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Irrigated Areas Discharge and Sediment Interaction Case Study Roseires Dam

Nabela Hamed Elamein *1, Abbas Abd Alla1, Gassan Khalid2

*1Department of Water Resource Engineering, Sudan University of Science and Technology, Khartoum, Khartoum, Sudan
*1Department of Water Resource Engineering, Sudan University of Science and Technology, Khartoum, Khartoum, Sudan
2Civil Engineering, Yarmouk College, Khartoum, Khartoum, Sudan

ABSTRACT

Dams and reservoirs are constructed in rivers for multipurpose. Irrigation is always predominant. Irrigated agriculture in Sudan produces about 50 % of the total crop production. There is always painstaking in removing sediments from the irrigation network system. The objective of this study is to assess the relations among sediment irrigated areas and discharge in Roseires Dam Reservoir. Dimensional analysis and SPSS models, in both simple and multiple correlations were conducted. The simple correlation gave acceptable results with high correlation coefficients. Complete set of dimensionless groups were obtained in the multiple regression correlation. Examination of the results indicated good correlation with acceptable error.
Keywords : irrigation network, agricultural schemes, Buckingham pi theorem, SPSS

I. INTRODUCTION

Dams and reservoirs are constructed in rivers for flood control, hydropower generation, irrigation, navigation, water supply, fishing and recreation. Irrigation dams are predominant. Sedimentation is one of the major problems, which endangers the performance, and sustainability of reservoirs.

Alarming rates of storage depletion have been reported worldwide and especially in drought prone areas. Mean yearly losses of 0.3% to 1.3% were reported in USA, 0.7 % to 1.5% in Turkey (Bechteler 1997), 1.67% in Sudan and 1% worldwide (Mahmood 1987).

Agriculture is the most significant element in Sudanese economy. Most of the important crops such as cotton, wheat, sorghum, and groundnut are produced by irrigation. Irrigated agriculture produces about 50 % of the total crop production. In the year 1990, due to siltation and reduced water availability, the Gezira scheme (760 000 ha), was dropped to 57% as 326800 ha were taken out of production (FAO report 1995a).

Depending on the annual sediment yield, quantities ranging from 10 to 20 million m3 of sediment were removed from the irrigation canals before the beginning of the coming season (Adam, A.M. 1997). In brief, the rate and magnitude of sedimentation in the new reservoirs and its impact on surface water management was received as a shock (Tan. Soon-Keat, Guoliang2005). This impact has manifested in progressive reduction in the irrigated areas of main crops The prevailing problems affecting Roseires Dam are several. They are mainly: Upstream downstream sediment transportation, diminishing downstream releases associated with decreasing and fluctuating cultivated areas.

The main objective is to assess the impact of sediment on irrigation water and optimization of use and consumption of water for irrigation. Specific objectives: Indication of interaction among discharge sediment and cultivated areas. Suggest some recommendations to measures that can be taken to reduce the amount of deposited sediment.

II. METHODS AND MATERIAL

A. Area of Study

The area of study is located in the Roseires Dam 550 km south of Khartoum and 110 km from the Sudanese Ethiopian border. The storage capacity of Roseires Dam reservoir is 3.3 milliards ($3.3 \times 10^9 m^3$) at 481 R.L. in 1966.In 2007 it was found that about 42.3% of its storage capacity was Lost. Figure (1), shows the Sudan boundaries and Roseires Dam geographical location. Figure (2), shows detailed boundaries in the vicinity of Roseires Dam. An overview of the area of study reveals that the Nile Basin encompasses 11 riparian countries: Burandi, Democratic Republic of Congo, Ethiopia, Kenia, Rowanda,Tanzania and Ughanda in the upstream (7), Sudan, Eritrea South Sudan in mid-stream (3). Egypt is most downstream country.

The results of this study will help in understanding the situation of river system and the impact of sediment on irrigation water. It will help in planning better way of thinking for decision makers and clear management lines.

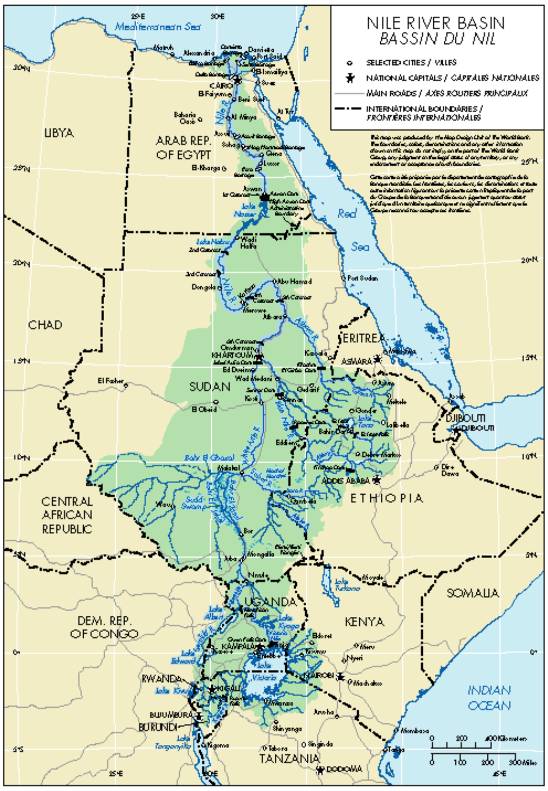

Figure 1. Sudan Boundaries and Roseires Dam Geographical Location

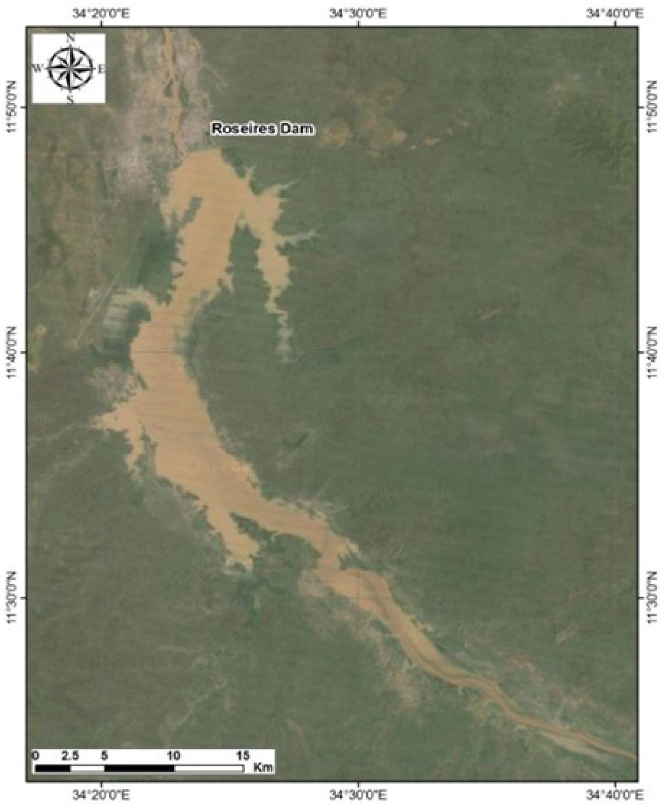

Figure 2. Detailed Boundaries in the Vicinity of Roseires Dam Reservoir

B. Methodology

The methodology is the road map including materials and equipments used to analyse the problems. The prevailing problems are mainly intakes reduced hydropower. Sediment transportation, and decreasing cultivated areas, as well as complexity in operation and river bank erosion are other main problems.

Analysis of the problems clarified and paved the road to the objectives fulfillment. The objectives are mainly assessment of the impact of sediment on irrigation water and optimization of use and consumption of water for irrigation. It determined impact of the Reservoir operation on the schemes of the Gezira, Suki, Rahad, and North West Sennar Sugar Factory areas. The road map necessarily included both desk and filed studies including laboratory works and investigations. Review of previous researchers covering both the problems and the objective was conducted.The main researchers were Sayed Mahgoub 2013 who indicated that enhanced sediment distribution at the vicinity of power plant intakes using double rows of vanes and groins as a case study, new Tebbin power plant was very effective.Abdel Fattah (2004) studied the river morphological changes.

He used two dimensional (2-D) numerical models and investigated sediment distribution at El-Kurimat thermal power plant intake. He revealed that using groins and dredging upstream intake increased the flow ratio in front of intake and diverts sediment away off it.Other reviewers were AbdelHaleem (2008) Hassanpour and Ayoubzadeh (2008), Yasir (2014) and (15) Ageel I. Bushara. Aggradation degradation and scour:- was reviewed by the researchers *Black, Richard (2009-09-21)* ,and Hydraulic Engineering Circular No. 18 Manual (HEC-18) was published by the Federal Highway Administration (FHWA).The Assessment of Sediment Impact and Optimized Consumption of Irrigation Water : was reviewed by Islam Al Zayed1et.al and Yasir(2013). Rouseires Dam Operation And Maintenance Difficulties was reviewed by the consultant Sir Alexander Gibb & Partners who proposed a manual 1973.Other reviewers are UNESCO Chair in Water Resources, 2011). Dam Implementation Unit, 2012).The main parameters reviewed were the river discharge and the bathometric surveying.

C. Data Collection and Analysis

River engineering constructions are very expensive. At the first stage of design, resort must be made to theoretical approaches. If the whole design or part of it can not be predicted by theory, it is accordingly advisable to study the performance of the whole or part of the prototype by means of a hydraulic model.

Generally, hydraulic models are of two types. Those designed to solve a special hydraulic Those designed to solve a special hydraulic problem as for example a definite reach of a known river, and those designed for research for establishing hydraulic laws applicable to special problems within the field of river engineering. The first type produces qualitative results only applicable to known prototype river, while the second type produces quantitative results applicable to any prototype involving the same special problem with the same hydraulic laws. Unfortunately, the former cannot be applied, because a large hydraulic laboratory is needed which is not available. Similarly, the latter cannot be applied because of lack of sophisticated equipments usually needed in such case. However simple conceptual mathematical models using the standing computers strong SPSS techniques can be applied.

In this study, using this technique the details of SPSS Models facilities and analysis procedures are applied. A complete set of data on hydrological and morphological aspects events results are analysed and presented in the form of graphs and tables. Simple correlation is presented in table (1).

Table No.(1): Simple Correlation Among Power Sediment and Water Requirements

Correlation	High Coefficient	Low Coefficient
Discharge Power	0.9663,	0.0936
Discharge Sediment	0.80016	0.695
Discharge water Requirement	0.606	0.323

Using Dimensional Analysis, a property (A) , of any phenomenon can be expressed in terms of all or some of the (n), characteristic parameters of the phenomenon, in a functional relation of the form:-

$$A = \int_A (x_1, x_2, x_3 .....x_n) \text{-------} (1)$$

According to Backingham π theorem, the (n) dimensional parameters will have a general equation expressed as a function of (n-m) dimensionless π terms parameter as given in the matrix form table (2).

Table No. (2): Matrix Form of Dimensional Parameters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	B	A	V	D	d_s	g	ρ	μ	Q	P	d_{50}	Q_s	γ_s	τ	W_s
M	0	0	0	0	0	0	1	1	0	1	0	1	1	1	0
L	1	2	1	1	1	1	-3	-1	3	2	1	1	-2	-1	1
T	0	0	-1	0	0	-2	0	-1	-1	-3	0	-3	-2	-2	-1

The above matrix is (3x15) matrix of rank(3).The number of the dimensionless groups is the number of the parameters(n), minus the rank of the matrix (r=3). The number of the dimensionless π terms is

$$(15 - 3 = 12)$$

Choozing $\gamma_s, \tau, and\ W_s$ as the selected determinant its value is calculated as follows as given in table (3),of the determinant taken from the matrix form of table (2).

Table No. (3): Determinant Taken From The Matrix Table (2).

1	1	0
-2	-1	1
-2	-2	-1

$$\Delta = 1\times\left[(-1\times-1)-(-2\times1)\right] = 1\times\left[(1)-(-2)\right] = 3$$

Again choosing $\gamma_s, \tau, and\ W_s$ as the repeating variables, and. solving for their coefficients $(k_{13}, k_{14}, and\ k_{15})$ in terms of the other $ks(k_1\ to\ \mathrm{k}_{12})$

Gave the solution

$$K_{13} = K_1 + 2K_2 + K_4 + K_5 - K_6 + K_8 + 2K_9 + 2K_{10} + K_{11} + K_{12}$$

$$k_{14} = -k_1 - 2k_2 - k_4 - k_5 + k_6 - k_7 - 2k_8 - 2k_9 - 3k_{10} - k_{11} - 2k_{12}$$

$$k_{15} = -k_3 - 2k_6 + 2k_7 + k_8 - k_9 - k_{10} - k_{12}$$

Substituting these values in the matrix give the solution in table (4).

Hence as shown in table (4) ,the twelve (12), dimensionless groups are calculated as given below

$$\pi_1 = \frac{B\ \gamma_s}{\tau} \quad \pi_2 = \frac{A\ \gamma_s^2}{\tau^2} \quad \pi_3 = \frac{V}{W_s} \quad \pi_4 = \frac{D\ \gamma_s}{\tau}$$

$$\pi_5 = \frac{\mathrm{d_s}\gamma_s}{\tau} \quad \pi_6 = \frac{\mathrm{g}\tau}{\gamma_s \mathrm{W_s^2}} \quad \pi_7 = \frac{\rho W_s^2}{\tau} \quad \pi_8 = \frac{\mu\gamma_s}{\tau^2}\mathrm{W_s}$$

$$\pi_9 = \frac{\mathrm{Q}\ \gamma_s^2}{\tau^2 W_s} \quad \pi_{10} = \frac{\mathrm{P}\ \gamma_s^2}{\tau^3 \mathrm{W_s}} \quad \pi_{11} = \frac{d_{50}\gamma_s}{\tau} \quad \pi_{12} = \frac{Q_s\gamma_s}{\tau^2 \mathrm{W_s}}$$

The total number of the the dimensionless groups will be fourteen (14)

$$\pi_{13} = i \qquad \pi_{14} = \sigma$$

These equations can be put in the form

$$\pi_0 = \int_A \left(\frac{B\gamma_s}{\tau}, \frac{A\ \gamma_s^2}{\tau^2}, \frac{V}{W_s}, \frac{D\gamma_s}{\tau}, \frac{d_s\gamma_s}{\tau}, \frac{g\tau}{\gamma_s W_s^2}, \frac{\rho W_s^2}{\tau}, \frac{\mu\gamma_s W_s}{\tau^2}, \frac{Q\gamma_s^2}{\tau^2 W_s}, \frac{P\gamma_s^2}{\tau^3 W_s}, \frac{d_{50}\gamma_s}{\tau}, \frac{Q_s\gamma_s}{\tau^2 W_s}, i, \sigma \right) ---(2)$$

The resulting equation is the equation developed by the researcher in order to be able to solve the problems of the study and fulfill the objectives as well.

Table No. (4): Dimensionless π Parameters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	B	A	V	D	d_s	g	ρ	μ	Q	P	d_{50}	Q_s	γ_s	τ	W_s
π_1	1	0	0	0	0	0	0	0	0	0	0	0	1	-1	0
π_2	0	1	0	0	0	0	0	0	0	0	0	0	2	-2	0
π_3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	-1
π_4	0	0	0	1	0	0	0	0	0	0	0	0	1	-1	0
π_5	0	0	0	0	1	0	0	0	0	0	0	0	1	-1	0
π_6	0	0	0	0	0	1	0	0	0	0	0	0	-1	1	-2
π_7	0	0	0	0	0	0	1	0	0	0	0	0	0	-1	2
π_8	0	0	0	0	0	0	0	1	0	0	0	0	1	-2	1
π_9	0	0	0	0	0	0	0	0	1	0	0	0	2	-2	-1

π_{10}	0	0	0	0	0	0	0	0	0	1	0	0	2	-3	-1
π_{11}	0	0	0	0	0	0	0	0	0	0	1	0	1	-1	0
π_{12}	0	0	0	0	0	0	0	0	0	0	0	1	1	-2	-1

$$\frac{Q\gamma_s^2}{\tau^2 W_s}, = \int\left(\frac{P\gamma_s^2}{\tau^3 W_s}, \frac{Q_s\gamma_s}{\tau^2 W_s}, \frac{A\,\gamma_s^2}{\tau^2}\right) ---(3)$$

$$\frac{A\,\gamma_s^2}{\tau^2} = \int\left(\frac{P\gamma_s^2}{\tau^3 W_s}, \frac{Q_s\gamma_s}{\tau^2 W_s}, \frac{Q\gamma_s^2}{\tau^2 W_s}\right) ---(4)$$

$$\frac{P\gamma_s^2}{\tau^3 W_s} = \int\left(, \frac{Q_s\gamma_s}{\tau^2 W_s}, \frac{A\,\gamma_s^2}{\tau^2}, \frac{Q\gamma_s^2}{\tau^2 W_s}\right) ---(5)$$

$$\frac{Q_s\gamma_s}{\tau^2 W_s} = \int\left(\frac{P\gamma_s^2}{\tau^3 W_s}, \frac{Q\gamma_s^2}{\tau^2 W_s}, \frac{A\,\gamma_s^2}{\tau^2}\right) ---(6) \quad \frac{Q\gamma_s^2}{\tau^2 W_s}, = \int\left(\frac{P\gamma_s^2}{\tau^3 W_s}, \frac{Q_s\gamma_s}{\tau^2 W_s}, \frac{A\,\gamma_s^2}{\tau^2}\right) ---(3)$$

$$\frac{A\,\gamma_s^2}{\tau^2} = \int\left(\frac{P\gamma_s^2}{\tau^3 W_s}, \frac{Q_s\gamma_s}{\tau^2 W_s}, \frac{Q\gamma_s^2}{\tau^2 W_s}\right) ---(4)$$

$$\frac{P\gamma_s^2}{\tau^3 W_s} = \int\left(, \frac{Q_s\gamma_s}{\tau^2 W_s}, \frac{A\,\gamma_s^2}{\tau^2}, \frac{Q\gamma_s^2}{\tau^2 W_s}\right) ---(5)$$

$$\frac{Q_s\gamma_s}{\tau^2 W_s} = \int\left(\frac{P\gamma_s^2}{\tau^3 W_s}, \frac{Q\gamma_s^2}{\tau^2 W_s}, \frac{A\,\gamma_s^2}{\tau^2}\right) ---(6)$$

It is always desirable to reveal how closely two sets of dimensionless groups are associated. This can be tackled by ranking one of the dimensionless groups in increasing or decreasing order of magnitude and note the corresponding order of the other. $r_{xy} = \left(\frac{Cov(x,y)}{\sqrt{Var(x)Var(y)}}\right) = \frac{S_{xy}}{\sqrt{S_{xx}}\sqrt{S_{yy}}} = \frac{\sum_1^n (x-\bar{x})(y-\bar{y})}{\sqrt{\sum(x-\bar{x})^2 \sum(y-\bar{y})^2}} ---(7)$

Where:-

$\mathrm{var}(x), \mathrm{var}(y) =$ The mean variance of x and y.

$\{\mathrm{var}(x)\}^{\frac{1}{2}} \{\mathrm{var}(y)\}^{\frac{1}{2}} =$ The standard deviations of x and y.

$\mathrm{cov}(x,y) = \textit{Coveriance}$ of $(\mathrm{x,y}) =$ Measure of extend to which x and y

The numerical value of the linear correlation coefficient must lie in the range ± 1.The nearer this value to ± 1 the better the correlation and the closer x,y set of pairs plot a straight line. On the other hand the closer this value to zero, the more random the plot of x, y pairs.

However, some nonlinear relationships can sometimes be reduced to linear relationships by transformation of variables. For example if a curve of log y versus log x shows a linear relationship, its equation can be expressed in the form:-

$$y = \mathrm{a\,x^b} \quad \text{or} \rightarrow \mathrm{Log\,y} = \mathrm{Log\,a} + \mathrm{b\,Log\,x} \ ---(8)$$

The measured quantities are the cultivated area. It is measured on wheat area basis. The unit area of each crop is taken proportional to the crop water consumption from sowing to harvest. Total year Cultivated Area in all Gezira,Managil,Rahad,Suki,Sugar (Sennar + Guneid).Wheat 1 feddan unit (2528), Sorghum 1.12 feddan unit

(2820), ground nut 1.44 feddan unit,(3632),Cotton 2.27 feddan units,(5728) Sugar 3.61 feddan units.(9126) (Feddan unit = 4200 m^2). The areas for the five crops wheat ground nut sorghum cotton and sugar are as in table (5) in all the schemes downstream Rosaries dam.

Table No. (5): The Area for the Five Crops in All the Schemes Downstream Rosaries Dam

Year	Wheat $\times 10^6 m^2$	Cotton $\times 10^6 m^2$	G.nut $\times 10^6 m^2$	Sorghum $\times 10^6 m^2$	Sugar $\times 10^6 m^2$	Total $\times 10^6 m^2$
2005	882	3432	1149	3175	622	9260
2006	979	3385	1198	3629	622	9813
2007	949	3642	1282	3730	678	10281
2008	2012	1592	1173	4133	678	9939
2009	1470	1621	1718	1210	694	6713
2010	1428	1916	1282	957	678	6761
2011	769	1392	1869	1310	678	6018
2012	655	877	1814	1058	694	5098
2013	508	1144	1300	756	694	4402
2014	722	1573	1663	6552	622	11132
2015	643	1754	1724	806	678	5605

The collected data of discharge, power, sediment, and the areas of the five crops wheat ground nut sorghum cotton and sugar of table (5) are shown in table (6).

Table No.(6): Discharge Power Sediment And Areas Data

Year	Discharge Q $\times 10^9 m^3$ (milliard)	Power $P_{watt} \times 10^6$	Sediment ton $\times 10^3$	Area $\times 10^5 m^2$
2005	49349.10	1077.633	180.72	1567.76
2006	61263.36	1176.168	156.68	1345.90
2007	62640.15	1272.210	262.24	1601.44
2008	58932.45	1312.166	321.56	1702.00
2009	39941.88	1096.722	194.95	1086.52
2010	56211.78	1040.351	815.93	985.33
2011	47691.09	1094.961	630.52	940.32
2012	51897.71	1053.157	636.41	801.50
2013	57454.57	1503.732	639.67	648.70
2014	63958.48	1670.644	523.16	783.27
2015	42519.33	1496.295	464.45	843.65

The values of the parameters $\gamma_s, \tau,$ and W_s used were:-

$$\gamma_s = \frac{1500 \text{ kgr}}{\text{m}^2 \sec^2}; \quad \tau = \frac{0.52 \text{ kgr}}{\text{m} \sec^2}, and \quad W_s = 0.22 \text{ m/sec}$$

Sediment was increased by an amount of 20%,in table (6) approximating bed load . The values of the important dimensionless quantities of equation (3) to (6) are shown in table (7) as total of the year.

Table No.(7):Measured And Computed Data

Year	$\frac{Q\gamma_s^2}{\tau^2 W_s} \times 10^{20}$	$\frac{P\gamma_s^2}{\tau^3 W_s} \times 10^{15}$	$\frac{Q_s\gamma_s}{\tau^2 W_s} \times 10^{10}$	$\frac{A\,\gamma_s^2}{\tau^2} \times 10^{15}$
2005	19.50	86.1	477.00	77.04
2006	24.30	89.7	413.40	81.62
2007	24.84	96.5	693.24	85.33
2008	23.38	99.6	852.28	82.70

2009	15.85	92.9	515.16	55.83
2010	22.31	79.1	2162.40	56.24
2011	18.92	82.9	1669.56	50.09
2012	20.60	79.8	1685.40	42.43
2013	22.80	114.0	1695.00	36.61
2014	25.38	126.9	1386.48	92.60
2015	16.87	114.0	1230.72	46.68

To reveal the relationship among $\frac{Q\gamma_s^2}{\tau^2 W_s}$,and each of the dimensionless groups on the right hand side of equation (3), simple regression analysis could be conducted. The operation can be generated by taking $\frac{Q\gamma_s^2}{\tau^2 W_s}$,as the dependent variable with one group of the right hand side of equation (3),as the independent variable in each operation. The other relations were determined in a similar way.

The multiple regression analysis is conducted using a computer program Statistical Package for Social Sciences (SPSS) Model.The relevant dependent and independent dimensionless groups are arranged and fed to the computer. The transformed linear relationship among the dependent dimensionless group $\frac{Q\gamma_s^2}{\tau^2 W_s}$ and independent dimensionless groups $\left(\frac{P\gamma_s^2}{\tau^3 W_s}, \frac{Q_s\gamma_s}{\tau^2 W_s}, \frac{A\,\gamma_s^2}{\tau^2}\right)$, are revealed in the form of transformed regression equations. Each transformed model equation is expressed in the form of equation

$$Log\ \mathrm{y} = \mathrm{Log\ a_0} + a_1 Log\ \mathrm{x_1} + a_2 Log\ \mathrm{x_2} + a_3 Log\ \mathrm{x_3} --- (9)$$

Where:-

$y =$ Dependent variable taken as $\frac{Q\gamma_s^2}{\tau^2 W_s}$

$\mathrm{a_0} =$ Constant coefficient

$\mathrm{x_1 x_2 x_3} =$ Independent variables taken as $\left(\frac{P\gamma_s^2}{\tau^3 W_s}, \frac{Q_s\gamma_s}{\tau^2 W_s}, \frac{A\,\gamma_s^2}{\tau^2}\right)$

$\mathrm{a_1 a_2 a_3} =$ Exponent coefficients of $\mathrm{x_1 x_2 x_3}$ respectively.

The output of the transformed linear regression gives the correlation (r),the constant $\mathrm{a_0}$ and the exponential coefficients $\mathrm{a_1 a_2 a_3}$ with their standard error .Statistical test results namely Student (t),*Test* to the coefficients and excellence of fit F – value are also given by the computer. The model regression equations accepted are those which produce 95 % confidence level having a correlation coefficient close to (± 1),with F – Value and Student (t) values greater than the tables values.

It is also very important before the application of multiple regressions on this equation to verify that the researcher developed equations are dimensionless. The verification is carried out by the substitution of the dimensional terms units to each supposed or obtained dimensionless groups as follows:-

$$\frac{Q\gamma_s^2}{\tau^2 W_s} = \frac{\mathrm{L^3}.M^2.L^2.T^4.T}{\mathrm{T.L^4}.T^4.M^2.T.L} = \frac{\mathrm{M^2}.L^5.T^5}{\mathrm{M^2}.L^5.T^5} \rightarrow\rightarrow\therefore\rightarrow O.K.$$

$$\frac{P\gamma_s^2}{\tau^3 W_s} = \frac{M.L^2.M^2.L^3T^6.T}{T^3.L^4.T^4.M^3.L} = \frac{M^3.L^5.T^7}{M^3.L^5.T^7} \rightarrow \rightarrow \therefore\rightarrow \text{O.K.}$$

$$\frac{Q_s\gamma_s}{\tau^2 W_s} = \frac{M.L.M.L^2.T^4.T}{T^3.L^2.T^2.M^2.L} = \frac{M^2.L^3.T^5}{M^2.L^3.T^5} \rightarrow \rightarrow \therefore \rightarrow \text{O.K.}$$

$$\frac{A\,\gamma_s^2}{\tau^2} = \frac{L^2.M^2.L^2.T^4}{L^4.T^4.M^2} = \frac{M^2.L^4.T^4}{M^2.L^4.T^4} \rightarrow \rightarrow \therefore \rightarrow \text{O.K.}$$

Thus the four groups are dimensionless.

The substitution of the values of the quantities is shown in table (4.6).

Referring to tables (5),of the areas of the crops,and (6) of the dimensionless groups verified above and table (2) of all the other dimensional Parameters the results obtained are presented in the
Graphs in figures (4) to (7),containing tables, equations and charts.

❖ **Discharge Regression**

Variables Entered/Removed

Model	Variables Entered	Variables Removed	Method
1	logD, logx, logZ	.	Enter

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.679	.461	.230	.06036

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.022	3	.007	1.997	.203
	Residual	.026	7	.004		
	Total	.047	10			

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.060	.684		.088	.932
	logx	.063	.285	.063	.222	.830
	logZ	.144	.092	.537	1.568	.161
	logD	.395	.170	.803	2.329	.053

Residuals Statistics

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	1.2655	1.4229	1.3244	.04672	11
Residual	-.06780-	.08470	.00000	.05050	11
Std. Predicted Value	-1.260-	2.107	.000	1.000	11
Std. Residual	-1.123-	1.403	.000	.837	11

$$\frac{Q\gamma_s^2}{\tau^2 W_s}\times 10^{20} = 1.14815\left(\frac{P\gamma_s^2}{\tau^3 W_s}\times 10^{15}\right)^{0.063}\left(\frac{Q_s\gamma_s}{\tau^2 W_s}\times 10^{10}\right)^{0.144}\left(\frac{A\gamma_s^2}{\tau^2}\times 10^{15}\right)^{0.395}$$

$$Log\,\frac{Q\gamma_s^2}{\tau^2 W_s}\times 10^{20} = 0.06 + 0.063\log\left(\frac{P\gamma_s^2}{\tau^3 W_s}\times 10^{15}\right) + 0.144\log\left(\frac{Q_s\gamma_s}{\tau^2 W_s}\times 10^{10}\right) + 0.395\log\left(\frac{A\gamma_s^2}{\tau^2}\times 10^{15}\right)$$

$$Log\,\frac{Q\gamma_s^2}{\tau^2 W_s}\times 10^{20} = 0.06 + 0.063(1.94) + 0.144(2.68) + 0.395(1.89) = 1.31389$$

$$\therefore \frac{Q\gamma_s^2}{\tau^2 W_s}\times 10^{20} = 10^{1.31389} = 20.60$$

Chart

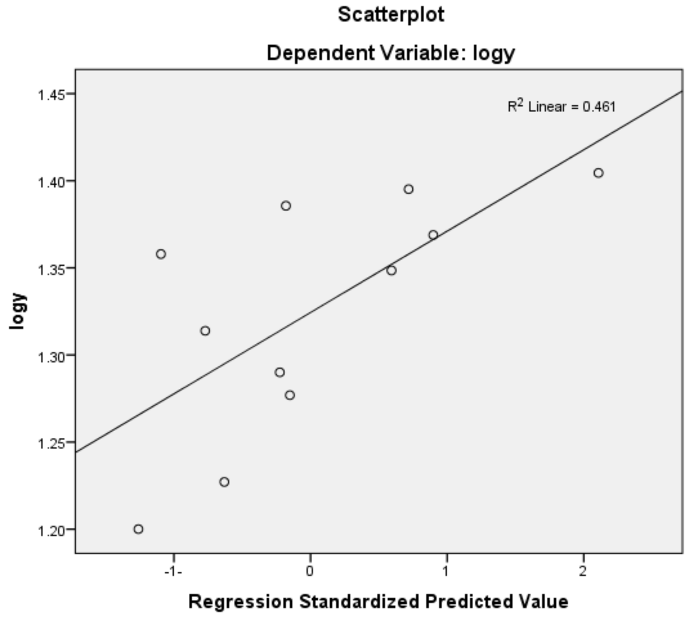

Fig.No.(3):Relationship Among Discharge power Sediment and Culivated Areas

❖ **Power Generation Regression**

Variables Entered/Removed

Model	Variables Entered	Variables Removed	Method
1	logD, logy, logZ		.Enter

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.220	.048	-.360-	.07984

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	.002	3	.001	.118	.947
1	Residual	.045	7	.006		
	Total	.047	10			

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.599	.673		2.374	.049
	logy	.111	.498	.111	.222	.830
	logZ	.035	.141	.130	.248	.811
	logD	.072	.298	.148	.243	.815

Residuals Statistics

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	1.9526	2.0062	1.9795	.01503	11
Residual	-.09283-	.09730	.00000	.06680	11
Std. Predicted Value	-1.789-	1.773	.000	1.000	11
Std. Residual	-1.163-	1.219	.000	.837	11

$$\frac{P\gamma_s^2}{\tau^3 W_s}\times 10^{15} = 39.7192\left(\frac{Q\gamma_s^2}{\tau^2 W_s}\times 10^{20}\right)^{0.111}\left(\frac{Q_s\gamma_s}{\tau^2 W_s}\times 10^{10}\right)^{0.035}\left(\frac{A\gamma_s^2}{\tau^2}\times 10^{15}\right)^{0.072}$$

$$Log\left(\frac{P\gamma_s^2}{\tau^3 W_s}\times 10^{15}\right) = 1.599 + 0.111 log\left(\frac{Q\gamma_s^2}{\tau^2 W_s}\times 10^{20}\right) + 0.035\log\left(\frac{Q_s\gamma_s}{\tau^2 W_s}\times 10^{10}\right) + 0.072\log\left(\frac{A\gamma_s^2}{\tau^2}\times 10^{15}\right)$$

$$Log\left(\frac{P\gamma_s^2}{\tau^3 W_s}\times 10^{15}\right) = 1.599 + 0.111 log(19.50) + 0.035\log(477.00) + 0.072\log(77.04) = 1.971785557$$

$$Log\left(\frac{P\gamma_s^2}{\tau^3 W_s}\times 10^{15}\right) = 10^{1.971785557} = 93.71$$

Charts

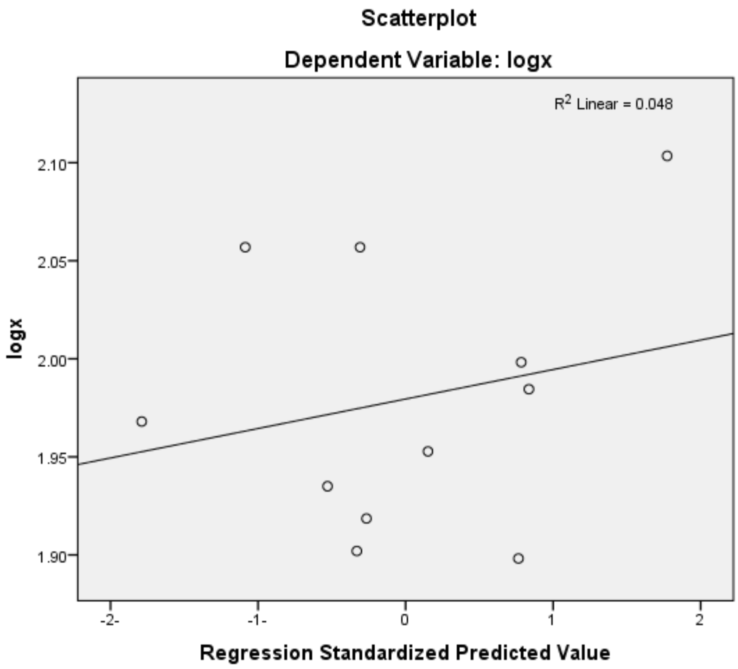

Fig.No.(4):Relatinship Among Power Discharge Sediment and Culivated Areas

❖ **Sediment Regression**

Variables Entered/Removed

	Variables Entered	Variables Removed	Method
	logD, logx, logy	.	Enter

Model Summary

	R	R Square	Adjusted R Square	Std. Error of the Estimate
	.717	.514	.305	.21370

ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	.338	3	.113	2.466	.147
Residual	.320	7	.046		
Total	.658	10			

Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	2.821	2.174		1.297	.236
logy	1.805	1.151	.484	1.568	.161
logx	.250	1.007	.067	.248	.811
log D	-1.512-	.560	-.824-	-2.698-	.031

Residuals Statistics

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	2.7802	3.4216	3.0022	.18380	11

Residual	-.30285-	.25183	.000000	.17879	11
Std. Predicted Value	-1.208-	2.282	.000	1.000	11
Std. Residual	-1.417-	1.178	.000	.837	11

$$\left(\frac{Q_s\gamma_s}{\tau^2 W_s}\times10^{10}\right)=662.265\left(\frac{Q\gamma_s^2}{\tau^2 W_s}\times10^{20}\right)^{1.805}\left(\frac{P\gamma_s^2}{\tau^3 W_s}\times10^{15}\right)^{0.250}\left(\frac{A\gamma_s^2}{\tau^2}\times10^{15}\right)^{-1.512}$$

$$Log\left(\frac{Q_s\gamma_s}{\tau^2 W_s}\times10^{10}\right)=2.821+1.805\log\left(\frac{Q\gamma_s^2}{\tau^2 W_s}\times10^{20}\right)+0.250\log\left(\frac{P\gamma_s^2}{\tau^3 W_s}\times10^{15}\right)-1.512\log\left(\frac{A\gamma_s^2}{\tau^2}\times10^{15}\right)$$

$$Log\left(\frac{Q_s\gamma_s}{\tau^2 W_s}\times10^{10}\right)=2.821+1.805\log(19.50)+0.250\log(86.1)-1.512\log(77.04)=2.780548255$$

$$\left(\frac{Q_s\gamma_s}{\tau^2 W_s}\times10^{10}\right)=10^{2.780548255}=603.32$$

Charts

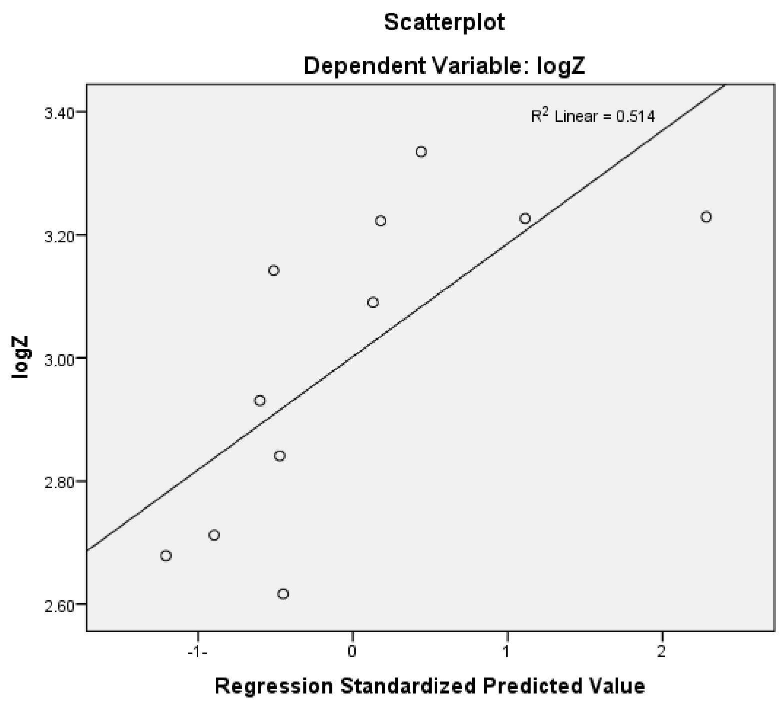

Fig.No.(5):Relationship Among Sediment Discharge Power and Culivated Areas

❖ **Agricultural Areas Regression**

Variables Entered/Removed

Model	Variables Entered	Variables Removed	Method
1	logw, logx, logy	.	Enter

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.797	.635	.478	.10093

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.124	3	.041	4.058	.058
	Residual	.071	7	.010		
	Total	.195	10			

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.108	1.064		1.041	.332
	logy	1.105	.474	.544	2.329	.053
	logx	.116	.476	.057	.243	.815
	logw	-.337-	.125	-.619-	-2.698-	.031

Residuals Statistics

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	1.6544	1.9829	1.7883	.11136	11
Residual	-.19410-	.12266	.00000	.08445	11
Std. Predicted Value	-1.202-	1.748	.000	1.000	11
Std. Residual	-1.923-	1.215	.000	.837	11

$$\left(\frac{A\gamma_s^2}{\tau^2}\times 10^{15}\right)=12.0781\left(\frac{Q\gamma_s^2}{\tau^2 W_s}\times 10^{20}\right)^{1.105}\left(\frac{P\gamma_s^2}{\tau^3 W_s}\times 10^{15}\right)^{0.116}\left(\frac{Q_s\gamma_s}{\tau^2 W_s}\times 10^{10}\right)^{-0.337}$$

$$Log\left(\frac{A\gamma_s^2}{\tau^2}\times 10^{15}\right)=1.108+1.105\log\left(\frac{Q\gamma_s^2}{\tau^2 W_s}\times 10^{20}\right)+0.116\log\left(\frac{P\gamma_s^2}{\tau^3 W_s}\times 10^{15}\right)-0.337\log\left(\frac{Q_s\gamma_s}{\tau^2 W_s}\times 10^{10}\right)$$

$$Log\left(\frac{A\gamma_s^2}{\tau^2}\times10^{15}\right)=1.108+1.105\log(19.50)+0.116\log(86.10)-0.337\log(477.00)$$

$$\left(\frac{A\gamma_s^2}{\tau^2}\times10^{15}\right) = 10^{1.8552879} = 71.66$$

Charts

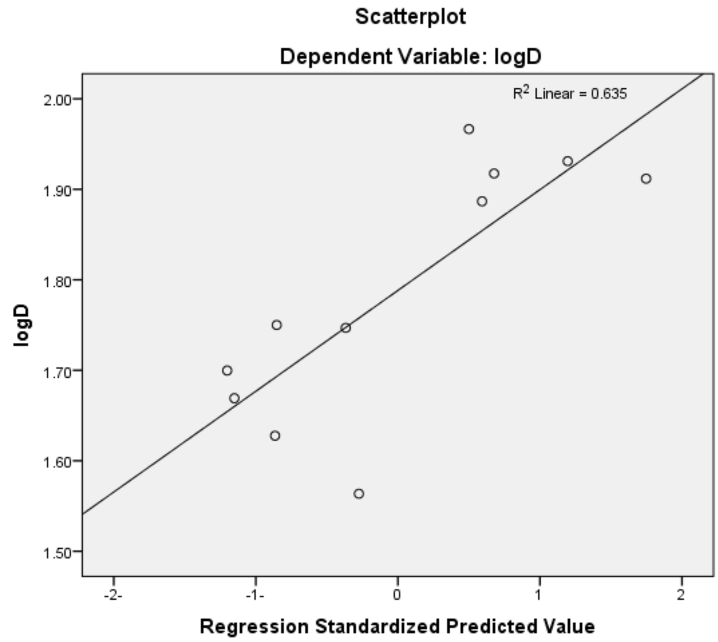

Fig.No.(6): Relationship Among Cultivated Areas Discharge Power and Sediment

III. RESULTS AND DISCUSSION

The relevant data similar to that in table (7), is not available because no previous investigators have conducted similar investigations. Most of the previous investigators have conducted experimental works about discharge sediment and power generation. No investigator has conducted work about cultivated areas of the different crops in the different schemes. Those who have conducted studies about discharge sediment and power generation, obtained quantitative and qualitative results of certain and specific areas that can not be applied in this study.

Although the previous investigators have covered important studies yet it was selective and not covering the parts studied by the researcher. However it was all covered in the literature review so that the study would not be incomplete. The procedures adopted by the researcher mainly rely on basic and advanced knowledge about dimensional analysis and theory of models backed with SPSS supported by the advancing knowledge of the computer analysis. Consequently, it is very difficult if not impossible to apply the developed empirical equations (3) to (6) to any of the previous investigators. Equations (3) to (6) are, therefore applied to the data taken from Rosaries Dam.

In the present study, the Cultivated Area Aspects Relations with the other aspects was considered. The results to the three dimensionless groups developed by the researcher are shown in tables (8), (9),,and (10),respectively.

Table No. (8):Cultivated Area Aspects Relations

$$\frac{A\,\gamma_s^2}{\tau^2}\times10^{15}$$

Year	Predicted	Actual	Error
2005	71.49407	77.04	-5.54593

2006	96.13466	81.62	14.51466
2007	83.4411	85.33	-1.8889
2008	73.05669	82.7	-9.64331
2009	55.89462	55.83	0.064619
2010	49.34464	56.24	-6.89536
2011	45.12321	50.09	-4.96679
2012	49.19489	42.43	6.764891
2013	57.24005	36.61	20.63005
2014	69.8152	92.6	-22.7848
2015	45.71303	46.68	-0.96697

Tables No. (9): Discharge Aspects Relations

$$\frac{Q\gamma_s^2}{\tau^2 W_s}\times 10^{20}$$

Year	Predicted	Actual	Error
2005	20.58046	19.5	1.08046
2006	20.67918	24.3	-3.62082
2007	22.77655	24.84	-2.06345
2008	23.22182	23.38	-0.15818
2009	18.41228	15.85	2.562285
2010	22.47368	22.31	0.163676
2011	20.7451	18.92	1.825103
2012	19.40853	20.6	-1.19147
2013	18.74121	22.8	-4.05879
2014	26.44571	25.38	1.065714
2015	19.69994	16.87	2.829941

Table No.(10):Sediment Aspects Relations

$$\frac{Q_s\gamma_s}{\tau^2 W_s}\times 10^{10}$$

Year	Predicted	Actual	Error
2005	502.3195	397.5	104.8195
2006	691.8788	344.5	347.3788
2007	685.4882	577.7	107.7882
2008	649.3667	710.2	-60.8333
2009	572.9939	429.3	143.6939
2010	1009.09	1802	-792.91
2011	903.2958	1391.3	-488.004
2012	1340.726	1404.5	-63.7741
2013	2199.936	1412.5	787.4358
2014	674.3261	1155.4	-481.074
2015	884.5655	1025.6	-141.034

IV. CONCLUSION

1. Depletion has been reported worldwide in drought prone areas. In the Sudan, yearly losses attained the range from 0.3% to 1.67%.
2. Although Sudan irrigated agriculture produces about 50 % of the total crop production,yet it is associated with painstaking of removing sediments from the irrigation network system and reservoirs.
3. Based on the results obtained in this research, it could be admitted that Roseires Reservoir lost a great part of its capacity due to the sedimentation problems.
4. Data from 2005 to 20015 was used to calibrate the hydrodynamic and morphodynamic model of the Roseires Reservoir, and the calibration results showed good agreements to observed data.

V. RECOMMENDATIONS

1. Complexity in reservoir operation and maintenance coupled with downstream the dam river bank erosion, sediment deposition, insufficient irrigation water for the agricultural schemes, with problems in power generation; require urgent mitigation.
2. The assessment of the impact of sediment on irrigation water and optimization of use and consumption of water for irrigation suggested in this research are recommended.
3. Further research is required to evaluate the extend of direct and indirect impact of sedimentation on existing reservoirs where real data are available. This will bring about the understanding, through case studies.
4. Further research is required using modern sophisticated model to investigate the Reservoir sedimentation problems.

5. Dams and reservoirs data about soil, shear, and water depth. are essential tools used in reseach.It is therefore highly recommended to establish a data base recoding all relevant research parameters.

VI. REFERENCES

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