration rate and at early mid and late sowing dates).

The model was used to study the optimal irrigation scheduling of a cala cotton (Sunni Minor) is located in Tyba block Area in Gezira Scheme.

Data collected included metrological data soil data, crop and agricultural Data and economic data.

The results obtained by the developed model is all mostly typical to the value used in design and for standard practices of Gezira scheme.

The developed model is employed as experimental tool to quantify the impacts of changing the most important model input parameters (crop evapotranspiration, sowing date, and rainfall amounts) affecting irrigation scheduling. This is viewed by many investigators as a test of model sensitivity to variations of its inputs on resulting outputs.

The model was manage to determine amount and timing of irrigation of cotton crop through the growing season and compared with CROPWAT models.

The developed model was found to schedule on farm irrigation and predict cotton yield at different senarious and deficit irrigation water supply satisfactory.

conclusion and recommendation plans were stated for policy making Model results concerning the timing of deficit irrigation and determination of watering calendar may be integrated in extension program to build capacity of users and for the future research the developed model can be adapted in the future for prediction of the yield of other crops especially sorghum in rain fed areas .

ملخص الأطروحة

تواجه الأجزاء الشمالية من السودان ندرة شديدة في المياه نسبة للجفاف والتصحر ولكن كميات هائلة من الماء عادة تطبق على المحاصيل المروية

هذا الري المفرط يساهم في زيادة مشكلة عدم توفر المياه لذا وجب القيام بتحسين سبل حفظ مياه الري خاصة من خلال جدولة الري المثلي . تبعاً لذلك هنالك خطوتان (المحاكاة والبرمجة الديناميكية) تم إدخالها في هذه الدراسة لحل هذه المشكلة المعقدة لجدولة المياه المثلي، لمحصول واحد في مستوى الحقل، تمت العملية تحت نظام تحرير الماء المرن .

التعقيدات الحقيقية في وضع العالم تتمثل في عدم الارتباط بين النموذج الأمثل في مصادر مياه الري ومياه الأمطار وطبيعة الديناميكية للمحصول المزروع.

البيانات الخطية بالإضافة إلي دالة إنتاجية ماء المحصول قد تم دمج المنفعة المالية كأداء لتقييم سيناريوهات الري البديل .

معرفة سلوك المحصول للتغيرات في مستوى الماء المستخدم خلال المراحل المختلفة لنمو المحصول حيوي لعمل قرار منطقي بنى على أغلب الاستخدام الاقتصادي للمياه المحدودة.

نموذج جدولة الري المطور بنى على فترات إدارية ، موازنة المياه قواعد المحاكاة

البرمجة الديناميكية تعمل على جدولة الري تحت رؤى إدارية مختلفة ، لمحصول واحد في حواشه واحده . نموذج المحصول الفردي محاولة لإيجاد التوزيع الأفضل للماء المتاح في الزمن ولزيادة الإنتاجية المتوقعة للمحصول المعطي . تم إستخدام عدة نماذج تحتية تتداخل مع بعضها البعض ومع البرمجة الديناميكية من أجل خلق تسجيل أمثل بين مستويات الري.

تم إنشاء النموذج باستخدام (بيئة إكسل – مستخدمين الفأرة) وقد استخدمت بيانات المناخ والمحصول والتربة كمدخلات وأساس لتعظيم الموازنة المائية .

نموذج البرمجة الديناميكية أعطى كمية الماء المثلى لكافة مراحل النمو وأدى إلى زيادة الإنتاجية بالهكتار للمحصول المعطى مع وضع حساب لحساسية مراحل النمو للعجز المائي وتم تطبيق النموذج لجدولة محصول القطن (من منطقة طيبة بالجزيرة) .

تم اختبار صحة النموذج بواسطة بيانات حقلية وبرنامـج منظمـة الغـذاء والزراعة العالمي وقد تنبأ النموذج بعد الريـات وحجـم المـاء المسـتخدم وتـم مقارنته بنموذج البرمجة الديناميكية وبرنامج منظمة الغذاء والزراعة العالميـة وأعطت النتائج اختلاف نتيجة لعدم أخذ احتياج النبات للماء عند كل مرحلة من مراحل النمو.

نموذج المحاكاة المستحدث لجدولة الري حُدِث لمشابهة بـدائل جدولـة الري المحسنة ثم تحليل عدد من استراتجيات الري حوّت المطـالب المناخيـة المختلفة (الـري فـي فـترة الجفـاف والرطوبـة تحـت اسـتهلاك مـائي عـالي وأوسط وأدنى للمحصول وتاريخ زراعة متقدم وأوسط ومتأخر) .

استخدم النموذج لدراسة جدولة الري لمحصول القطـن بمنطقـة طيبـة بالجزيرة. وقد تم تجميع البنيات المناخيـة وبيانـات التربـة وبيانـات المحصـول وبيانات اقتصادية . النتائج المعطاة بالنموذج مطابقة لنتائج النمـوذج القياسـي المتبع بالجزيرة.

اسـتخدم النمـوذج أدوات حقيقـة لحسـاب الأثـر الفعلـي لتغيـر معظـم المقـاييس المدخلـة (الاسـتهلاك المـائي للمحصـول – تاريـخ الزراعـة وكميـة الأمطار) وهذه موجهات لعدد من المحققين الذين اختبروا حساسـية النمـوذج وتأثير تغيير مدخلات البرامج علي المخرجات

النموذج موجه لتحديد كمية المياه وزمن الـري لمحصـول القطـن خلال فترات النمو السنوي مقارنة مع برنامج (CROPWAT) .

وقد وجـد البرنامـج الجدولـة الحقيقـة للـري وتنبـأ بالإنتاجيـة لمحصـول القطن لسيناريوهات مختلفة وعجز الماء وإمداد الماء الكافي .

في الخلاصة والتوصيات ذكرت الخطط المصـنوعة لإنتاجيـة المحاصـيل من خلال تحسين إدارة الموارد القومية المتاحة .