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A Computer System Development for Rainfall Analysis and Crop Selection

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Abstract:- The main objective of this study was to develop a computer system to act as a tool for rainfall analysis and crop selection in dry land farming areas. The system was prepared using MS-Excel and Visual Basic computer soft-wares. Annual rainfall totals were collected from Sudan Meteorological Authority for different stations, for a period of 33 years. The system calculates the probability P (%) of occurrence or execedance for each rain observations and inversely predicts the magnitude of the rain according to any probability level. Then according to the planned probability determines the crops that can be grown based on their water requirements. The verification and validation showed high levels of accuracy in prediction. The comparison between the actual and predicted rainfall gave a high correlation coefficient (R2 = 0.87).The sensitivity analysis of the units showed that different input variables can affect the output results. The system was applied for Gedarif (Sudan) by using annual rain amount for the years from 1977 to 2009. It was found that rain amount at 20%, 50% and 80% probability were 638, 526 and 480 mm, respectively. These rain amounts are enough water to grow sorghum, and sesame, while sunflower can only be grown under 20% and 50% probabilities. Therefore the system can be used for pre-season management and decision–making with great confidence.

I. INTRODUCTION

Climatic factors, especially rainfall, have direct and indirect effect on machinery management through its affect on the scale, type and total agricultural production. It also determines the length of the growing season and the crops that can be grown as well as the available days for machinery field work.

Rainfall is the main factor governs the productivity of semi-arid regions. It affects the yields of crops because each crop has certain water requirements during its growth. However, rainfall naturally fluctuates from season to season and within the same season. Good rain distribution means crop plant will not suffer from dry periods during its growth, and this implies good crop yields. Good rain distribution may also means greater number of rainy days, and this in turn affects the time available for the execution of field operations.

Because of the complex nature of rainfall, it is difficult to predict the occurrence of rainfall in advance. Therefore, the crop production planners and field managers in dry land farming areas need to select the appropriate proposed (anticipate) rainfall probability according to which the type of crops and their required operations can be determined. Adam and Abdalla (2007) defined the dependable (propose) rainfall as the total amount of rains during the cropping season at or above which may be occurred (received) at the cropped area. The anticipated rainfall is determined via long term records on annual rainfall and it usually assigned a certain probability of occurrence or execedance.

Rainfall values are usually analyzed by statistical measures to provide information to satisfy the requirement of the users; these measures include the annual mean, variability, probability, and confidence levels (Adam and Abdalla, 2007). Subbulakshmi, *et al.,* (2005) used probability analysis to find out the amount of anticipated rainfall at different probability levels (50% and 75% probability). Rappold (2005) conducted a statistical rainfall analysis to detect the probability of rainfall exceedance during the vegetation period. A lot of research works were conducted elsewhere to analyze rainfall data, by different statistical methods and for different purposes (Abdullah and Al-Mazroui, 1998; Odekunle, 2005; Bhakar, *et al.*, 2006; Walker, 2007; Taschetto and Matthew, 2008). Islam and Kumar (2003) developed computer program (HYDRO) for the analysis of rainfall data.

The mechanized rainfed agriculture in Gedarif state is divided in to three sub ecological zones according to rainfall. The variations in rain amount in these areas make variations in the start and the end of field operations as well as choice of the crops and the cropping system. Management of a rainfed farm is a complex process. The complexity is due to the nature of various and interrelated factors involve in crop production process. These factors include; selection of crops, field operation and agricultural machinery (tractors &implements); the expected available time for field operation, inputs cost and outputs prices. It was believed that promotion of farm management can be realized by the use of modern aids like computer systems which facilitate the process of planning and decision making.

II. MATERIALS AND METHODS

Characteristics of the study area

The study was conducted in Gedarif State, which lies in the Eastern part of the Sudan between latitudes 12.67º and 15.75º N and longitudes 33.57 º and 37.0º E, where about more than 3 million ha are put under mechanized rainfed agriculture annually. The State stretches from north to south over three climatic zones with high summer temperature and worm winters. Rainfall is always in summer and most of effective rainfall occurs during June to October and reaches it's the peak in July- August. The soil is heavy cracking clay soils (Vertisols), with 65% to 75% clay content.

III. DATA COLLECTION AND ANALYSIS

Annual rainfall-recorded data were collected from Sudan Metrological Authority (SMA) for different Stations, for period of 33 years (1977-2009). The annual water requirements for cotton, sunflower, sesame and sorghum crops were taken as 650, 500, 450 and 450 mm, respectively.

Statistical measures employing mean, standard deviation, maximum and minimum, correlation analysis were used as data analysis tools. Also, T-test was used to compare and test the significant between the unit predicted and actual data.

IV. SYSTEM DEVELOPMENT AND DESCRIPTION

A computer system was developed as a tool for pre-season decision-aid. The system estimates the amount of rainfall on probability base and accordingly predicts the possible crops that can be grown. The system was developed in Excel and Visual basic computer soft-wares. Input data include; the location of studied area, first year of rain events, number of years and annual rain totals. The system is designed to work for years from 7 to 100 years. Then the system ranks the annual rainfall totals, in a descending order and gives each rain event a rank number. After that the system calculates the probability P (%) of occurrence or execedance for each of the ranked rain observations according to the equation of Blom (1958) cited by Will and Klaus (1991).

$$P (\%) = (m - 0.375)*100 / (N + 0.25)$$

Where: P = probability in % of the observation of the rank m

m = the rank of the observation

N = total number of observations used

Inversely, the system also estimates the magnitude of the rain corresponding to a given probability according to the following equation.

$$Y = 10^{\{a + (\log(X)) \times b\}}$$

Where:

Y = predicted rainfall amount

X = probability

a = constant

b = coefficient

When comparing the annual water requirements for each crop with the planned (designed) rainfall probability and its corresponding predicted rain amount the unit predicts the possible crops to be grown, such as sorghum, sesame, sunflower and/or cotton. The system output can be displayed on the screen or print out. The system flow chart is shown in Fig. 1.

V. RESULTS AND DISCUSSION:

System verification

A computer unit was developed to analysis annual rainfall data, estimate rain amount corresponding a certain proposed probability and accordingly determine the crops that can be grown. For the verification of the unit long-term annual rainfall records from Mogadishu, Somalia, (1957 to 1988) were used (Table1). It was observed that when the user enters the required input data the unit immediately computes the probability for each rainfall event and estimates their corresponding rain amount.

The correlation analysis between the predicted and actual rainfall amount gave a correlation coefficient of (0.92). This proves that the unit is able to estimate the annual rainfall amount with a high level of accuracy.

VI. SYSTEM VALIDATION

The ability of the developed unit to predict annual rainfall according to a probability of occurrence was tested against RANBOW, a software system for frequency analysis and probability plotting of hydrological data, which developed by Faculty of Agricultural and Applied Biological Sciences, Department of Land management. Annual rainfall data from Damazin and Kadugli metrological stations for the years from 1977 to 2009 were entered in the system and RAINBOW. The predicted rain amounts according to probabilities ranging from 10 to 90%, at 10% interval were obtained (Table2). The correlation analysis between the unit prediction and RAINBOW prediction gave a correlation coefficient (R^2) of 0.96 and 0.97 for Damazin and Kadugli, respectively.

Also, T-test for comparison between unit and RAINBOW showed no significant differences (P = 0.01) between the predicted rain amounts for both locations (Table3). These prove that the unit is able to estimate rain amount according to corresponding probability with a high level of accuracy.

VII. SYSTEM SENSITIVITY ANALYSIS

Since the concept of sensitivity analysis is based on changing input data, the only two variables that can be changed in this system are rainfall amount and number of rainfall event. So rainfall data from Kadugli metrological station for 33 years (1977 to 2009) were altered at 15%, 30% and 45% at increasing and decreasing rates also, the number of rain event was changed at 6 years interval starting at nine years and ending at 33 years. The resulting figures from each procedure were entered independently in the system to study the effect of changing rain amount and number of rain events on unit prediction. The predicted rain amounts were taken at five levels of probability; 10%, 20%, 50%, 80% and 90%. The results showed that changing rain amount from 45% to -45% from annual rainfall changed the predicted rain by about 776.7, 678.5, 567.7, 518.0 and 505.6 mm for probability levels of 10%, 20%, 50%, 80% and 90%, respectively (Table4). Also, increasing number of rainfall events from 9 to 33 resulted in decreasing the predicted rain amount by 19.5, 1.6, - 15.1, -21.5 and -22.8 mm for probability levels of 10%, 20%, 50%, 80% and 90%, respectively (Table5).

Furthermore, another method was employed to test the sensitivity of the unit in term of changing rain amount input data. In this method, the annual rainfall data for 33 years from Damazin was increased and decreased at a constant rate (10%), from 10% to 40%, and the resulting figures were used as input data. The average changes in input and output data were obtained by the following formula:

$ACID = (I_{i1} – I_{i2})/ [(I_{i1}+I_{i2})/2]$

$ACOD = (O_{j1} – O_{j2})/ [(O_{j1}+O_{j2})/2]$

Where:

ACID = average change in input data

I = average input rainfall amount for all years

i = increase or decrease rate of input rain amount

1&2 = indicates to each two pair of rain amount, e.g., +10% and -10%

ACOD = average change in output data

O = average output rainfall amount for all years

j = increase or decrease rate of output rain amount

The results showed that the ACID and ACOD were completely identical as illustrated in Figure1. These results means that changes in the system output are followed changes in the input and this ensures and proves the sensitivity of the system. It can be said that the system could be used to predict the rain amount everywhere with great confidence.

VIII. SYSTEM APPLICATION

The system was applied in Gedarif mechanized rain fed agriculture to estimate rain amount at three levels of probabilities and accordingly determine the crops that can be grown. The results of rainfall analysis from Gedarif Metrological Station, during the period from 1977 to 2009, revealed that the expected annual rain amount at 20% (wet season), 50% (normal season) and 80% (dry season) probabilities were 638, 526 and 480 mm, respectively (Table6). The three predicted annual rain amounts represent enough water to meet the requirements of sorghum, and sesame crops, while sunflower can only grown on wet or normal seasons as shown in Table6. These results indicate that the system was well designed and built to achieve the objective of the study. Therefore, the system can help farm managers and planners to choose types of crops that can be grown, and this leads to pre-season management and schedule of farm operations.

IX. CONCLUSIONS

A computer system for rainfall analysis and crop selection was developed. It is user-friendly and could be run on most available computers. The units was validated and statistically analyzed and it is accuracy was proved. The computer system can be employed as a pre-seasonal planning tool to predict the rain amount that will be received in any location according to anticipated probability where enough and dependable rainfall data are in hand and hence determining the possible crop that can be grown according their water requirements. The system can be improved in the future considering the crops yield according to the predicted rain amount and management practices.

REFERENCES

[1]. Adam, Hussein S. and Abdalla, Haroun A. (2007). Meteorology and Climatology. NUESCO Chair of desertification University of Khartoum, Khartoum University press, Khartoum, Sudan.

[2]. Abdullah, M. A. and M. A. Al-Mazroui (1998). Climatological study of the southwestern region of Saudi Arabia. I. Rainfall analysis. Clim. Res. Vol. 9: 213-223.

[3]. Bhakar, S. R., Anil Kumar Bansal, Neeraj Chhajed and R. C. Purohit (2006). Frequency Analysis of Consecutive Days Maximum Rainfall at BANSWARA, RAJASTHAN, INDIA. ARPN (Asian Research Publishing Network) Journal of Engineering and Applied Sciences. VOL.1 (3):64-67.

[4]. Blom, G. (1958), Statistical estimates and transformed beta variables, John Wiley and Sons, New York.

[5]. Islam, A. and A. Kumar (2003). HYDRO : A Program for Frequency Analysis of Rainfall Data. IE(1) Journal-AR. Vol. 84.

[6]. Odekunle, T.O. (2005). Rainfall and the Length of the rowing Season in Nigeria. AIACC Working Paper No. 9 (Abstract Only) June 2005.An electronic publication of the AIACC project available form www.aiaccproject.org

[7]. Rappold, Gerhard D. (2005). Precipitation analysis and agricultural water availability in the Southern Highlands of Yemen. *Hydrol. Process.* **19**, 2437–2449. Published online in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/hyp.5894

[8]. Subbulakshmi, S.; R. Selvaraju and S. Manicka Sundaram (2005). Rainfall probability analysis for crop planning in selected locations of Tamil Nadu. Madras Agric. J. 92 (1-3): 76-83.

[9]. Taschetto, Andr´ea S. and Matthew H. England (2008). An analysis of late twentieth century trends in Australian rainfall. INTERNATIONAL JOURNAL OF CLIMATOLOGY. *Int. J. Climatol.* Published online in Wiley InterScience (www.interscience.wiley.com) DOI: 10.1002/joc.1736.

[10]. Walker, Bruce F. (2007). Rainfall Data Analysis at Newport and the Relationship to Land sliding in Pittwater. Australian Geomechanics. Vol. 42 (1): 197- 212.

[11]. Will Critchley and Klaus Seigert (1991). Water harvesting. Food and Agriculture Organization of the United Nations. AGL/MISC/17/91, Rome, pp. 1- 133.

Table1. Probability and amount of rainfall in Mogadishu, Somalia, (1957 to 1988)

Rank	Years	Actual Rain (mm)	Probability (%)	Estimated Rain (mm)
1	1961	960	1.90	1323
2	1967	890	5.00	924
3	1968	680	8.10	773
4	1977	660	11.20	686
5	1972	655	14.30	626
6	1963	633	17.40	582
7	1979	594	20.50	548
8	1981	563	23.60	520
9	1980	544	26.70	497
10	1987	533	29.80	477
11	1988	531	32.90	460
12	1958	529	36.00	445
13	1982	526	39.10	431
14	1965	498	42.20	419
15	1964	489	45.30	408
16	1957	484	48.40	398
17	1962	453	51.60	389
18	1985	423	54.7	381
19	1975	411	57.8	373
20	1960	403	60.9	366
21	1966	395	64	359
22	1973	371	67.1	353
23	1976	339	70.2	347
24	1969	317	73.3	341
25	1959	302	76.4	336
26	1970	300	79.5	331
27	1983	273	82.6	327
28	1971	271	85.7	322
29	1984	270	88.8	318
30	1974	255	91.9	314
31	1986	251	95	310
32	1978	216	98.1	306

Table2. Validation of rainfall analysis unit with RAINBOW system

Probability level, %	Damazin		Kadugli	
	Unit	RAINBOW	Unit	RAINBOW
10	849.5	861.2	862.9	873.4
20	755.0	796.7	754.0	799.8
30	704.6	753.1	696.7	750.7
40	670.9	717.8	658.8	711.1
50	645.9	686.4	630.7	676.0
60	626.2	656.3	608.7	642.7
70	610.0	625.3	590.7	608.8
80	596.3	591.4	575.6	571.4
90	584.4	547.0	562.5	523.3
R^2	0.96		0.97	

Table3. T-test for the mean difference of predicted rain amount by the unit and RAINBOW for Damazin and Kadugli

Statistical Parameters	Damazin	Kadugli
Variance of the difference between the means	90.474	107.449
Standard deviation of the difference	9.5118	10.3658
Effective degree of freedom	8	8
Probability of t	0.0545	0.0488
f-calculated	1.3591	1.3162
T-calculated	-2.2510	-2.3217
T-tabulated	3.355	3.355

Table4 Effect of changing annual rainfall on predicted rain amount at different probability level

Change	Probability levels %				
	10	20	50	80	90
+ 45 %	1251.3	1093.2	914.6	834.6	815.0
+ 30 %	1121.8	980.2	820.0	748.2	731.3
+ 15 %	992.4	867.1	725.3	661.9	646.9
Annual	862.9	754.0	630.7	575.6	562.5
- 15 %	733.5	640.9	536.1	489.2	478.1
- 30 %	604.1	527.8	441.5	402.9	393.8
- 45 %	474.6	414.7	346.9	316.6	309.4

Table5. Effect of changing number of rain events on predicted rain amount at different probability levels

Years	Duration	Probability levels %				
		10	20	50	80	90
9	1977- 1985	882.4	755.6	615.6	554.1	539.7
15	1977 – 1991	841.2	732.8	610.6	556.1	543.2
21	1977- 1997	875.6	753.0	616.8	556.8	542.7
27	1977- 2003	883.2	763.4	629.6	570.3	556.4
33	1977 – 2009	862.9	754.0	630.7	575.6	562.5

Table6. Possible crops to be grown under different probabilities and rain amount in Gedarif rainfed area

Designed rainfall probability	Expected rain amount, mm	Possible grown crops
20% (wet season)	640.4	Sorghum + Sesame + sunflower
50% (normal season)	529.2	Sorghum + Sesame + sunflower
80% (dry season)	479.9	Sorghum + Sesame

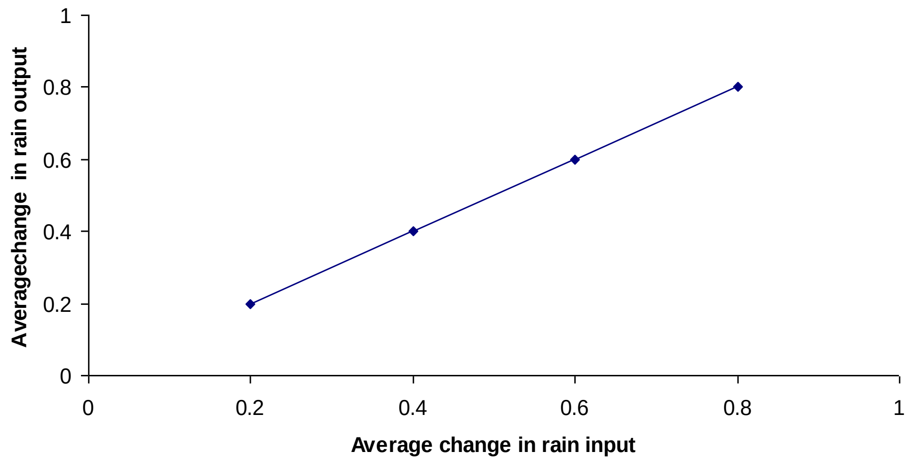

Fig.4.1. Effect of changing input rain amount on module output

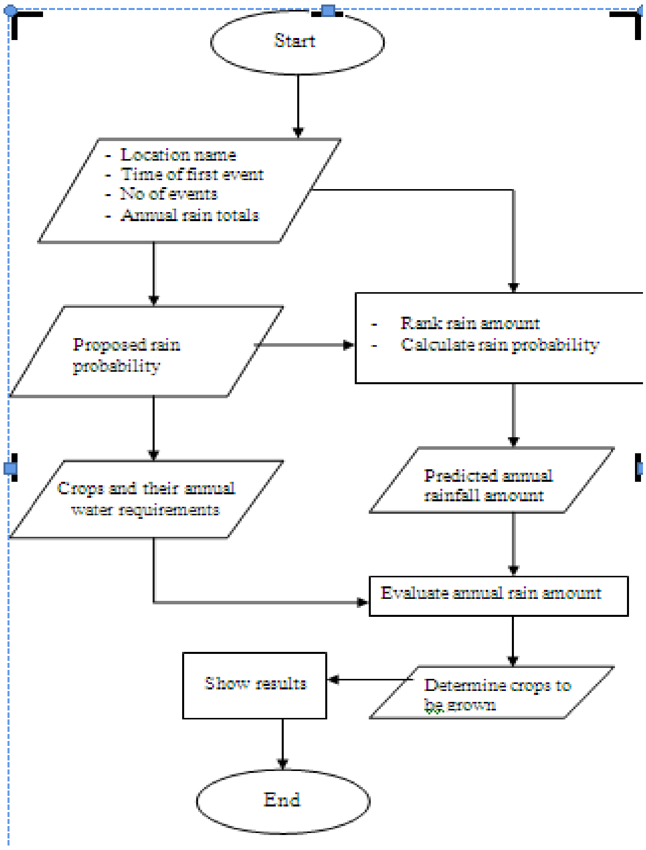

Fig.1. Rainfall analysis for crop selection unit flow chart