

# Analysis of BEME on the multipurpose objective projects in South-Eastern River Basin, Nigeria.

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## ABSTRACT

The study was aimed to analyze the Bill of Engineering measurement and Evaluation (BEME) calculated from the data obtained for full capacity utilization of the river basin resources. The objective was to use the net benefits obtained from the BEME to analyze the various Net benefits against the purpose in a multi-purpose/multi-objective South-East river basin development capital projects for optimization of the resources at the river basin. The methodology involve method/experiment as a solution problem by calculating the data from ministries/parastatals and river basin area to obtain Net benefits values for optimal utilization of the river basin assets. The purpose and Net benefits were analyzed using descriptive statistics like graphical analysis for the optimization of the river basin resources. The result shows that the highest net benefits was on economic efficiency under Reservoir/Gullies with ₦72 billion while the lowest net benefit was on Gender Equality under irrigation Agriculture with a figure of ₦1.12billion. This values were used as basis for further iteration on analysis of Bayesian and Game Decision theory model to optimize the resources at the river basin.

**Keyword:** Optimization, Net benefits, resources, river basin, purpose, objectives

## I. INTRODUCTION

Water resources planning consists of orderly consideration of a project from the original statement of purpose through the evaluation of alternatives to the final decision on a course of action. Planning for water resources development project consists of main, secondary and

miscellaneous purposes respectively. The main purposes are for irrigation, hydroelectric power generation, flood control, domestic and industrial water supply for municipal use and navigation. The secondary purposes are for drainage control, watershed management, sedimentation control, salinity control, pollution control, fish and wild life, recreational use of water and artificial precipitation. Miscellaneous purposes may include employment and increased income sources for better living standard, and acceleration of various public works for regional development. Water requirements are multipurpose projects when they serve more than one purpose. The objectives may include; increased agricultural production, industrial development of the area, improvement in the living standard of people, social stability etc. There could be variation in the objectives depending upon the particular agency planning the project.

## II. METHODOLOGY

This includes the study area, which would help in the determination of Bill of Engineering Measurement and Evaluation (BEME) used in the analysis for various objectives and purpose in the river basin.

### 2.1 Study Area

The South-Eastern River Basin studied in this research work is situated at South-East states of Nigeria. It covers Enugu, Anambra, Imo with part of Abia and Ebonyi States of Nigeria. The area lies between latitudes 5°N and 7°N and longitudes 6.5°E and 7.8°E.

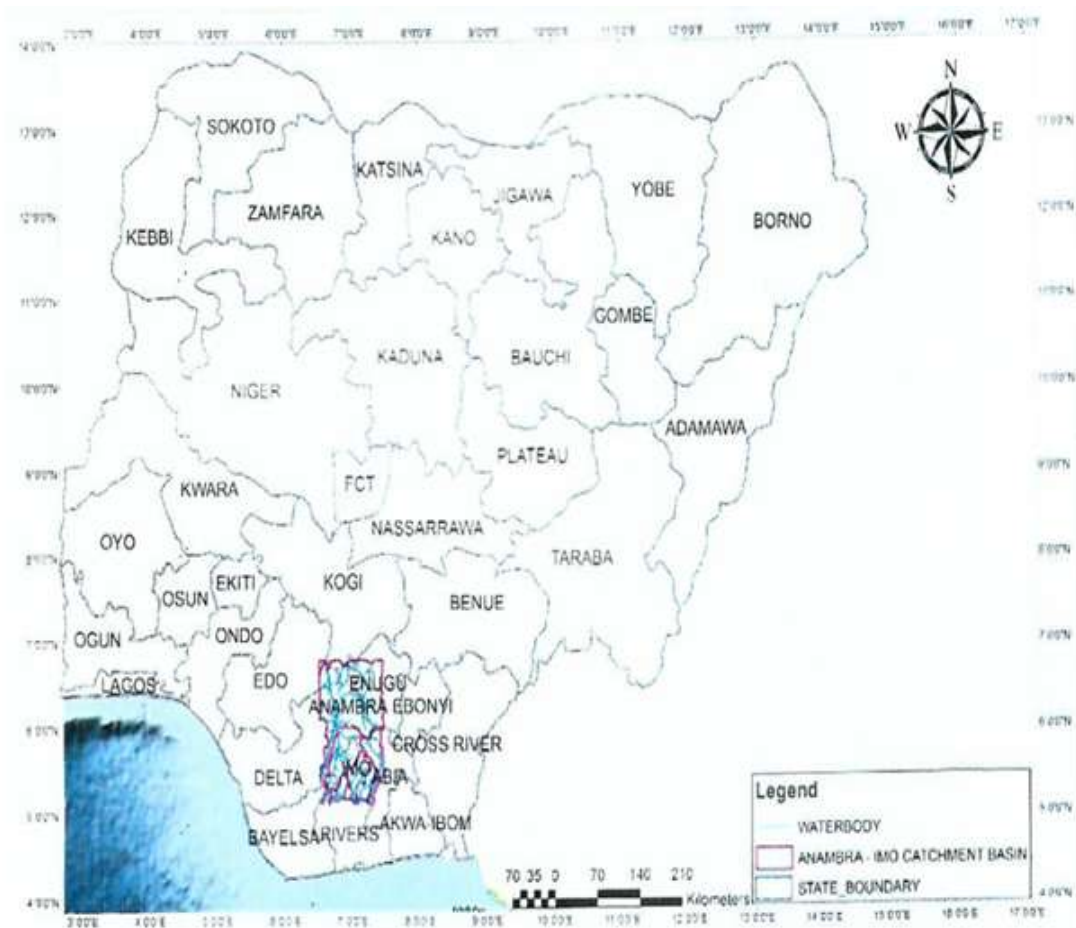


Figure 1: Map of Nigeria showing South-Eastern River Basin

Source: goggle map from Anambra-Imo River Basin

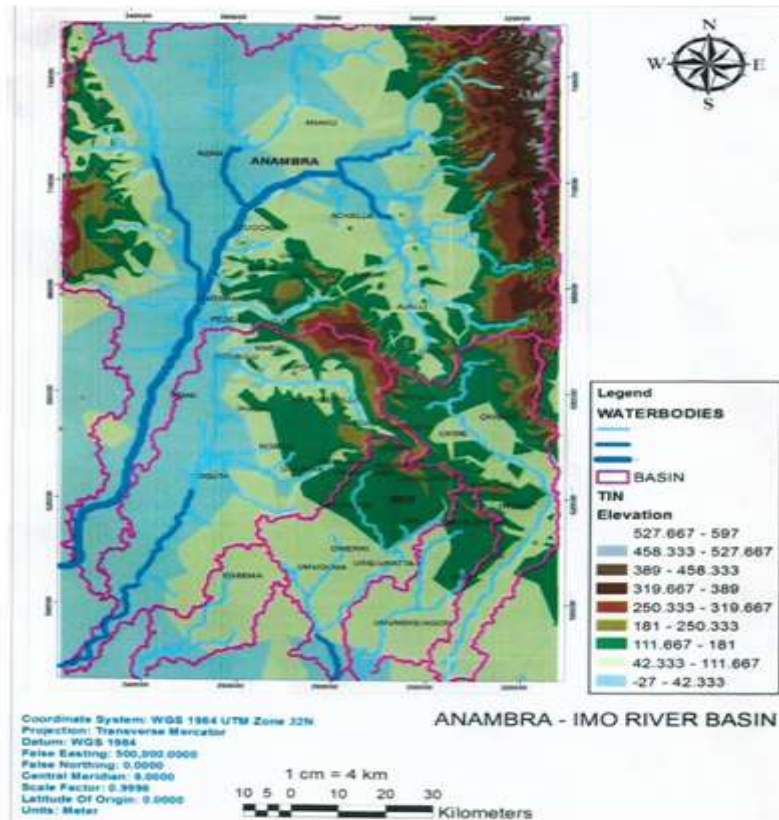


Figure 2: Elevation Map of the River Catchment Basin within Anambra-Imo River Basin  
 Source: goggle map from Anambra-Imo River Basin

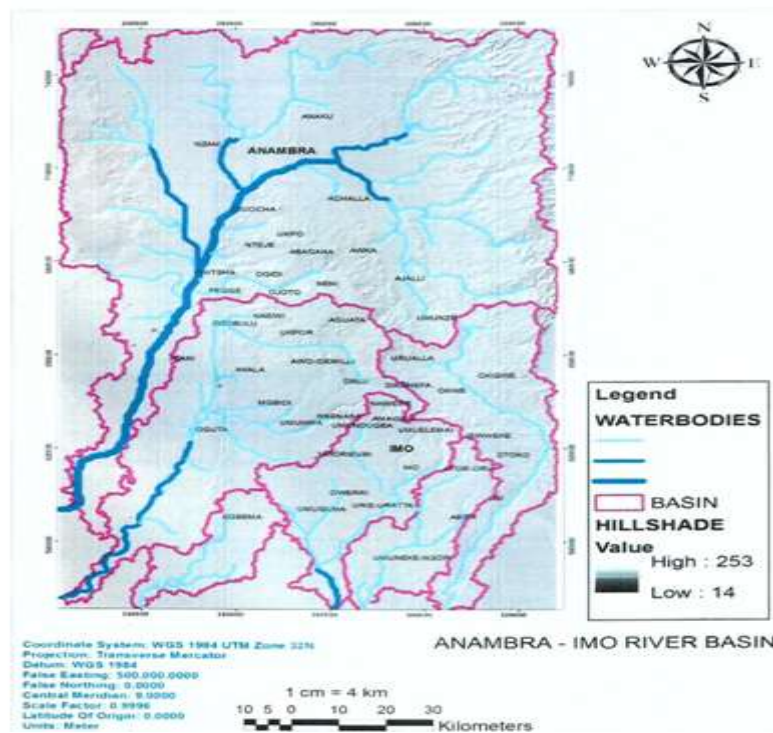


Figure 3: Water bodies in South-Eastern River Basin  
 Source: goggle map from South-Eastern River Basin

**2.2 Method/Experiment:** The experiment involved in the collection of data based on the information from ministries/parastatals and river basin to obtain the net benefits used in the analysis of BEME. The main objectives in a Multi-objective water resources development considered in this research are; (i) Economic efficiency, (ii) Federal Economic Redistribution, (iii) Regional Economic Redistribution, (iv) State Economic Redistribution, (v) Local Economic Redistribution (vi) Social Well-being, (vii) Youth Empowerment, (viii) Environmental Quality Improvement, (ix) Gender Equality, (x) Security Improvement.

- (a) Irrigation entails improvement on land value and yields from agricultural activities.
- (b) Hydro-electric power generation from net returns from the sale of electrical energy.
- (c) Water supply which are net returns from the sale of water
- (d) Water Transport/Navigation,
- (e) Drainage/ Dredging of rivers – value of areas of land drained and reclaimed.
- (f) Flood control: value of land area protected from flood.
- (g) Recreation / Tourism – area of land value designated for recreation purposes.
- (h) Erosion control: area of land reclaimed and protected from erosion menace

- (i) Plantation / Forestry: plantation intended to reduce carbon emission from fossil fuel in the environment
- (j) Reservoir / Gullies to encourage the generation of hydro-electric power.

**2.3 Experimental Area**

The river basin covered the five South east states of Nigeria: (i) Abia State (ii) Anambra State (iii) Ebonyi State (iv) Enugu State and (v) Imo State. The estimated populations of the five states were projected based on 2006 census every decade including year 2022 to year 2056 – using geometric extrapolation method.

**III. ANALYSIS AND DISCUSSION OF RESULTS**

**3.1 Population estimation for the Study area**

For example for Abia State,

$$N_t = P \cdot e^{rt}, N_{2016} = P_{2016} \cdot e^{0.03 \times 10}$$

$$N_{2016} = 2,845,380 \times e^{0.3} = 3,840,861$$

$$N_{2022} = 2,845,380 \times e^{0.03 \times 16} = 4,598,346$$

$$N_{2026} = 2,845,380 \times e^{0.03 \times 20} = 5,184,620$$

$$N_{2036} = 2,845,380 \times e^{0.03 \times 30} = 6,998,506$$

$$N_{2046} = 2,845,380 \times e^{0.03 \times 40} = 9,446,994$$

$$N_{2056} = 2,845,380 \times e^{0.03 \times 50} = 12,752,108$$

Table 1: Population of the South-Eastern States of Nigeria

S/N	States	2006	2016	2022	2026	2036	2046	2056
1	Abia	2,845,380	3,840,861	4,598,346	5,184,620	6,998,506	9,446,994	12,752,108
2	Anambra	4,177,828	5,639,478	6,751,681	7,612,499	10,275,799	13,870,877	18,873,726
3	Ebonyi	2,176,947	2,938,571	3,518,108	3,966,656	5,354,426	7,227,719	9,756,340
4	Enugu	3,267,837	4,411,119	5,281,068	5,954,387	8,037,582	10,849,601	14,645,429
5	Imo	3,927,563	5,301,656	6,347,234	7,156,486	9,660,246	13,039,968	17,602,116
6	<b>Total</b>	<b>16,395,555</b>	<b>22,131,685</b>	<b>26,496,437</b>	<b>29,874,648</b>	<b>40,326,559</b>	<b>54,435,159</b>	<b>73,629,719</b>

**3.2 Summary of Net benefits for all the objectives against the purposes in Billion naira from Bill of Engineering measurement and Evaluation (BEME)**

Table 2: Summary of Net Benefits for all the Objectives against the Purposes in Billion Naira

S/N	Purpose	B <sub>1</sub>	B <sub>2</sub>	B <sub>3</sub>	B <sub>4</sub>	B <sub>5</sub>	B <sub>6</sub>	B <sub>7</sub>	B <sub>8</sub>	B <sub>9</sub>	B <sub>10</sub>
(a)	Irrigated Agriculture	3.65	4.84	6.36	3.60	3.44	4.37	4.05	4.22	1.12	8.73
(b)	Hydro-electric power generation	13.38	7.55	9.60	9.68	9.29	5.46	6.05	6.39	1.37	10.95

(c)	Water supply	4.54	4.34	6.04	3.78	3.52	4.56	4.22	4.37	1.13	9.13
(d)	Navigation	8.30	5.83	10.46	8.19	8.24	11.39	10.96	12.20	3.33	25.77
(e)	Drainage/ Dredging	17.21	6.01	12.26	3.68	6.08	8.96	11.51	10.83	3.00	21.96
(f)	Flood control	19.43	5.58	10.20	3.39	1.55	8.68	10.32	11.35	2.90	22.12
(g)	Recreation / Tourism	16.93	3.94	10.36	3.42	3.33	10.57	11.33	12.25	3.33	25.94
(h)	Erosion control	13.91	3.01	10.27	3.15	3.26	9.56	7.13	8.72	2.21	16.78
(i)	Plantation / Forestry	14.01	6.83	8.08	6.40	6.59	8.96	7.66	8.40	2.26	18.08
(j)	Reservoir / Gullies	82.72	5.66	12.16	3.36	3.48	19.99	20.54	20.71	5.77	41.23

Where;

B<sub>1</sub> = Economic efficiency,  
Social Well-being,

B<sub>2</sub> = Federal Economic Redistribution,  
B<sub>7</sub> = Youth Empowerment,

B<sub>3</sub> = Regional Economic Redistribution,  
Environmental Quality Improvement,

B<sub>4</sub> = State Economic Redistribution,  
B<sub>9</sub> = Gender Equality,

B<sub>5</sub> = Local Economic Redistribution,  
B<sub>10</sub> = Security

B<sub>6</sub> =

B<sub>8</sub> =

a multipurpose water resources development involving irrigation agriculture, hydroelectric power generation, water supply, navigation, drainage/dredging, flood control, recreation/tourism, erosion control, plantation/forestry and reservoirs/gullies. The objectives were optimized in stages as a multi-stage decision problems which include economic efficiency, federal economic redistribution, regional, economic redistribution, state economic redistribution, local economic redistribution, social-well being, youth empowerment, environmental quality improvement, gender equality and security.

The benefits accruing to each purpose were determined as shown with data as collected and the analysis of the summaries were stated in the following Tables 3 to Table 12 below.

### 3.3 Analysis of Bill of Engineering Measurement and Evaluation (BEME) on the Multi-Purpose/Multi-Objective Projects

The consideration of ₦12.504 billion fund received by South-Eastern river basin for five year strategic plan 2015-2020 capital projects by Federal Ministry of water Resources in Nigeria for

#### (A). Economic Efficiency:

The results of net benefit under objective of economic efficiency are shown in Table 3

Table 3: Net Benefit under Economic Efficiency as Objective

S/N	Purpose	Abbreviation	Net Benefits (in billion naira)
(a)	Irrigated Agriculture	IA	3.65
(b)	Hydro-electric power	Hep	13.38
(c)	Water supply	WS	4.54
(d)	Navigation	NG	8.30
(e)	Drainage/Dredging	D/D	17.21
(f)	Flood control	FC	19.43
(g)	Recreation / Tourism	R/T	16.93
(h)	Erosion control	EC	13.91
(i)	Plantation / Forestry	P/F	14.01
(j)	Reservoir / Gullies	R/G	82.72

#### Discussion of Results in Table 3

(i). Table 3 shows the objectives of economic efficiency net benefit for various purposes.

(ii). Reservoirs and gullies has the highest benefits of ₦ 82.72 billion followed by ₦19.43 billion for Flood control, ₦17.21 billion for

drainage/dredging and others as stated in the table.  
 (iii).Irrigation agriculture has the least benefits of ₦3.65 billion

(iv).These are expected to yield more returns on investment in the river basin resources utilization.

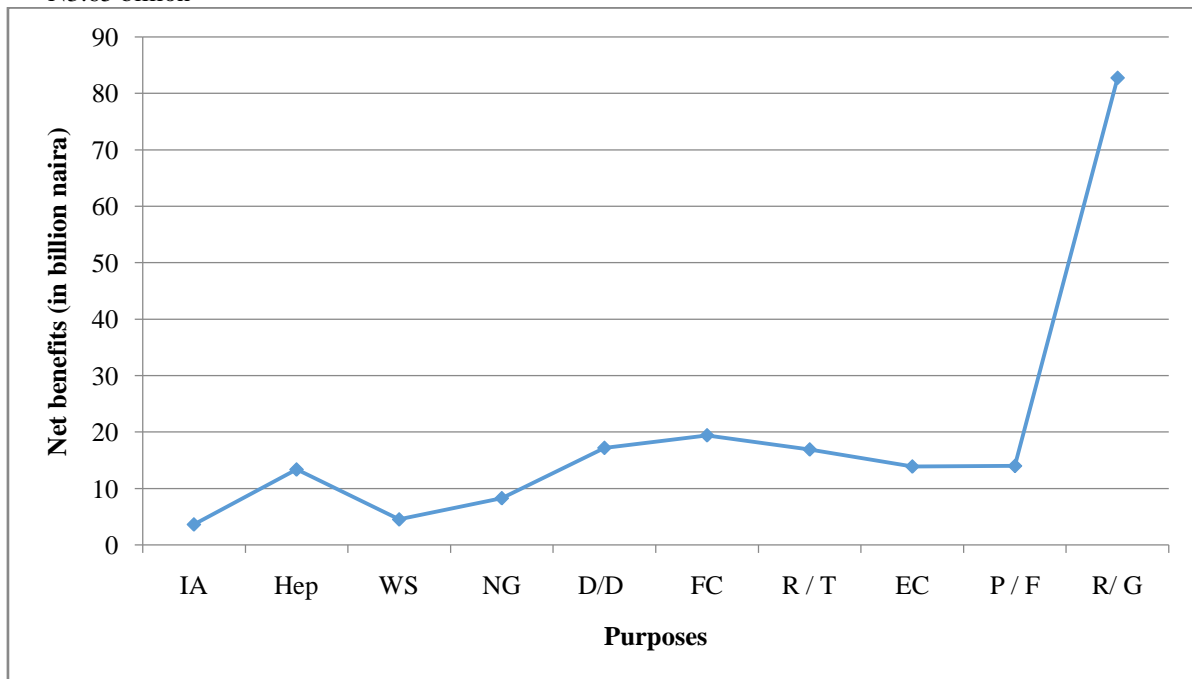


Figure 1: Graph of Net Benefit under Economic Efficiency as Objective

**Discussion of Results in Figure 1**

(i). This shows the net benefits under economic efficiency as objective to each project such as irrigation agriculture, hydroelectric power generation, water supply, navigation, drainage/dredging, flood control, recreation/tourism, erosion control, plantation/forestry and reservoirs/gullies.

(ii). The optimization of the objectives in stages as a multi-stage decision problem include: economic efficiency, federal economic redistribution, regional, economic redistribution, state economic

redistribution, local economic redistribution, social-wellbeing, youth empowerment, environmental quality improvement, gender equality and security.

(iii). The accruing benefits to each purpose were determined with the data collected.

**(B). Federal Economic Redistribution**

The results of net benefit under objective of Federal Economic Redistribution are shown in Table 4.

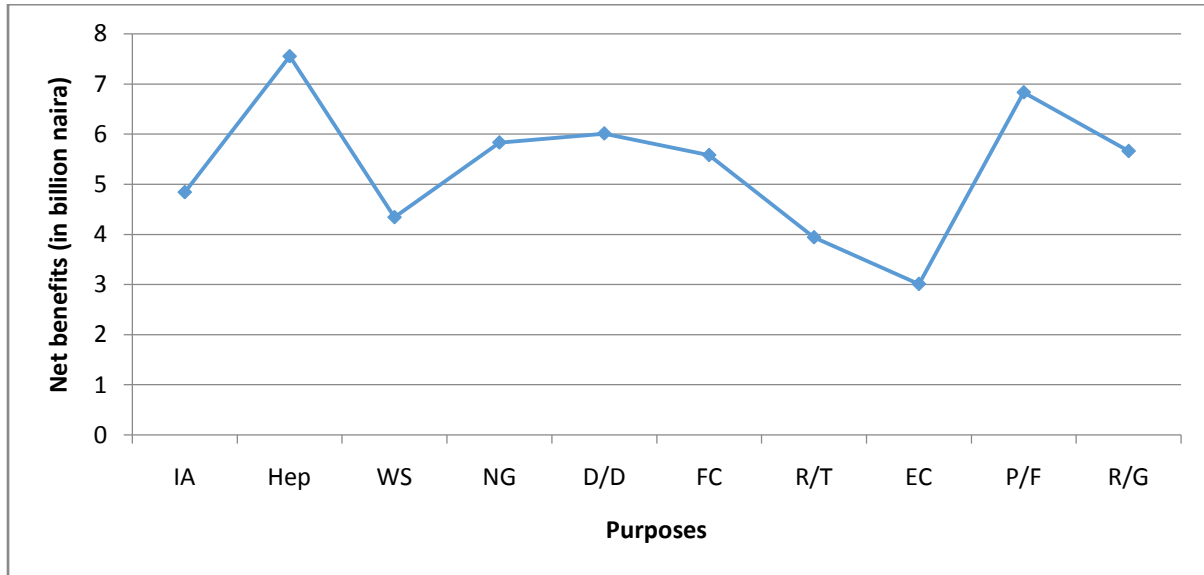
Table 4: Net Benefit under Federal Economic Redistribution as Objective

S/N	Purpose	Abbreviation	Net Benefits (in billion naira)
(a)	Irrigated Agriculture	IA	4.84
(b)	Hydro-electric power	Hep	7.55
(c)	Water supply	WS	4.34
(d)	Navigation	NG	5.83
(e)	Drainage/Dredging	D/D	6.01
(f)	Flood control	FC	5.58
(g)	Recreation / Tourism	R/T	3.94
(h)	Erosion control	EC	3.01
(i)	Plantation / Forestry	P/F	6.83
(j)	Reservoir / Gullies	R/G	5.66

**Discussion of Results in Table 4**

- (i). Table 4 shows the objectives of Federal Economic Redistribution net benefit for various purposes.
- (ii). Hydroelectric power generation has the highest benefits of ₦7.55 billion followed by ₦6.83

- billion for plantation/forestry, ₦6.01 billion for drainage/dredging and others as stated in the table.
- (iii). Erosion control has the least benefits of ₦3.01 billion
- (iv). These are expected to yield more returns on investment in the river basin resources utilization.



**Figure 2: Graph of Net Benefit under Federal Economic Redistribution as Objective**

**Discussion of Results in Figure 2**

- (i). This shows the net benefits under Federal Economic Redistribution as objective to each project such as irrigation agriculture, hydroelectric power generation, water supply, navigation, drainage/dredging, flood control, recreation/tourism, erosion control, plantation/forestry and reservoirs/gullies.
- (ii). The optimization of the objectives in stages as a multi-stage decision problem include: economic efficiency, federal economic redistribution, regional, economic redistribution, state economic

- redistribution, local economic redistribution, social-well being, youth empowerment, environmental quality improvement, gender equality and security.
- (iii). The accruing benefits to each purpose were determined with the data collected.

**(C). Regional Economic Redistribution**

The results of net benefit under objective of Regional Economic Redistribution are shown in Table 5.

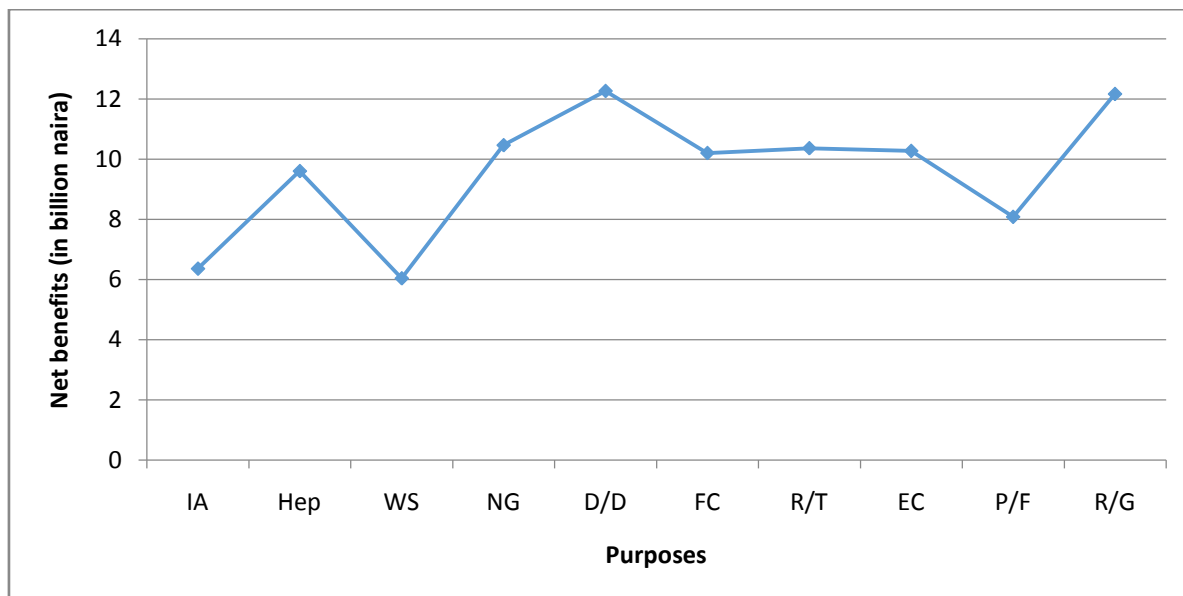
**Table 5: Net Benefit under Regional Economic Redistribution as Objective**

S/N	Purpose	Abbreviation	Net Benefits (in billion naira)
(a)	Irrigated Agriculture	IA	6.36
(b)	Hydro-electric power	Hep	9.60
(c)	Water supply	WS	6.04
(d)	Navigation	NG	10.46
(e)	Drainage/Dredging	D/D	12.26
(f)	Flood control	FC	10.20
(g)	Recreation / Tourism	R/T	10.36
(h)	Erosion control	EC	10.27
(i)	Plantation / Forestry	P/F	8.08
(j)	Reservoir / Gullies	R/G	12.16

**Discussion of Results in Table 5**

- (i). Table 5 shows the objectives of Regional Economic Redistribution net benefit for various purposes.
- (ii). Drainage/dredging has the highest benefits of ₦12.26 billion followed by ₦12.16 billion for

- Reservoir / Gullies, ₦10.46 billion for drainage/dredging and others as stated in the table.
- (iii). Water supply has the least benefits of ₦6.04 billion
- (iv). These are expected to yield more returns on investment in the river basin resources utilization.



**Figure 3: Graph of Net Benefit under Regional Economic Redistribution as Objective**

**Discussion of Results in Figure 3.**

- (i). This shows the net benefits under Regional Economic Redistribution as objective to each project such as irrigation agriculture, hydroelectric power generation, water supply, navigation, drainage/dredging, flood control, recreation/tourism, erosion control, plantation/forestry and reservoirs/gullies.
- (ii). The optimization of the objectives in stages as a multi-stage decision problem include: economic efficiency, federal economic redistribution,

- regional, economic redistribution, state economic redistribution, local economic redistribution, social-well being, youth empowerment, environmental quality improvement, gender equality and security.
- (iii). The accruing benefits to each purpose were determined with the data collected.

**(D). State Economic Redistribution**

The results of net benefit under objective of State Economic Redistribution are shown in Table 6.

**Table 6: Net Benefit under State Economic Redistribution as Objective**

S/N	Purpose	Abbreviation	Net Benefits (in billion naira)
(a)	Irrigated Agriculture	IA	3.60
(b)	Hydro-electric power	Hep	9.68
(c)	Water supply	WS	3.78
(d)	Navigation	NG	8.19
(e)	Drainage/Dredging	D/D	3.68
(f)	Flood control	FC	3.39
(g)	Recreation / Tourism	R/T	3.42
(h)	Erosion control	EC	3.15
(i)	Plantation / Forestry	P/F	6.40
(j)	Reservoir / Gullies	R/G	3.36

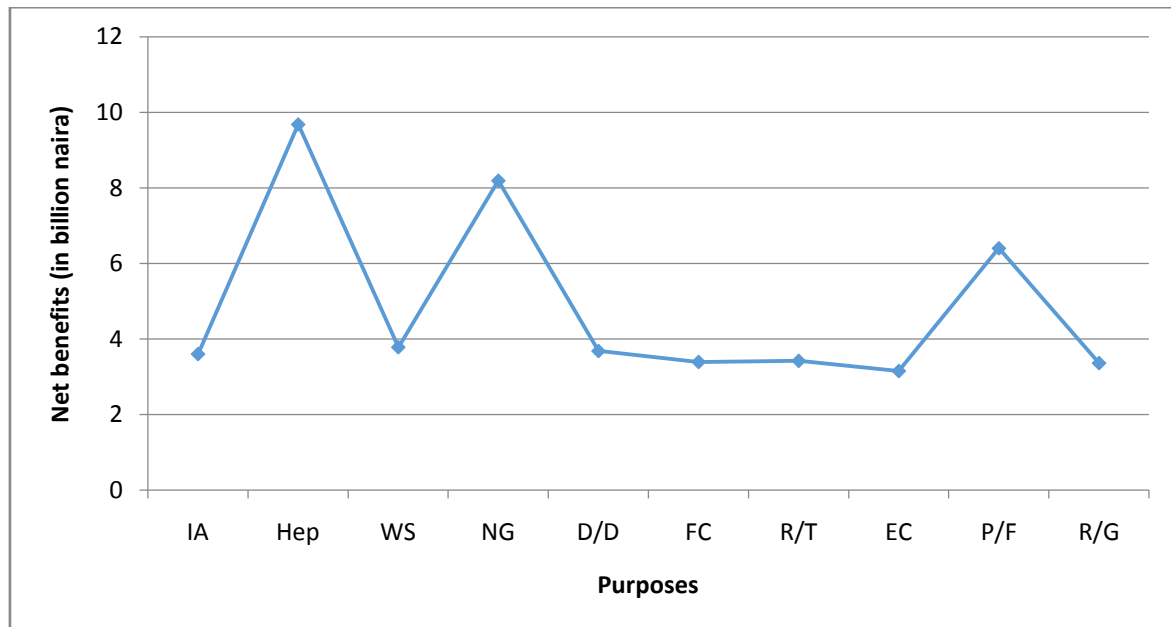


**Discussion of Results in Table 6**

- (i). Table 6 shows the objectives of State Economic Redistribution net benefit for various purposes.
- (ii). Hydro-electric power generation has the highest benefits of ₦9.68 billion followed by ₦8.19 billion for Navigation, ₦6.40 billion for

Plantation/Forestry and others as stated in the table.

- (iii). Erosion control has the least benefits of ₦3.15 billion
- (iv). These are expected to yield more returns on investment in the river basin resources utilization.



**Figure 4: Graph of Net Benefit under State Economic Redistribution as Objective**

**Discussion of Results in Figure 4**

- (i). This shows the net benefits under State Economic Redistribution as objective to each project such as irrigated agriculture, hydroelectric power generation, water supply, navigation, drainage/dredging, flood control, recreation/tourism, erosion control, plantation/forestry and reservoirs/gullies.
- (ii). The optimization of the objectives in stages as a multi-stage decision problem include: economic efficiency, federal economic redistribution,

regional, economic redistribution, state economic redistribution, local economic redistribution, social-well being, youth empowerment, environmental quality improvement, gender equality and security.

- (iii). The accruing benefits to each purpose were determined with the data collected.

**(E). Local Economic Redistribution**

The results of net benefit under objective of Local Economic Redistribution are shown in Table 7.

**Table 7: Net Benefit under Local Economic Redistribution as Objective**

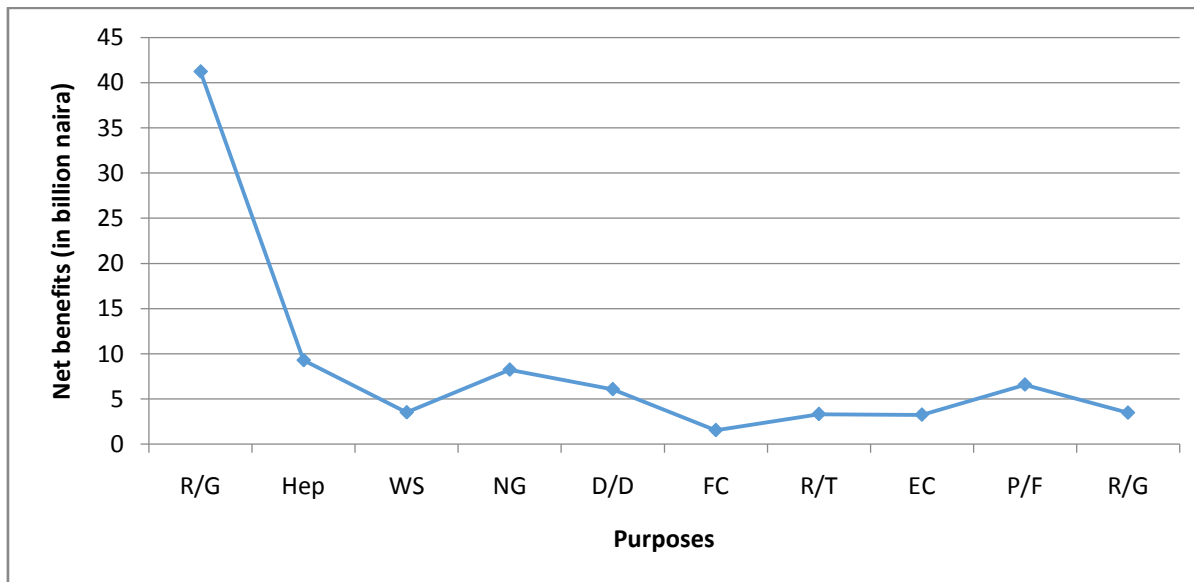
S/N	Purpose	Abbreviation	Net Benefits (in billion naira)
(a)	Irrigated Agriculture	IA	3.44
(b)	Hydro-electric power	Hep	9.29
(c)	Water supply	WS	3.52
(d)	Navigation	NG	8.24
(e)	Drainage/Dredging	D/D	6.08
(f)	Flood control	FC	1.55
(g)	Recreation / Tourism	R/T	3.33
(h)	Erosion control	EC	3.26
(i)	Plantation / Forestry	P/F	6.59
(j)	Reservoir / Gullies	R/G	3.48

**Discussion of Results in Table 7**

- (i). Table 7 shows the objectives of Local Economic Redistribution net benefit for various purposes.
- (ii). Hydro-electric power generation has the highest benefits of ₦9.29 billion followed by ₦8.24 billion for Navigation, ₦6.59 billion for

Plantation/Forestry and others as stated in the table.

- (iii). Flood control has the least benefits of ₦1.55 billion
- (iv). These are expected to yield more returns on investment in the river basin resources utilization.



**Figure 5: Graph of Net Benefit under Local Economic Redistribution as Objective**

**Discussion of Results in Figure 5**

- (i). This shows the net benefits under Local Economic Redistribution as objective to each project such as irrigation agriculture, hydroelectric power generation, water supply, navigation, drainage/dredging, flood control, recreation/tourism, erosion control, plantation/forestry and reservoirs/gullies.
- (ii). The optimization of the objectives in stages as a multi-stage decision problem include: economic efficiency, federal economic redistribution,

regional, economic redistribution, state economic redistribution, local economic redistribution, social-wellbeing, youth empowerment, environmental quality improvement, gender equality and security.

- (iii). The accruing benefits to each purpose were determined with the data collected.

**(F). Social Well-Being**

The results of net benefit under objective of Social Well-Being are shown in Table 8.

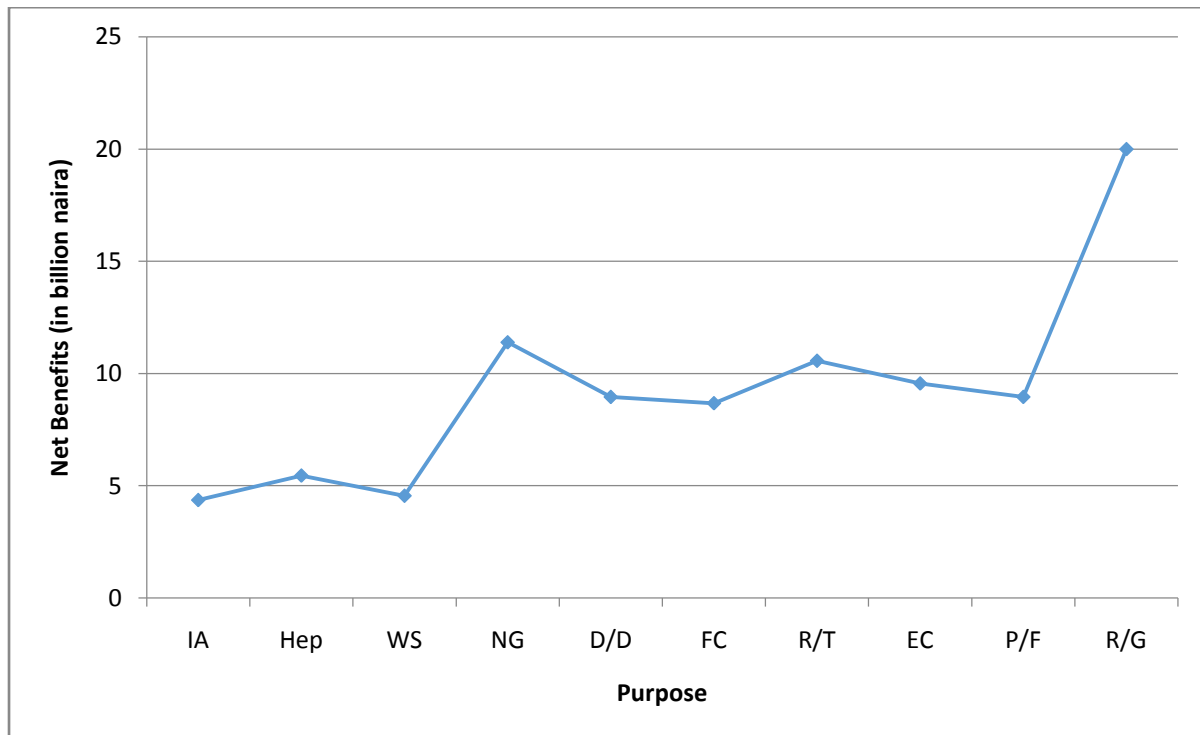
**Table 8: Net Benefit under Social Well-Being as Objective**

S/N	Purpose	Abbreviation	Net Benefits (in billion naira)
(a)	Irrigated Agriculture	IA	4.37
(b)	Hydro-electric power	Hep	5.46
(c)	Water supply	WS	4.56
(d)	Navigation	NG	11.39
(e)	Drainage/Dredging	D/D	8.96
(f)	Flood control	FC	8.68
(g)	Recreation / Tourism	R/T	10.57
(h)	Erosion control	EC	9.56
(i)	Plantation / Forestry	P/F	8.96
(j)	Reservoir / Gullies	R/G	19.99

**Discussion of Results in Table 8**

(i). Table 8 shows the objective of Social Wellbeing net benefit for various purposes.  
 (ii). Reservoir/Gullies has the highest benefits of ₦19.99 billion followed by ₦11.39 billion for Navigation, ₦10.57 billion for Recreation /Tourism and others as stated in the table.

(iii). Irrigation Agriculture has the least benefits of ₦4.37 billion  
 (iv). These are expected to yield more returns on investment in the river basin resources utilization.



**Figure 6: Graph of Net Benefit under Social Well-being as Objective**

**Discussion of Results in Figure 6**

(i). This shows the net benefits under social well-being as objective to each project such as irrigation agriculture, hydroelectric power generation, water supply, navigation, drainage/dredging, flood control, recreation/tourism, erosion control, plantation/forestry and reservoirs/gullies.  
 (ii). The optimization of the objectives in stages as a multi-stage decision problem include: economic efficiency, federal economic redistribution, regional, economic redistribution, state economic

redistribution, local economic redistribution, social-wellbeing, youth empowerment, environmental quality improvement, gender equality and security.  
 (iii). The accruing benefits to each purpose were determined with the data collected.

**(G). Youth Empowerment**

The results of net benefit under objective of Youth Empowerment are shown in Table 9.

**Table 9: Net Benefit under Youth Empowerment as Objective**

S/N	Purpose	Abbreviation	Net Benefits (in billion naira)
(a)	Irrigated Agriculture	IA	4.05
(b)	Hydro-electric power	Hep	6.05
(c)	Water supply	WS	4.22
(d)	Navigation	NG	10.96
(e)	Drainage/Dredging	D/D	11.51
(f)	Flood control	FC	10.32
(g)	Recreation / Tourism	R/T	11.33

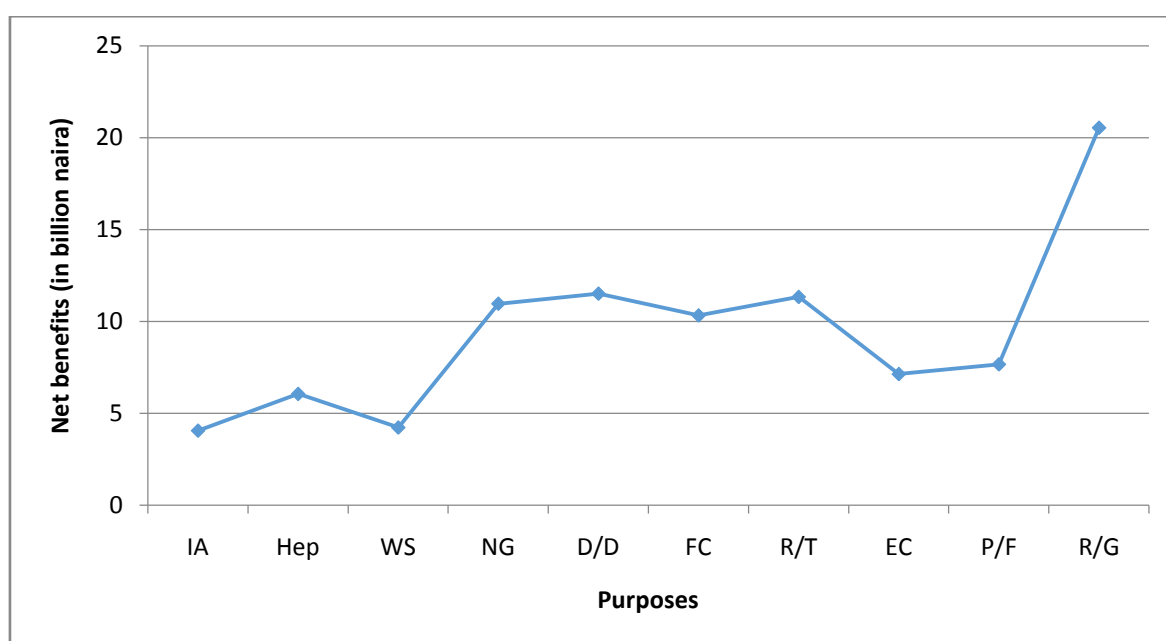
(h)	Erosion control	EC	7.13
(i)	Plantation / Forestry	P/F	7.66
(j)	Reservoir / Gullies	R/G	20.54

**Discussion of Results in Table 9**

- (i). Table 9 shows the objective of Youth Empowerment net benefit for various purposes.
- (ii). Reservoir/Gullies has the highest benefits of ₦20.54 billion followed by ₦11.51 billion for Drainage/Dredging, ₦11.33 billion for

Recreation /Tourism and others as stated in the table.

- (iii). Irrigation Agriculture has the least benefits of ₦4.05 billion
- (iv). These are expected to yield more returns on investment in the river basin resources utilization.



**Figure 7: Graph of Net Benefit under Youth Empowerment as Objective**

**Discussion of Results in Figure 7**

- (i). This shows the net benefits under Youth Empowerment as objective to each project such as irrigation agriculture, hydroelectric power generation, water supply, navigation, drainage/dredging, flood control, recreation/tourism, erosion control, plantation/forestry and reservoirs/gullies.
- (ii). The optimization of the objectives in stages as a multi-stage decision problem include: economic efficiency, federal economic redistribution, regional, economic redistribution, state economic

redistribution, local economic redistribution, social-well being, youth empowerment, environmental quality improvement, gender equality and security.

- (iii). The accruing benefits to each purpose were determined with the data collected.

**(H). Environmental Quality Improvement**

The results of net benefit under objective of Environmental Quality Improvement are shown in Table 10.

**Table 10: Net Benefit under Environmental Quality Improvement as Objective**

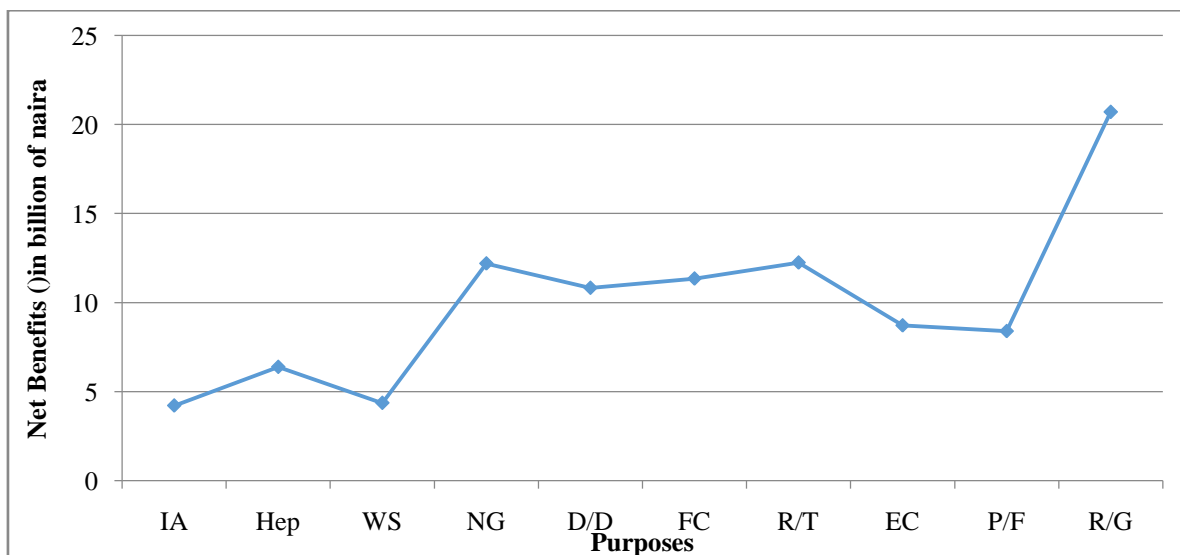
S/N	Purpose	Abbreviation	Net Benefits (in billion naira)
(a)	Irrigated Agriculture	IA	4.22
(b)	Hydro-electric power	Hep	6.39
(c)	Water supply	WS	4.37
(d)	Navigation	NG	12.20
(e)	Drainage/Dredging	D/D	10.83

(f)	Flood control	FC	11.35
(g)	Recreation / Tourism	R/T	12.25
(h)	Erosion control	EC	8.72
(i)	Plantation / Forestry	P/F	8.40
(j)	Reservoir / Gullies	R/G	20.71

**Discussion of Results in Table 10**

- (i). Table 10 shows the objective of Environmental Quality Improvement net benefit for various purposes.
- (ii). Reservoir/Gullies has the highest benefits of ₦20.71 billion followed by ₦12.25 billion for

- Recreation/Tourism, ₦12.20 billion for Navigation and others as stated in the table.
- (iii). Irrigation Agriculture has the least benefits of ₦4.22 billion
- (iv). These are expected to yield more returns on investment in the river basin resources utilization.



**Figure 8: Graph of Net Benefit under Environmental Quality Improvement as Objective**

**Discussion of Results in Figure 8**

- (i). This shows the net benefits under Environmental Quality Improvement as objective to each project such as irrigation agriculture, hydroelectric power generation, water supply, navigation, drainage/dredging, flood control, recreation/tourism, erosion control, plantation/forestry and reservoirs/gullies.
- (ii). The optimization of the objectives in stages as a multi-stage decision problem include: economic efficiency, federal economic redistribution,

- regional, economic redistribution, state economic redistribution, local economic redistribution, social-well being, youth empowerment, environmental quality improvement, gender equality and security.
- (iii). The accruing benefits to each purpose were determined with the data collected.

**(I). Gender Equality**

The results of net benefit under objective of Gender Equality are shown in Table 11.

**Table 11: Net Benefit under Gender Equality as Objective**

S/N	Purpose	Abbreviation	Net Benefits (in billion naira)
(a)	Irrigated Agriculture	IA	1.12
(b)	Hydro-electric power	Hep	1.37
(c)	Water supply	WS	1.13
(d)	Navigation	NG	3.33
(e)	Drainage/Dredging	D/D	3.00
(f)	Flood control	FC	2.90
(g)	Recreation / Tourism	R/T	3.33

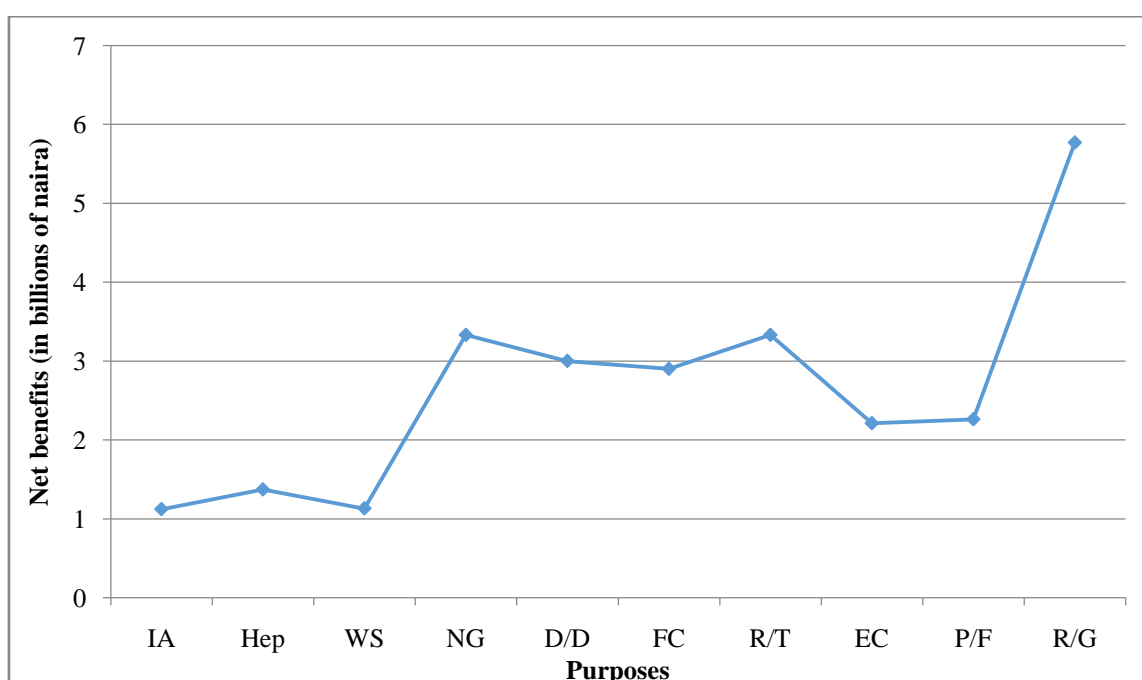
(h)	Erosion control	EC	2.21
(i)	Plantation / Forestry	P/F	2.26
(j)	Reservoir / Gullies	R/G	5.77

**Discussion of Results in Table 11**

- (i). Table 11 shows the objective of Gender Equality net benefit for various purposes.
- (ii). Reservoir/Gullies has the highest benefits of ₦5.77 billion followed by ₦3.33 billion for Navigation, ₦3.00 billion for

Recreation/Tourism and others as stated in the table.

- (iii). Irrigation Agriculture has the least benefits of ₦4.22 billion
- (iv). These are expected to yield more returns on investment in the river basin resources utilization.



**Figure 9: Graph of Net Benefit under Gender Inequality as Objective**

**Discussion of Results in Figure 9**

- (i). This shows the net benefits under Gender Inequality as objective to each project such as irrigation agriculture, hydroelectric power generation, water supply, navigation, drainage/dredging, flood control, recreation/tourism, erosion control, plantation/forestry and reservoirs/gullies.
- (ii). The optimization of the objectives in stages as a multi-stage decision problem include: economic efficiency, federal economic redistribution,

regional, economic redistribution, state economic redistribution, local economic redistribution, social-wellbeing, youth empowerment, environmental quality improvement, gender equality and security.

(iii). The accruing benefits to each purpose were determined with the data collected.

**(J). Security Improvement**

The results of net benefit under objective Security Improvement are shown in Table 12.

**Table 12: Net Benefit under Security Improvement as Objective**

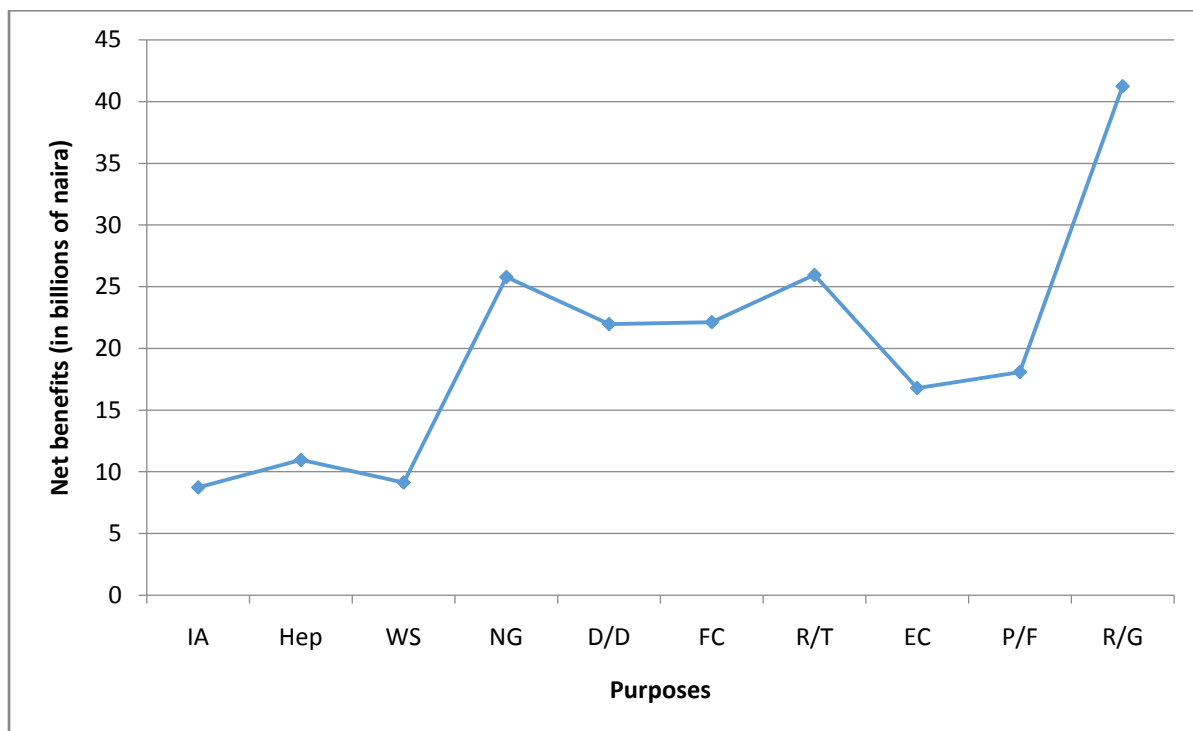
S/N	Purpose	Abbreviation	Net Benefits (in billion naira)
(a)	Irrigated Agriculture	IA	8.73
(b)	Hydro-electric power	Hep	10.95
(c)	Water supply	WS	9.13
(d)	Navigation	NG	25.77
(e)	Drainage/Dredging	D/D	21.96

(f)	Flood control	FC	22.12
(g)	Recreation / Tourism	R/T	25.94
(h)	Erosion control	EC	16.78
(i)	Plantation / Forestry	P/F	18.08
(j)	Reservoir / Gullies	R/G	41.23

**Discussion of Results in Table 12**

- (i). Table 12 shows the objective of Security Improvement net benefit for various purposes.
- (ii). Reservoir/Gullies has the highest benefits of ₦41.23 billion followed by ₦25.94 billion for Recreation/Tourism, ₦25.77 billion for Navigation and others as stated in the table.

- (iii). Irrigation Agriculture has the least benefits of ₦3.73 billion
- (iv). These are expected to yield more returns on investment in the river basin resources utilization.



**Figure 10: Graph of Net Benefit under Security Improvement as Objective**

**Discussion of Results in Figure 10**

- (i). This shows the net benefits under Security Improvement as objective to each project such as irrigation agriculture, hydroelectric power generation, water supply, navigation, drainage/dredging, flood control, recreation/tourism, erosion control, plantation/forestry and reservoirs/gullies.
- (ii). The optimization of the objectives in stages as a multi-stage decision problem include: economic efficiency, federal economic redistribution, regional, economic redistribution, state economic redistribution, local economic redistribution, social-well being, youth empowerment,

- environmental quality improvement, gender equality and security.
- (iii). The accruing benefits to each purpose were determined with the data collected.

**IV. CONCLUSION AND RECOMMENDATIONS**

The analysis of Bill of Engineering Measurement and Evaluation (BEME) was based on the information derived from the calculation of BEME at South-Eastern river basin for optimal utilization of the river basin resources. These were the basis for the use of other iterative processes like Bayesian decision theory model, Game decision theory model, chi-square test regression and

correlation analysis, trend in climate variability, prior-posterior iteration algorithm etc. to determine the optimal solution to mitigate the effects of climate change at the river basin.

#### REFERENCES

- [1]. Adebayo. H. and Oluwasegun. 2017, CIS Analysis of Flood Vulnerable Area in Benin Owena River Basin Nigeria, Indonesian Journal of Geography, **49**(1): 27-33
- [2]. Ahmadreza, S., Dastgerdi, M., Sargolini, S., Broussard, A., Allison, C. and Giuseppe, D. L. (2020). Climate Change and Sustaining Heritage Resources: A Framework for Boosting Cultural and Natural Heritage Conservation in Central Italy, **8**: 2-13.
- [3]. Amangabaral. G. T, (2015). Drainage Morphology of Into Basin in the Anambra-Imo river basin area, of Into State, Southern Nigeria. Journal of Geography, Environment and EarthScienceInternational, **3**(1): 1-11,2015; /Article no. JGEES/.17114
- [4]. Akpabio, F. M., Watson, N.M., lie. U. E. and Ckpong. 1. E. (2007) Integrated Whiter Resources Management in the Cross-River Basin. Nigeria. International Journal of Whiter Resources Development.
- [5]. Bonell, M. (2004). How do we move from ideas to action? The role of the HELP programme, International Journal of Water Resources Development, **20** (3):283-296.
- [6]. Bongaarts, J. (2001). Household size and composition in the developing world, downloaded from [www.popcouncil.org/uploads/pdfs/wp/144.pdf](http://www.popcouncil.org/uploads/pdfs/wp/144.pdf) on 19<sup>th</sup> of February, 2015 by 14.14pm Nigeria time.
- [7]. Eme, L.C. (2010). Water Resources Engineering Development Scheme: Optimal Strategy for Multipurpose/Multi-objective Water Resources Engineering Development Scheme. African Journal of Engineering Research and Development, **3**(3): 27 – 33.
- [8]. Eme, L.C. (2012). Model of Environmental Quality and Recreation: A Case Study of River rine Regions of Nigeria. African Journal of Engineering Research and Development, **5**(1): 122 – 127.
- [9]. Eme, L.C. (2012). Rural Water Supply Scheme Model in Africa: A Case Study of Eastern States of Nigeria. African Journal of Engineering Research and Development, **5**(2): 123 – 20.
- [10]. Eme, L.C. (2015). Simulation Optimization for Model and Prototype using Non Parametric Method: A Case Study of Anambra/Imo River Basin Engineering Development Scheme. American Academic & Scholarly Research Journal, **7**(4): 63 – 61.
- [11]. Hassan I. M. (2007). Egypt's Water Resources Management Under Pressure Of Development.
- [12]. Hong, Z., Gui J. and Yan Y. (2018). Review of River Basin Water Resource Management in China, Journal Of Water Resources, **10**: 425.
- [13]. Iloeje, N.P. (1981). A new Geography of Nigeria. New revised Edition, Longman, Great Britain.
- [14]. Jasper, F.G.W. (2003). Institutional Arrangements for Integrated Water Resources Management. Water Policy, **5**:77-90.
- [15]. Matsukawa, J., Finney, B.A. and Willis, R. (1992). Conjunctive Use Planning in Mad River Basin, California, Journal of Water Resources Planning and Management, ASCE, **118** (2): 115-132.