Interactive Optimization for Model and Prototype: a case study of the Twelve Nigerian River Basin Engineering Development Schemes

Dr. Luke C. Eme, (B.Sc, PGD, PGDE, M.Eng. Ph.D)
Department of Civil Engineering,
Anambra State University, Uli-Nigeria.
Leeworks2002@yahoo.com

Abstract: Experiments in this work is aimed at an alternative method of testing null hypothesis for the twelve Nigerian River Basin Engineering Development Schemes (prototype) and the contingency, reliability theory (model). The work assesses the relationship between the experimental and theoretically expected results and tests the null hypothesis, as follows:(a) If no maintenance is applied by the decision maker next year's productivity depends on this year's condition of the basins. (b) If maintenance is applied by the decision maker, next year's productivity depends on this year's condition of the basins. (c) If the cost function depends on the strategy (courses of action) of the decision maker in terms of loss during a-1- year period. (d) If the return function depends on the course of action of the decision maker in terms of gain during a 1-year period. (e) If simulation optimization depends on the minimization of expected cost .(f) If simulation optimization depends on the maximization of the expected revenue. The methodology involves contingency, reliability test and alterative interactive model of Pearson product moment correlation. Data were collected for the model and prototype from the Ministries and Parastatals. The problem of providing more information about a phenomenon or interactions in the analysis of variance was solved. The researcher analyzed the data with other powerful parametric tests such as Pearson's product moment correlation, scatter diagrams and the least of squares equation which coincided with r = 0.83 as height of perfection of performance of the prototype when compared with the model.

Keywords: Cost-minimization, performance-optimization, revenue- maximization.

1 INTRODUCTION

Contingency, reliability interaction was simulated based on the following background. The chi-square test is a measure of relationship, association or independence, introduced by Pearson (1990). The chi-square test is probably the best known and the most important of all non parametric method. It involves a measure of reliability by comparing observed frequency distribution failure mode with theoretical expected distribution failure mode when the hypothesis is false. In this case it is to say a comparism of the performance between the twelve Nigerian River Basin and theoretical expected results.

It is a non-parametric interaction which is fairly robust with respect to violations of assumption having more power efficiency (the power of an interaction relative to the sample size which permits one to compare the power of two different statistical tests. The power of a statistical test is the probability that the test will correctly reject a null hypothesis when that hypothesis is false). There were five basic conditions that necessitated the valid application of chi-square analysis in the Nigerian River Basin Authorities and the theoretical expected results. These are: the sample observations are independent of each other, sample data are drawn at random from the population, sample data are expressed in original units, the sample contains sixty-four observations with eight experiments in each cell and not more than 20% of the expected frequency is less than 5.

1.1 Statement of problem

The problem starts from the violation of one or more parametric assumption in the River Basin development objectives such as the dynamics of a true life situation, in adequate parameters, uncertainties etc and therefore:

Non-parametric test makes no assumption about the shape of the distribution or population data, the data represent an ordinal or nominal scale because the parametric assumption has been greatly violated and the nature of the distribution is unknown, there is problem of providing more information about a phenomenon or interactions in the analysis of variance in realizing the objective.

2 METHODOLOGY

Methodology involves methods and experiments in sixty-four observations. Data were collected from the ministries, parastatals. Analysis of the data were done with more powerful parametric test such as the Pearson product moment correlation, scatter diagrams and the least of squares equation .

Table 1Computation of actual –frequency table P^1 (probabilities) without maintenance

State of the system this year (P^1)	State of the system next year (P^1)								Total
	1	2	3	4	5	6	7	8	
1	.20	.11	.12	.11	.13	.11	.12	.10	1.0
2	0	.25	.18	.15	.11	.11	.10	.10	1.0
3	0	0	.34	.10	.15	.10	.11	.20	1.0
4	0	0	0	.40	.10	.10	.10	.30	1.0
5	0	0	0	0	.40	.12	.13	.35	1.0
6	0	0	0	0	0	.45	.22	.33	1.0
7	0	0	0	0	0	0	.55	.45	1.0
8	0	0	0	0	0	0	0	1.00	1.0
Grand total	.20	.36	.64	.76	.89	.99	1.33	2.83	8.0

Table 2 Chi-square (x^2) contingency table without maintenance

Observed (0)	Expected (E)	0 – E	(0 – E)2	(0 – E)2 X2
.20	0.025	0.175	0.030625	1.225
.11	0.045	0.065	0.004225	0.093889
.12	0.08	0.040	0.0016	0.02
.11	0.195	0.015	0.000225	0.002368
.13	0.111	0.019	0.000361	0.003252
.11	0.124	-0.014	0.000196	0.001581
.12	0.166	-0.046	0.002116	0.012747
10	0.354	-0.254	0.064516	0.182249
0	0.025	-0.025	0.000625	0.025
.25	0.045	0.205	0.042025	0.933889
.18	0.08	0.100	0.01	0.125
.15	0.095	0.055	0.003025	0.031842
.11	0.111	-0.001	0.000001	0.000009
.11	0.124	-0.014	0.000196	0.001581
.10	0.166	-0.065	0.004356	0.026241
.10	0.354	-0.254	0.064516	0.182249
0	0.025	-0.025	0.000625	0.025
.0	0.045	-0.045	0.002025	0.045
.34	0.08	0.26	0.0676	0.845
.10	0.095	0.005	0.000025	0.000263
.15	0.111	0.039	0.001521	0.013703

.10	0.124	-0.024	0.000576	0.004645
.11	0.166	-0.056	0.003136	0.018892
.20	0.354	-0.154	0.023716	0.066994
0	0.025	-0.025	0.000625	0.025
0	0.045	-0.045	0.002025	0.045
0	0.08	-0.08	0.0064	0.08
.40	0.095	0.305	0.093025	0.979211
.10	0.111	-0.011	0.000121	0.001090
.10	0.124	-0.024	0.000576	0.004645
.10	0.166	-0.066	0.004356	0.026241
.30	0.354	-0.054	0.002916	0.008237
0	0.025	-0.025	0.000625	0.025
0	0.045	-0.045	0.002025	0.045
0	0.08	-0.08	0.0064	0.08
0	0.095	-0.095	0.009025	0.095
.40	0.111	0.289	0.083521	0.752441
.12	0.124	-0.04	0.000016	0.000129
.13	0.166	-0.036	0.001296	0.007807
.35	0.354	-0.004	0.000016	0.000045
0	0.025	-0.025	0.000625	0.025
0	0.045	-0.045	0.002025	0.045
0	0.08	-0.08	0.0064	0.08
0	0.095	-0.095	0.009025	0.095
0	0.111	-0.111	0.012321	0.111
.45	0.124	0.326	0.106276	0.857065
.22	0.166	0.054	0.002916	0.017663
.33	0.354	-0.024	0.000576	0.001627
0	0.025	-0.025	0.000625	0.025
0	0.045	-0.045	0.002025	0.045
0	0.08	-0.08	0.0064	0.08
0	0.095	-0.095	0.009025	0.095
0	0.111	-0.111	0.012321	0.111
0	0.124	-0.124	0.015376	0.124
.55	0.166	0.384	0.147456	0.888289
.45	0.354	0.096	0.009216	0.026034
0	0.025	-0.025	0.000625	0.025
0	0.045	-0.045	0.002025	0.045
0	0.08	-0.08	0.0064	0.08
0	0.95	-0.095	0.009025	0.095
0	0.111	-0.111	0.012321	0.111
0	0.124	-0.124	0.015376	0.124
0	0.166	-0.166	0.027556	0.166
1.0	0.354	0.646	0.417316	1.178859
8.0	8.0	0	----	10.512777

3 DISCUSSION

Result of experiments (1) on the model without maintenance: the chi-square (X^2)value of 10.512777 is interpreted from the X^2 tables (1) and (2) of probability value at 0.10 level of significance. The degree of freedom necessary to intercept X^2 values are determined from the frequency table by the number of rows minus one, times the number of columns minus one (r –I) (c- I) ie (8 – 1) (8 – 1) = 49.Since the obtained x^2 value of 10.512777 is less than the critical value of 63.1671, and falls in the acceptance region, therefore the null hypothesis is accepted. There is no significant difference between the experimental and theoretically expected result, which led to the acceptance of null hypothesis and proof of independent, characteristics of the two data. The Chi-square was not based on a fictitious data, in the case of the manager's problem when maintenance is not applied. In the test of how well the linear estimator, y = a + bx fits the raw data, the correlation coefficient, c = 0.8 results in a perfect fit for the raw data.

3.1 Discussion of results of experiments (2) on the model with maintenance

The X^2 value of 5.699 is interpreted from the probability value at 0.10 level of significance. The degree of freedom necessary to intercept X^2 values are determined from the frequency table by the number of rows minus one, times the number of columns minus one (r – 1) (C – 1) i.e. (8 – 1) (8 - 1) = 49.Since the obtained x^2 value of 5.699 is less than the critical value of 63.1671 and falls in the acceptance region therefore the null hypothesis is accepted.. There is no significant difference between the experimental and theoretically expected result, which led to the acceptance of null hypothesis, therefore a proof of independent, characteristics of data. The chi-square was not based on a fictitious data, in the case of the manager's problem when maintenance is not applied. In the test of how well the linear estimator, y = a + bx fits the raw data, the correlation coefficient, C = 0.63 results in a better fit for the raw data.

Table 3 Computation of actual cell frequencies table R^1 (revenue) cell without maintenance.

State of system this year (P2)	State of the system next year (P2)								Total
	1	2	3	4	5	6	7	8	
1	4.6	3.5	14.0	3.5	2.9	5.5	4.6	5.6	44.2
2	3.5	2.3	8.1	3.5	11.5	7.8	3.5	7.8	48.0
3	72.5	10.4	10.4	12.5	11.4	(-3.5)	3.2	4.6	128.5
4	5.8	21.3	6.9	3.5	3.0	2.3	3.5	4.8	51.1
5	27.6	5.8	6.9	4.4	3.9	2.5	4.4	3.7	59.2
6	(-34.5)	4.6	8.1	1.2	7.7	9.2	4.6	5.5	75.4
7	4.6	3.5	6.9	3.5	3.0	2.9	4.0	10.4	38.8
8	18.4	5.8	9.2	3.2	2.9	3.5	4.4	4.8	52.2
Grand total	171.5	57.2	70.5	35.3	46.3	37.2	32.2	47.2	497.4

Table 4 Chi-square x^2 contingency table without maintenance

Observed (0)	Expected (E)	0 – E	(0 – E)2	(0 – E)2 X2
4.6	15.24	-10.64	113.21	7.43
3.5	5.08	-1.58	2.50	0.49
14.0	6.26	7.74	59.91	9.57
3.5	3.14	0.36	0.13	0.04
2.9	4.11	-1.21	1.46	0.36
5.5	3.31	2.19	4.80	1.45
4.6	2.86	1.74	3.03	1.06
5.6	4.19	1.41	1.99	0.47
3.5	16.55	-13.05	170.30	10.29
2.3	5.52	-3.22	10.37	1.88
8.1	6.80	1.3	1.69	0.25
3.5	3.41	0.09	0.01	0.002
11.5	4.47	7.03	49.42	11.06
7.8	3.59	4.21	17.72	4.94
3.5	3.11	0.39	0.15	0.05
7.8	4.55	3.25	10.56	2.32

72.5	44.31	28.19	794.68	17.93
10.4	14.78	-4.38	19.18	1.30
10.4	18.21	-7.81	61.00	3.35
12.5	9.12	3.38	11.42	1.25
11.4	11.96	-0.56	0.31	0.03
3.5	9.61	-6.11	37.33	3.88
3.2	8.32	-5.12	26.21	3.15
4.6	12.19	-7.59	57.61	4.73
5.8	17.62	-11.82	139.71	7.93
21.3	5.88	15.42	237.78	40.44
6.9	7.24	-0.34	0.12	0.02
3.5	3.63	-0.13	0.02	0.005
3.0	4.76	-1.76	3.10	0.65
2.3	3.82	-1.52	2.31	0.60
3.5	3.31	0.19	0.04	0.01
4.8	4.85	-0.05	0.003	0.001
27.6	20.41	7.19	51.70	2.53
5.8	6.81	1.01	1.02	0.15
6.9	8.39	-1.49	2.22	0.26
4.4	4.20	0.20	0.04	0.01
3.9	5.51	-1.61	2.59	0.47
2.5	4.43	-1.93	3.72	0.84
4.4	3.83	0.57	0.32	0.08
3.7	5.62	-1.92	3.69	0.66
34.5	26.53	7.97	63.52	2.39
4.6	8.67	-4.07	16.56	1.91
8.1	10.69	-2.59	6.71	0.63
1.2	5.35	-4.15	17.22	3.22
7.7	7.02	0.68	0.46	0.07
9.2	5.64	3.56	12.67	2.25
4.6	4.88	-0.28	0.08	0.02
5.5	7.15	-1.65	2.72	0.38
4.6	13.38	-8.78	77.09	5.76
3.5	4.46	-0.96	0.92	0.21
6.9	5.50	1.4	1.96	0.36
3.5	2.75	0.75	0.56	0.20
3.0	3.61	-0.61	0.37	0.10
2.9	2.90	0	0.	0
4.0	2.51	1.49	2.22	0.88
10.4	3.68	6.72	45.16	12.27
18.4	18.00	0.4	0.16	0.01
5.8	6.40	-0.2	0.04	0.01
9.2	7.40	1.8	3.24	0.44
3.2	3.70	-0.5	0.25	0.07
2.9	4.86	1.96	3.84	0.79
3.5	3.90	-0.4	0.16	0.04
4.4	3.38	1.02	1.04	0.31
4.8	4.95	-0.15	0.02	0.005
497.4	497.91	0	----	174.26

3.2 Discussion of Results of Experiments (3) on the Prototype without Maintenance

The chi-square (X^2)value of 174.26 is interpreted from the X^2 tables (3) and (4) of probability value at 0.10 level of significance. The degree of freedom necessary to intercept X^2 values are always determined from the frequency table by the number of rows minus one, times the number of columns minus one (r – 1) (C – 1) ie (8 – 1) (8 - 1) = 49. The obtained value of x^2 = 174.26 is large than the critical value of 63.1671, and falls in the rejection region. Thus null hypothesis (H_0) is rejected. The study shows that there is a significant difference between the actual experiment and theoretically expected result, which led to the rejection of (H_0). Therefore the results expected of the model is not exactly the same with the prototype. This is due to superiority in the performance of the twelve Basins (prototype) when compared to the model. The fisher-test was further used to test the adequacy of each of the prototype and the model data. Thus, by the use of regression equation (Pearson product moment correlation coefficient, r), the researcher determined whether the sample variances between (0) and (E) for the two sets of data are respectively significantly different. To further test the hypothesis, If the population correlation coefficient is in fact, 0.00, the critical value of r = 0.235 is found smaller than the obtained value of r =0.825717929. Therefore, (H_0) is again rejected. This confirms that the performance of the Basins (Prototype) is really higher than the theory (model) with high component interaction. The scatter chart/diagram, and the regression equation show a positive perfect fit of the data within the least of squares.

In conclusion there is a relationship between the cost function and developments which depends on the action of the managing engineer when no maintenance is applied. Therefore simulation optimization is dependent on the minimization of expected cost. In this case, next year's productivity depends on this year's state of the Basins, when the managing engineer did not apply maintenance.

3. 3 Discussion of Results of Experiments (4) on the Prototype with Maintenance

The chi-square (X^2)value of 151.9 is interpreted from the probability value at 0.10 level of significance. The degree of freedom necessary to intercept X^2 values are always determined from the frequency table by the number of rows minus one, times the number of columns minus one (r – 1) (C – 1) ie (8 – 1) (8 - 1) = 49. The obtained value of x^2 = 151.9 is large than the critical value of 63.1671,and falls in the rejection region. Thus null hypothesis (H_0) is rejected. The study shows that there is a significant difference between the actual experiment and expected theoretical result, which led to the rejection of (H_0). Therefore, the results expected of the model is not exactly the same with the prototype. This is due to superiority in the performance of the Basins (prototype) when compared to the model.

The fisher-test was further used to test the adequacy of the prototype and the model data. Thus, by the use of regression equation – Pearson product moment correlation coefficient (r), the researcher determined whether the sample variances between (0) and (E) for the two sets of data are respectively significantly different. Tables 3.5, 3.6, 3.7 and figures 3.1and 3.2 are the computer solutions. To further test the hypothesis, If the population correlation coefficient is in fact, 0.00, the critical value of r = 0.198 is found smaller than the obtained value of 0.825717929. Therefore, (H_0) is again rejected. This confirms that the performance of the Basins (prototype) is really higher than the theory (model) with high component interaction. The scatter chart/diagram and the regression equation show a positive perfect fit of the data within the least of squares.

In conclusion there is a relationship between the benefit cost function and developments which depends on the action of the managing engineer or decision maker when maintenance is applied. Therefore simulation optimization is dependent on the minimization of expected revenue. In this case, next year's productivity depends on this year's state of the Nigerian River Basins, when the decision maker applies maintenance.

4 CONCLUSION

The study shows that there is a significant difference between the actual experiment of the twelve River Basin schemes and expected theoretical result for both maintenance and without maintenance of the scheme, which led to the rejection of (H_0) . To further test the hypothesis, if the population correlation coefficient is in fact zero, critical values were found smaller than the obtained values. Therefore (H_0) was again rejected. This confirms that the performance of the River Basins were really higher than the model with high component interaction. The scatter diagram and the regression equation show a positive perfect fit of the data within the least of squires.

There is a relationship between the cost function and developments which depends on the action of the managing engineer when no maintenance is applied. Therefore simulation optimization is dependent on the minimization of expected cost. In this case next year's productivity depends on this year's state of the system when the managing engineer did not apply maintenance. Also there is a relationship between the benefit function and developments which depends on the action of the decision maker when maintenance is applied. Therefore simulation optimization is dependent on the maximization of expected revenue. In this case, next year's productivity depends on this year's state of the system, when the decision maker applies maintenance.

References

Anderson, P.R Piwomi M. Wikenkamp J.A, Elam J. And Miller G (2008) "Multi-Objective Decision Model For Urban Water Use: Planning For A Regional Water Re-Use Ordinance" Institute of Technology, Chicago, Metropolitan Agency For Planning, Illinois Sutanable Technology ,Center.EPA Grant Number: X3832204 IIIinois.

Abdelaziz, B. and Sameh, M.(2001) "Application of Goal Programming in a Multi-Objective Reservoir Operation Model in Tunisia", European Journal of Operation Research, Vol.133, Issue 2,pp 352-369.

Anambra/Imo (2012)"Effect of Flood in South East Nigeria" A Report Submitted to the Anambra Imo River Basin Development Authority Owerri.

Battaglin, W.A., Hay, L.E., Parker, R.S., and Leavesley, G.H., (1993) "Application of a Gis for Modeling the Sensitivity of Water Resources to Alterations in Climate in the Gumison River Basin Colorado", Resources Bull. Vol. 29, No. 6, pp.1021-1028.

Bredehoeft, J.D and Young, R.A., (1983)"Conjunctive Use of Groundwater and Surface water for Irrigated Agriculture: Risk Aversion" Water Resources Research, vol. 19, pp. 1111-1121.

Brown, T.C., Harding, B, L. and Paytn, E. A.,(1990) "Marginal Economic Value of Stream flow: A Case Study for the Colorado River Basin" Water Resources Research Wreraq Vol., 26, N0. 12pp.2845-2859.

Brown., T.C., (1988) "Consumptive Use of Stream Flow Increases in the Colorado River Basin" Water Resources Bulletin Warbag Vol24, N0 4, pp. 801-814.

Booker, J.F., and Young, R.A.,(1994) "Modeling Interstate and Markets for Colorado River Water Resources", Journal of Environmental Economics and Management. Vol. 26, N0. 1, pp.66-87.

Bogle, M.G.V and Osullivan, M,J(1979) "Stochastic Optimization of a Water Supply System" Water Resources Research Vol. 15, No 4, pp. 778-786.

Buras, N.,(1963) "Conjunctive Operation of Dams Aquifers", Journal of Hydraulic Div., American Society of Civil Engineering., Vol. 89(HY-6), pp.111-133.

Burt, O.R.,(1964) "The Economics of Conjunctive Use of Ground and Surface Water", Hilgradia, vol. 36(2), pp.31-111.

Can, E.K And Houck, M.H.,(1985) "Problems with Modeling Real-Time Reservoir Operation", Journal of Water Resources Planning and Management (ASCE) Jwrmd 5 Vol. 111, No 4, Pp.367-381.

Can, E.K., and Houck, M.H.,(1984) "Real-Time Reservoir Operations by Goal Programming", Journal of Water Resources Planning and Management, Vol. 110, No. 3, Pp., 297-309.

Dr. Luke C. Eme is a Senior Lecturer and former Head of Department of Civil Engineering, Anambra State University, Uli-Nigeria. He holds First Degree, Masters of Engineering and Doctor of Philosophy Degrees in Civil Engineering with Distinctions and Specializes in Water Resources Engineering and Environmental Engineering. He is a member of many professional bodies and organizations which include: IWA London, AASRC etc. He had received many prizes/awards nationally and internationally such that the outcome his Ph.D research work in 2012 at Anambra State University accorded him an International Award from Glen Daigger, President of the International Water Association London in the form of Books/Journals which he donated to the Library of Anambra State University. He received the honor for emerging first at a poster presentation held to

mark the Association's 2012 World Water Congress and Exhibition, during the competition held from September 16 to 21, at Bussan, Korea, a total of 387 poster presenters participated. Out of this number, five were short listed for the finals where Dr. Eme's presentation was chosen as the best in the World. He had several other publications.