Infinite Stage Simulation Model Optimization Solution Using Exhaustive Enumeration Method for the Anambra/Imo River Basin Engineering Development Scheme, Nigeria.

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Abstract. This paper applied Exhaustive Enumeration Method of Markovian Decision theory and considered N12.3 billion released from 2007 to 2011 for capital projects to Anambra / Imo River Basin Development Authority, Nigeria under the supervision of Federal Ministry of Water Resources in Nigeria, with the sole aim at optimization of allocation to various projects and maximization of expected revenue to the Authority. The developmental projects are: Irrigation, Water Supply, Hydro – electric Power Generation, Flood Control, Drainage, Navigation, Recreation/Tourism and Erosion Control.

The objectives optimized in stages as a multi – stage decision problems are: Economic Optimization, Federal, Regional State and Local Economic Redistribution, Social Well – being, Youth Employment and Environmental Quality Improvement.

The problem then becomes how to allocate (apportion) the N12.3billion limited developmental funds among the various projects so as to optimize the returns even under the worst conflict situation.

Methodology involves methods and experiments and data were collected from Anambra / Imo River Basin Authority, Owerri, Ministries and Parastatals.

From interpretation of the results of the experiments, Policy 10 yields the largest expected yearly revenue of N2.7billion under the worst conflict condition. The developmental projects should be apportioned by the planning and management engineer as follows: Irrigated Agriculture (N0.24 billion), Water Supply (N.54billion), Hydroelectric Power Generation (N.84billion), Flood Control (N1.08billion), Drainage (N1.42billion), Navigation (N1.57billion), Recreation (N2.82billion) and Erosion Control (N3.8billion) for optimal solution in maximization of investment on the River Basin which has limited fund allocated to it from Federal budget.

Keywords: Allocation, Limited -Fund, Optimization, Investment, River Basin.

1 INTRODUCTION

Most of the previous works on multi-purpose Water Resources and Environmental Engineering Development project planning with regard to optimization have considered a single objective; this objective in question is economic optimization. However, in real life situation this is not always the case; other objectives can play significant roles along-side economic efficiency to determine levels of development to be apportioned to various purposes involved in water resources projects.

Consequently, they cannot be ignored in thorough planning. Thus, the planning Engineer has considered benefits accruing from objectives outside economic efficiency as either too difficult and too abstract to measure or intangible. However, the fact is that these other objectives are considered very vital by interest groups at the level of authorization. Hence, the myth of immeasurability and intangibility of benefits accruing from them must be destroyed. Scientifically, all measures are relative. Therefore, intangibility and immeasurability cannot be in absolute terms. Hence, there must be a measure for a benefit that exits. As a matter of fact, a thorough analysis of benefits in the light of, for instance, a multi-purpose dam project can show that tangible benefits are accruable under each of the objectives. It can also be plausible to consider the benefit accruable by each purpose (development) to vary with respect to each objective.

In view of the fore going, it becomes necessary in multi-purpose water resources planning to consider not only economic efficiency but also any other objectives that may be deemed necessary at planning stage for explicit, exhaustive and effective decision making. In the same vein, it is necessary to look at simulation modeling in optimization in multi-purpose water resources projects from the point of view of multi-objectivity. Then, we can set our mind on resolving the engineering conflict situation arising from it with markovian decision theory and the overall performance of the system.

The Anambra / Imo River Basin Development Authority usually encounters some problems and constraints in executing its statutory functions ,some of the major problems of constraints include: late approval of yearly appropriations, non release of expected capital funds resulting to indebtedness hence completion of jobs awarded is impaired. Most project execution are not started or completed within the year of approval but can run-over to the next year. The delay may result to non assessment of approved funds, which put the Authority always in conflict with the limited fund.

So from the objective of this paper it determined the way of optimization of allocation of limited fund to the Authority, in a case of multi-purpose/ multi-objectivity by solving the problem with respect to the area of authorization, such as vandalization, kidnapping, disagreement between Federal Government, Planning Engineers, and Interest Groups. During the problem in question, economic optimization was the only objective considered.
A benefit study of the eight developmental projects under each of the eight objectives was carried out. The summary of out come of the study is shown in table 1.0 (net benefits) and table 2.0 (gross benefits).

2 METHODS

Methodology involves methods and experiments and data were collected from Anambra/ Imo River Basin Authority Owerri, Ministries, and Parastatals.

The analysis and presentation of results were based on the steady-state behavior of a Markovian process which is independent of the initial state of the system. This model is interested in evaluating policies for which the associated Markov chains allow the existence of a steady-state solution to provide the conditions under which a Markov chain can yield steady-state probabilities.

There are two methods for solving the infinite-stage problem. The first method calls for evaluating all possible stationary policies of the decision problem faced by the planning and managing engineer. This is equivalent to an exhaustive enumeration process and can be used only if the number of stationary policies is reasonably small.

The decision problem faced by the Engineer has total of S. stationary policies, and that P^s, R^s, are the (one-step) transition and revenue matrices associated with the policy, S = 1, 2, ... , S.

Table 1.0 (with maintenance)
(Net) Benefits to N12.3 Billion released from 2007 to 2011 for Capital Project to Anambra / Imo River Basin Development Authority under various objectives.

Development project	Objectives							
	Economic Efficiency	Federal Economic Redistribu-Tion	Regional Economic Redistribu-Tion	State Economic Redistribu-tion	Local Economic Redistribu-Tion	Social Well-Being	Youth Employ Ment	Environ mental Quality Improve-Ment
Irrigation	0.17	0.99	1.58	0.89	0.85	1.08	1.0	1.04

Water supply	1.32	0.94	1.62	0.93	0.87	1.13	1.05	1.09
Hydro-electric Power Generation	0.60	2.59	3.23	2.41	2.3	1.62	1.5	1.58
Flood control	0.96	0.36	2.5	0.39	0.41	2.86	2.79	2.81
Drainage	0.92	0.94	3.23	0.91	0.83	2.97	2.86	2.93
Navigation	-0.64	2.39	3.95	2.2	2.04	3.31	3.21	3.27
Recreation	0.82	0.94	3.24	0.84	0.80	3.32	3.20	3.28
Erosion Control	0.52	0.74	2.36	0.78	0.78	2.2	2.0	2.16

Table 2.0 (without maintenance)
(gross) benefits to n12.3 billion released from 2007 to 2011 for capital project to anambra / imo river basin development authority under various objectives

Development Projects	Objectives							
	Economic Efficiency	Federal Economic Redistribu-Tion	Regional Economic Redistribu-tion	State Economic Redistribu-Tion	Local Economic Redistrib ution	Social Well-being	Youth Employ Ment	Environ mental Quality Improve-ment
Irrigation	0.25	1.24	2.98	1.11	1.06	1.35	1.25	1.3
Water supply	1.5	1.18	2.03	1.16	1.09	1.13	1.31	1.36
Hydro electric Power Generation	0.69	3.24	4.04	3.01	2.88	2.03	1.88	1.98
Flood control	5.78	0.45	3.13	0.49	0.51	3.58	3.49	3.51
Drainage	0.22	1.18	4.04	1.14	1.04	3.71	5.58	3.66
Navigation	4.0	2.99	4.94	2.75	2.55	4.14	4.01	4.09
Recreation	4.91	1.18	4.05	1.05	1.0	4.15	4.0	4.10
Erosion Control	2.25	0.93	2.95	0.98	0.98	2.75	5.0	2.7

3 RESULTS AND CONCLUSION

The results are interpreted as follows: (i) Policy 10 yields the largest expected yearly revenue of N2.7billion under worst conflict condition when ever the Anambra – Imo River Basin Engineering Development projects are in state 8 (very poor). From the result of the infinite stage simulation model optimization solution for policy (decision) 10 yields:

π^{10}_{1} represents Irrigated Agriculture = 0.0193
π^{10}_{2} represents Water Supply = 0.0441
π^{10}_{3} represents Hydro-Electric Power Generation = 0.0671
π^{10}_{4} represents Flood Control = 0.0876
π^{10}_{5} represents Drainage = 0.1158

π^{10}_{6}	represents	Navigation	=0.1279
π^{10}_{7}	represents	Recreation	= 0.2292
π^{10}_{8}	represents	Erosion Control	=0.3092

(ii) The result in policy 10 means that the eight objectives were optimal in multi-stages under the worst possible conflict condition. The development should be apportioned by the planning and management engineer as follows:

π^{10}_{1}	Irrigated Agriculture	---- 0.0193	= .24 Billion
π^{10}_{2}	Water Supply	---0.0441	= 0.54 Billion
π^{10}_{3}	Hydro-Electric Power Generation	---- 0.0671	= 0.83 Billon
π^{10}_{4}	Flood Control	--- 0.0876	= 1.08 Billion
π^{10}_{5}	Drainage	--- 0.1158	= 1.42 Billion
π^{10}_{6}	Navigation	--- 0.1279	= 1.57Billion
π^{10}_{7}	Recreation	--- 0.2292	= 2.82Billion
π^{10}_{8}	Erosion Control	--- 0.3092	= 3.80Billion
E^{10}	represents expected yearly revenue:		=2.7Billion

(iii) When ever the Anambra – Imo River Basin Engineering Development is apportioned as in policy 10, from the limited available fund of the Federal Ministry of Water Resources release of N12.3Billion (from 2007 to 2011) at least a revenue of 2.7Billion was achieved under the worst conflict condition

(iv) The matrices P^s and R^s for policy 8 through 21 which are derived from policy 1 and 2 means that the River Basin has a minimum capacity utilization of eight years and maximum capacity utilization of the basin's assets of twenty one years.

References

Federal Ministry of Water Resources (2010) "Anambra/Imo River Basin and Rural Development Authority" Annual Reports Audited Account Pp.2 and 25, 31st Dec.

John, M., (2011) "Intergrated Governance and Water," Magazine of the international Water Association, June, pp53.

Simonovic, S.P., (1992) "Reservoir Systems Analysis. Closing Gap Between Theory And Practice", Journal Of Water Resources Planning And Management, Vol. 118, No.3, Pp.262- 280,

Slobodan,P.S. (2000) "Water Management And Sustainability", Water International, Vol.25, Issue 1 Pp. 76-88.

Sonuga,J.O., (2000) Water Resources Management Problems In Developing Counties, Key Note Address, Conference Of Lahr Contact Committee For Africa.

Stamatelatos, M., (2002) Probabilistic Risk Assessment Procedures Guide for NASA Managers and Practitioners, NASA Office of Safety and Mission Assurance.

Still Water, L.C., (1993) "Upper Colorado River Simulation/ Optimization Model", In: Proceeding Of the Federal Interagency Workshop On Hydrologic. Modeling Demands for the 90's. Us Geological Survey Water Resources Investions Report 93-4018, Pp 7-13,

Stevens D., (1986) "Computer Models In Lower Colorado River Operation" Journal of Water Resources L Planning and Management (ASCE) Jwrmd 5 Vol. 112. N0. 3, Pp 395-408,

U.S. Congress, (1971) Procedures for Evaluation of Water and Related Land Resources Projects, Senate Committee on Public Works, 92nd Congress, 1st Session, Pp. 6-11.

U.S. Water Resources Council, Special Task Force, (1970a) Principles for Planning Water And Land Resources Projects, Washington D.C.

U.S. Water Resources Council, Special Task Force, (1970b) A Summary Analysis of Nineteen Tests of Proposed Evaluation Procedures on Selected Water And Land Resources Projects, Washington D.C.

U.S. Water Resources Council, Special Task Force, (1977) Proposed Principles And Standards For Planning Water And Related Land Resources, Federal Register., Vol 36, N0. 245, Pp24, 144-24, 194.

Vesely, A Miral L.I and Daly S.A (2002) Fault Tree Handbook With Aerospace Applications NASA Office Of Safety And Mission Assurance.

Wurbs, R.S., (1993) "Reservoir System Simulation And Optimization Models" Journal Of Water Resources Planning And Management (ASCE) Jwrnds, Vol. 119, No 4. Pp. 455-475.

Yi Jaceung, (1996) Decision Support System for Optimal Basin-Wide Scheduling Of Hydro Power Units.

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