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Discharge Sediment and Power Generation Interaction Case Study Roseires Dam

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ABSTRACT

The prevailing problem of Rosaries Dam Reservoir is the sedimentation problem which endangered its operation performance. Rosaries Dam Reservoir is suffering from downstream river bank erosion, with problems in power generation. The objective of this study is to assess the relations among discharge sediment, and power generation. The researcher conducted dimensional analysis using Buckingham pi theorem and SPSS models, for both simple and multiple correlation. The software name of SPSS originally stood for Statistical Package for the Social Sciences. The simple correlation gave acceptable results with high correlation coefficients. Complete set of dimensionless groups were obtained using the rules of dimensionless analysis and theory of models in the multiple regression correlation. The results obtained clearly defined the interationship among the variable groups in a single equation. To reveal the interrelationship among discharge, sediment, generated power and irrigated areas, each dimensionless variable was put as independent variable on the left hand side of the equation and the other three on the right hand side to reveal the interaction and the degree of dependence. Examination of the results indicated good correlation with acceptable error.

Keywords: Roseires Dam, SPSS Models, Dimensionless Groups

I. INTRODUCTION

Construction of dams and reservoirs in rivers fist mainly for flood control, hydropower generation, irrigation, navigation, water supply, fishing and recreation. Among multipurpose dams, hydropower and irrigation dams are predominant. Environmental impacts and long-term morphological changes of the natural water course due to human intervention are inevitable. Sedimentation is one of the major problems which endangers the performance and sustainability of reservoirs. It reduces the effective flood control volume. It also affects the operation of low-level outlets gates and valves, reduces stability, water quality and recreational benefits.

Sedimentation is a complex hydro-morphological process and is difficult to predict. It has been underestimated in the past and was perceived as a minor problem which could be controlled by sacrificing a certain volume of the reservoir for accumulation of the sediment (dead zone). However, nowadays it is of paramount importance to take design and implementation of sediment control measures into consideration in the planning, design, operation and maintenance phases of the reservoirs. The cost of restoring lost storage by conventional dredging, without the additional cost of providing disposal areas and containment facilities, varies from \$2 to \$3 per cubic meter (Mahmood 1987).

Dams play an important role in meeting people's needs (WCD, 2000) Hydropower accounts for more than 90% of the total electricity supply in 24 countries, such as Brazil and Norway. In at least 75 countries large dams have been built to control floods. For many nations, dams remain the largest single investment project in the country (Antila, H.1997).

There are 45 000 large dams in the world today. A large dam is defined as a dam with a height of 15 m or more from the foundation, or a height of 5 m or more but with a reservoir volume of more than 3 million cubic meters (WCD, 2000). Dams can be classified according to, their hydraulic design, or the material of which they are constructed. Roseires Dam shown in figure (1) is classified as Concrete Gravity Dam. Concrete gravity dams depend on its own weight for stability.

Figure 1. Roseires Concrete Gravity Dam

The prevailing problems affecting Roseires Dam are several.

- ✓ Intakes reduced hydropower as well as power outage.
- ✓ Upstream downstream sediment transportation.
- ✓ Diminishing downstream releases .
- ✓ Complexity in reservoir operation and maintenance coupled with downstream the dam river bank erosion.
- ✓ The main objective is to assess the impact of sediment on discharge and power gerneration. Specific objectives:
- ✓ Indicate the interaction between discharge sediment.
- ✓ Indicate the interaction between discharge and power.
- ✓ Suggest some recommendations to measures that can be taken to reduce the amount of deposited sediment.

II. 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 ($3.3\times10^{9}m^{3}$) at 481 R.L. in 1966.In 2007 it was found that about 42.3 % of its storage capacity was Lost. Figure (2), shows the Sudan boundaries and Roseires Dam geographical location.Figure (3), shows detailed boundaries in the vicinity of Roseires Dam. 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.

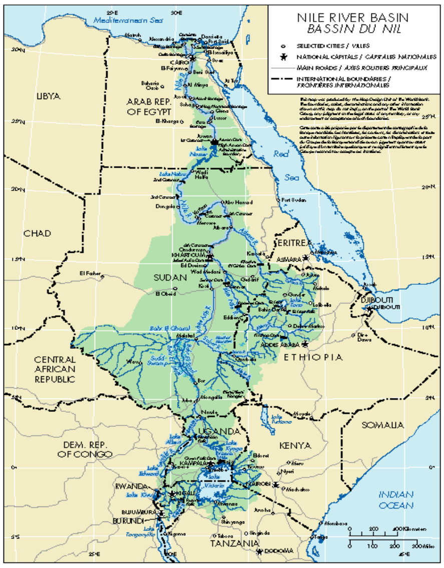

Figure 2. Sudan Boundaries and Roseires Dam Geographical Location

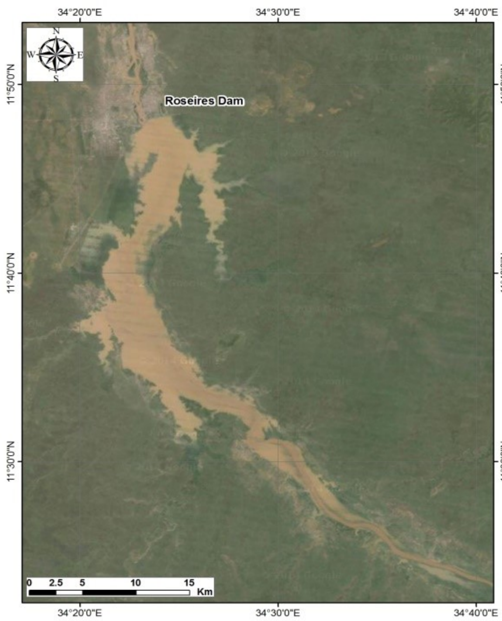

Figure 3. Detailed Boundaries in the Vicinity of Roseires Dam Reservoir

III. METHODS AND MATERIAL

The main problems are decreasing discharge intakes reduced hydropower, sediment accumulation and transportation. This is associated with complexity in operation and river bank erosion 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 power generation and optimization of downstream discharges water releases. 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 model 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 Abdel Haleem (2008) Hassanpour and Ayoubzadeh (2008), Yasir (14) 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.

1. 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 cannot 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 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 analyzed and presented in the form of graphs and tables. Simple correlation is presented in table (1).

Table 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:-

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

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 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 (3×15) 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 3. Determinant Taken From The Matrix Table (2).

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

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

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

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

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

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

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

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 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

This gives the following equations:-

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

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

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

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

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:-

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

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

$\text{cov}(x,y)=Coveriance$ of $(x,y)=$ 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

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

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 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 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:-

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

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 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:-

$$Log\ \text{y} = \text{Log a}_0 + a_1 Log\ \text{x}_1 + a_2 Log\ \text{x}_2 + a_3 Log\ \text{x}_3 ---(9)$$

Where:-

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

$\text{a}_0 =$ Constant coefficient

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

$a_1 a_2 a_3$ = Exponent coefficients of $x_1 x_2 x_3$ respectively.

The output of the transformed linear regression gives the correlation (r),the constant a_0 and the exponential coefficients $a_1 a_2 a_3$ 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:-

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

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

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

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

Thus the four groups are dimensionless. The substitution of the values of the quantities is shown in table (4). 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

$$\frac{Q\gamma_s^2}{\tau^2 W_s}\times10^{20}=1.14815\left(\frac{P\gamma_s^2}{\tau^3 W_s}\times10^{15}\right)^{0.063}\left(\frac{Q_s\gamma_s}{\tau^2 W_s}\times10^{10}\right)^{0.144}\left(\frac{A\gamma_s^2}{\tau^2}\times10^{15}\right)^{0.395}$$

$$Log\,\frac{Q\gamma_s^2}{\tau^2 W_s}\times10^{20}=0.06+0.063\log\left(\frac{P\gamma_s^2}{\tau^3 W_s}\times10^{15}\right)+0.144\log\left(\frac{Q_s\gamma_s}{\tau^2 W_s}\times10^{10}\right)+0.395\log\left(\frac{A\gamma_s^2}{\tau^2}\times10^{15}\right)$$

$$Log\,\frac{Q\gamma_s^2}{\tau^2 W_s}\times10^{20}=0.06+0.063(1.94)+0.144(2.68)+0.395(1.89)=1.31389$$

$$\therefore\frac{Q\gamma_s^2}{\tau^2 W_s}\times10^{20}=10^{1.31389}=20.60$$

Chart

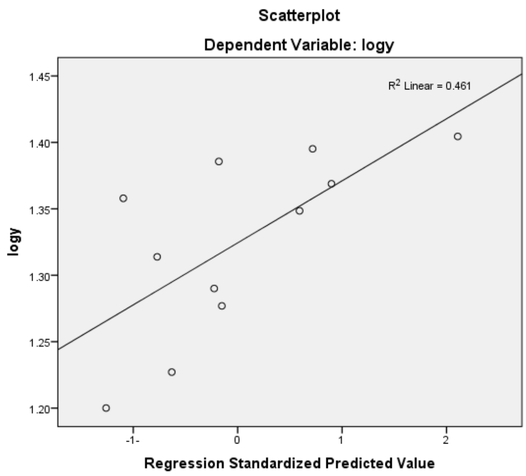

Figure 4. Relationship Among Discharge power Sediment and Culivated Areas

❖ **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.
1	Regression	.002	3	.001	.118	.947
	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

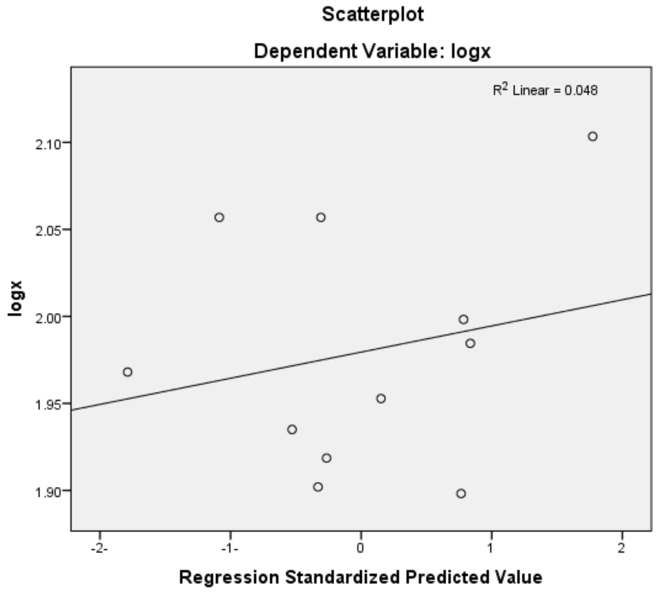

Figure 5. Relatinship Among Power Discharge Sediment and Culivated Areas

❖ **Sediment Regression**

Variables Entered/Removed			
Model	Variables Entered	Variables Removed	Method
1	logD, logx, logy	.	Enter

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.717	.514	.305	.21370

ANOVA						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	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		
1	(Constant)	2.821	2.174		1.297	.236
	logy	1.805	1.151	.484	1.568	.161
	logx	.250	1.007	.067	.248	.811
	logD	-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	.00000	.17879	11

Std. Predicted Value	-1.208-	2.282	.000	1.000	11
Std. Residual	-1.417-	1.178	.000	.837	11

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

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

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

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

Charts

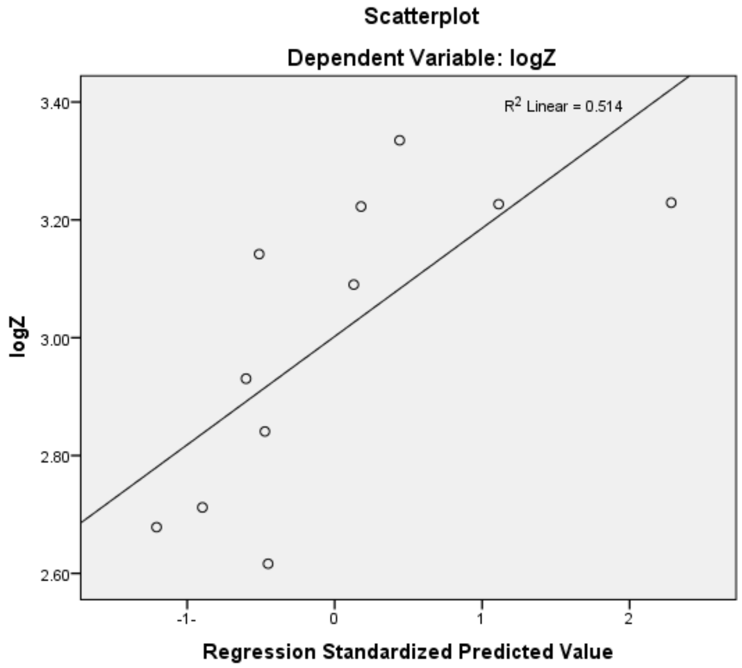

Figure 6. Relationship Among Sediment Discharge Power and Cultivated Areas

- **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

$$\left(\frac{A\gamma_s^2}{\tau^2}\times10^{15}\right)=12.0781\left(\frac{Q\gamma_s^2}{\tau^2 W_s}\times10^{20}\right)^{1.105}\left(\frac{P\gamma_s^2}{\tau^3 W_s}\times10^{15}\right)^{0.116}\left(\frac{Q_s\gamma_s}{\tau^2 W_s}\times10^{10}\right)^{-0.337}$$

$$Log\left(\frac{A\gamma_s^2}{\tau^2}\times10^{15}\right)=1.108+1.105\log\left(\frac{Q\gamma_s^2}{\tau^2 W_s}\times10^{20}\right)+0.116\log\left(\frac{P\gamma_s^2}{\tau^3 W_s}\times10^{15}\right)-0.337\log\left(\frac{Q_s\gamma_s}{\tau^2 W_s}\times10^{10}\right)$$

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

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

Charts

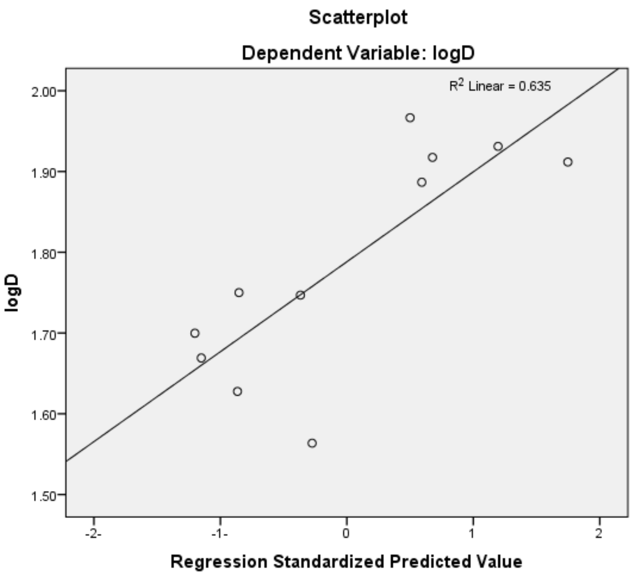

Figure 7. Relationship Among Cultivated Areas Discharge Power and Sediment

IV. RESULT 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 Discharge 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.

Tables 8: 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

Tables 9: 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

Tables 10 : Power Aspects Relations $\frac{P\gamma_s^2}{\tau^3 W_s}\times 10^{15}$

Year	Predicted	Actual	Error
2005	93.75933	86.1	7.659328
2006	95.99609	89.7	6.29609
2007	98.3017	96.5	1.801695
2008	98.12976	99.6	-1.47024
2009	89.76863	92.9	-3.13137
2010	98.09309	79.1	18.99309
2011	94.65429	82.9	11.75429
2012	94.44854	79.8	14.64854
2013	94.52786	114	-19.4721
2014	101.5525	126.9	-25.3475
2015	91.99658	114	-22.0034

V. CONCLUSION

1. Depletion has been reported world-wide 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 morph dynamic model of the Roseires Reservoir, and the calibration results showed good agreements to observed data.

VI. 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, water depth, are essential tools used in research. It is therefore highly recommended to establish a data base recoding all relevant research parameters.

VII. REFERENCES

[1]. Ageel I. Bushara The hydraulics Research Center (HRC) Ministry of Water resources and Electricity, Sudan

[2]. Antila, H. (1997). Hydro Power Dynamics in Power Systems Planning. Tampere University of Technology, Publications, 216.

[3]. Dams Implementation Unit, 2012, Sudan.

[4]. Mahmood, K, (1987) reservoir sedimentation impact.

[5]. WCD. (2000). Dam and Development : A New Framework for Decision- Making. The report of the World Commission on Dam. London: Earth can.