

## **HYDRO-HABITAT SUSTAINABILITY AND ECONOMIC VALUATION OF KANGIMI DAM RESERVOIR, KADUNA NIGERIA**

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### **ABSTRACT**

*Hydro-habitat is an ecosystem that sustains fish-like creature for the benefit of humanity. The system has value to benefit the living things in it and at same time sustains live in generality. Thus there is a need to qualify its value for the existence of the habitat and environ-ecosystem. The work could not be evaluated without consultation with the people of the area on what the reservoir means to them, what purpose does it serve apart from domestic use, or whether they are ready to protect the ecosystem if needs be. The research makes use of questionnaire as a method of evaluation called contingent evaluation method. The output of the study indicated that people are ready to protect the reservoir and ready to pay for its sustainability through recreational activities, appreciating the eco-habitat and its uses. It is expected that Kaduna State will generate over two hundred million Naira (N200Million) every year for recreational purpose and if the reservoir is maintained it will sustain the government purpose of establishment. The study recommends that resort and activities of illegal fishing should be restricted through appropriate rules and regulations within the reservoir.*

**KEYWORD:** *Hydro-habitat, Valuation, Sustainability, Ecosystem, Recreational, Reservoir.*

### **INTRODUCTION**

Instream water uses have actively joined the competition among the other uses. This is a new policy in many African Countries, and overtime, the policy of in stream flow reservation has emerged in many years in United States of America. Montana's 1995 water use act as an example, formally recognized instream flow for recreational and other purposes as a beneficial use of water (Duffield et al, 1992).

Rivers and reservoirs can provide many services to humans, including water supply for municipal, industrial and agricultural uses, fish

habitat and recreation. With excess demand, the appropriated reservoir basin contents have been competitive. A dynamic society requires monitoring and adjusting the mix of these hydro-habitat services as society's priorities change (Bromley, 1997) to insure that the highest valued mix of services is produced. Since uses like fish habitat and recreation are not priced, this present a challenge to water managers.

The services provide many benefits to people: dilution of wastewater, as well as erosion control and water purification, and wetlands

improvement (Loomis et al, 2000). Increased water quality reduces water treatment costs (Moore and McCarl, 1987), increase the aesthetics of water for visitors and supports native fish and wildlife that different people like to view or harvest or simply know exist (Loomis et al, 2000). Since all of these uses of clean water benefit people, and are scarce, these services have economic value.

These ecosystem services have characteristics of public goods since it is difficult to exclude downstream users from receiving the benefits of improved water and many are non-rival in nature. Many people may view wildlife as enjoying-view-nature while to other it does not border them. Given these public good characteristics, it is difficult for private sector to market or sell those ecosystem services.

While the ecosystem services are often without prices, they do contribute utility to individuals and therefore have value. This value is monetized as the individual's net willingness to pay (WTP) or consumer surplus.

Streamflow levels can influence recreation benefits through a variety of mechanisms (Duffield et al, 1992). Flow level of a reservoir influence boating (Brown et al, 1991), stream aesthetics (Brown and Daniel, 1991), fishing, fish behavior, distribution and aquatic habitat (Duffield et al, 1992), anglers distribution (Johnson and Adams, 1988)

Instream flow requests to be protected as to protect fish, wildlife, recreational resources and some of important services it provided. However, in this part of the world, instream are generally not value, marketed and neglected,

and requiring novel approaches for estimating their economic value. Instream flow alone provided an estimation of \$13.23 million (N4.816Billion) per year in leasing (Landry, 1998). In Bitterroot and Big Hole, US, \$2.4 million (N873.6Million) and \$8.1 million (N2.948Billion), respectively, seasonal values have been realised (Krinsky and Robb, 1986). It is therefore, the aim of this paper to evaluate the economic value of Kangimi reservoir instream and its sustainable protection.

## **MATERIALS AND METHODS**

### **Study location.**

Kangimi earth dam reservoir (Fig. 1) was constructed across Kangimi River approximately 3.22km upstream of its confluence with Kaduna River. It lies in the Savanna region, between latitude 10°46' and longitude 7°25'E (Balogun, 2005). The reservoir has a total volume of 59,789,001m<sup>3</sup> of water. The surface area is 12km<sup>2</sup>, with about 9.63km in length and a maximum depth of 12.92m. When the reservoir is full, storm-water is routed over a 122metres long spillway weir at the Western end of the embankment through an overflow channel back to the downstream.

The Kangimi reservoir is reached by an existing tract running 12.88km South-east from Katabu at 1.61km on the A16 (Kaduna-Jos) trunk road. The water impounded is to be used to augment the existing water supply to Kaduna of about 45.5million litres per day, during periods of low flow on the Kaduna River and to irrigate a strip of 1,619ha of land on the North bank of the Kaduna River upstream of the town (Bamgboye, 2004).

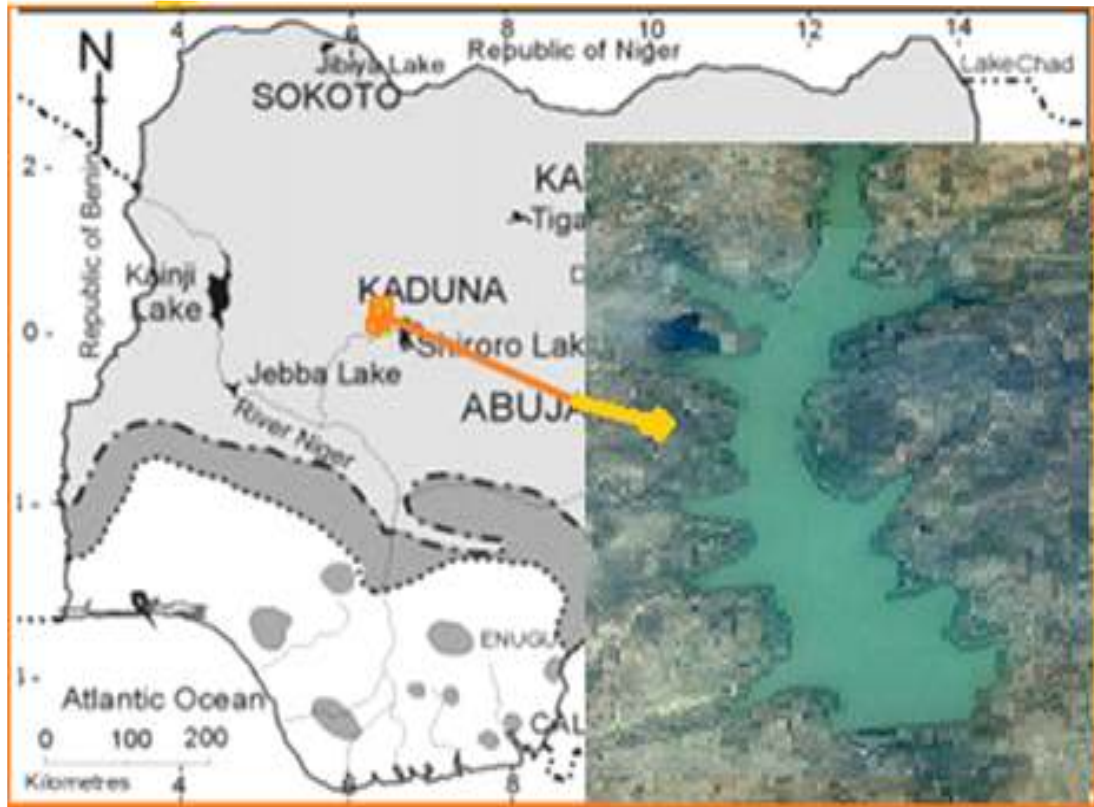


Figure 1 : The Map of Nigeria indicating Satellite Imagery of the Kangimi Dam Reservoir

The reservoir has about ten (10) majorly contributories which includes the main Kangimi River with total catchment area of 226.92km<sup>2</sup>. The estimated average annual yield of the reservoir was 43.05 x 10<sup>6</sup>m<sup>3</sup>/s (Bamgboye, 2004). Annual average rainfall from the relative Meteorological Station is 1,219.2mm. The area around the Kangimi reservoir represents a pen-plain underlain by pre-Cambrian rocks with the basement complex consists of granites and gneiss. The top surface of these rocks has been decomposed to give a non-uniform thickness of laterite soil, which is variable in grading, ranging from silty-clay to coarse sand clay and enjoyed relatively flat land. The diurnal variations in temperature were more pronounced in June compared with to January and March (Kemdirim, 2000).

The impounded raw water is drawn off from the reservoir via a multi-level outlet tower and culverted through the embarkment structure to a

distribution value chamber from where water is released into a concrete trapezoidal channel and downstream of river Kangimi which discharge into the River Kaduna of about 2km downstream the dam. National Water Resources Institute (NWRI) (2012) reported that the reservoir capacity has discharge to sustain continuous flows for 325days in case of drought

On the right abutment a 121.5m long uncontrolled ogee crested service spillway is located. The upstream face of the Dam is protected with riprap which is in reasonably good condition according to E863V2 (2004) report. The crest of the dam is about 4.5m wide. The downstream face has no protective covering and includes an approximately 3m wide berm with an open drain; an embedded pipe drain for seepage control is located at the toe of the dam.

The Haskoning Consult, (1994) indicates that signs of seepage were observed along certain

parts of the downstream slope. Seepage water was evacuated from those areas through an open drain which is connected at regular distances with the toe pipe drain. The spillway which operates every rainy season is in good condition, meaning the conditions of structures indicate good hydraulic performance of the waterway. Dam crest walked along full length with no signs of concentrated seepage along the downstream slope while seepage is quite minor at the backwaters with good conditions of upstream slope protection (E863V2, 2004).

The reservoir is surrounded by four (4) local governments and the local governments were contained in Kaduna Metropolis, namely Chikun, Igabi, Kaduna North and South. The total population of the local governments as at 2006 was one million, five hundred and seventy thousand, three hundred and thirty one people (1,570,331) (National Population Commission, (NPC), 2006).

#### **SURVEY DESIGN**

The contingent valuation method (CVM) of information sourcing was used. The CVM uses survey techniques to directly elicit information on societal WTP for goods that are not commonly traded in markets such as recreational sources and hydro environmental sustainability. CVM is expressed for the intrinsic values estimation associated with natural resources, uses questionnaire or interview to create a realistic event by hypothetical market or referendum, which allows respondents to indicate their WTP (Mitchen and Carso, 1989).

The survey was designed to test for the hypothesis that the societal WTP to restores ecosystem sustainability and provide recreational activities for sustainable health and

socio-economic development. The resources to be value was described (including pictorial) in such away that, the less privilege educated society will see to the reason to pay for more existence of the resource, and even make attempt to contribute to its value and sustainance. The socio-economic and demographic questions to indicate affordability of the society to pay were included; the formation of scenarios representing the value of the commodity to be sell and some information materials to equalized the respondents' knowledge and , thus, to improve the general quality as well as the comparability of answers as been the ingredient of WTP.

The sample frame target individuals living in the metropolis of Kaduna town to represent the underlying population. The questionnaires were formulated which included the hypothetical information and some background of the reservoir. The respondents are urged to answer the question to their satisfactions.

#### **RESULTS AND DISCUSSIONS**

##### **Level of Education**

The educational distribution of the chosen zones ranged between 8 – 31.2%. The level of education in Tudun Wada shows that average of 28.2% are University graduate, 15% are Polytechnic while College (NCE) are 16.9% and Secondary and others are 27.4%, 10.5%, respectively (Table 1). Rigachukun zone shows that University education is higher among the zones with 31.3%, Polytechnic 26%, NCE 14.8%, Secondary 12% and other 16%. Kabala west indicated University education level of 30%, Polytechnic 15.6%, while NCE and Secondary are 21.2%, 25.2%, respectively, others are 8%.



Table 1 : Respondents level of education

Zone	Univer sity%	Polytec hnic%	NCE %	Seco ndary %	Primary/ others%
T/Wada	28.2	15.7	16.9	27.4	10.5
Rigach ukun	31.2	26	14.8	12	16
Kabala West	30	15.6	21.2	25.2	8

### Occupational Distribution

Table 2 represent the occupational record distribution. The result indicated that the majority of the population are civil servants with the percentage that ranged from 58 - 84.4%. The population distribution of businessmen is between 14 – 27.2%, unemployment between 2.0 – 7.2% while population into farming are 1.6 – 6%, the remaining ones are occupied by the pensioners of 0.8 – 1.6%.

Table 2: Occupational distribution of respondents

Zone	Civil Serva nt%	Busin ess %	Unempl ment %	Farmi ng %	Pensio ner %
T/Wada	79.8	16.1	2.0	-	0.8
Rigach ukun	84.4	14	-	1.6	-
Kabala West	58	27.2	7.2	6.0	1.6

### Household Size Distribution

In Tudun Wada as indicated in the Table 3, the average household of less than 5 family is 12.1%, between 5 – 10 persons 33.5%, between 11 – 20 persons 28.2%, whereas greater than 20 persons 118.4%.

Also, Kabala west shows that the household less than 5 person have 31.2%, between 5 – 10 persons 50%, between 11 – 20 persons have 16% and the number greater than 20 persons 2.8%.

Table 3: Households distribution of respondents

Zone	<5 Persons	5 – 10 Persons	11 – 20 Persons	>20 Persons
T/Wada	12.1	33.5	28.2	26.2
Rigachuk un	8	35.6	38	18.4
Kabala West	31.2	50	16	2.8

### Average monthly income distribution

The Table 4, shows that the majority of the population in the selected zones earn averagely between ₦10,000 to ₦50,000 monthly of which the percentage is between 10.1 – 73.4%. The population earning less than ₦10,000 are 2 to 4%, while 10.1 – 34% of the population earn between ₦50,000 to ₦100,000. Whereas population earing greater than ₦100,000 are just between 4 to 12%.

Table 4 : Monthly income distribution of respondents

Zone	<₦10,0 00	₦10,000 -25,000	₦25,00 -	₦50,000 -100,000	
T/Wa da	2.4	10.1	73.4	10.1	4.0
Rigac hukun	2.0	14.0	38.0	34.0	12.0
Kabala West	4.0	26.0	44.0	22.0	4.0

### Awareness of Dam existence

The awareness of the respondents regarding dam reservoir might have an impact on the proposed recreational objective and WTP for the enjoyment of recreation and holiday goals. The Table 5 shows that relatively the respondents are aware of the existence of dam reservoir. The response to the questions by the respondents indicated “yes” with the percentage level of between 95 – 97.3%. There is impression of great awareness of the dam.

Table 5: Respondents result to dam awareness

Zone	YES	NO
T/Wada	96.0	4.0
Rigachukun	95.0	5.0
Kabala West	97.0	2.7

**Importance of Dam to individual**

Table 6 shows the level of importance of dam to individual. The respondents strongly agreed that dam is important for provision of agricultural needs, water for drinking, fishing, tourist attraction, economic resources and environmental modification. The assigned value of “5” was highly chosen by virtually all the zones indicated that there is very high importance of dam to the community.

Table 6: Result of Importance of dam to Respondents

Zone	For Agriculture	For Water Drinking	For Fishing	Recreational	Flood control
T/Wada	5	5	5	3	3
Rigachukun	5	5	5	2	2
Kabala West	5	5	5	4	2
Zone	For Biodiversity	For Economic	For Tourism	Climate modification	Wild life
T/Wada	4	5	4	3	2
Rigachukun	4	5	3	2	2
Kabala West	3	5	5	2	2

**Awareness on illegal uses of dam**

Table 7 shows that between 90 – 98.2% believed and aware that there are illegal users of dam, but the form is not clear to them.

Table 7: Responses to illegal uses of dam

Zone	YES	NO
T/Wada	90.0	10.0
Rigachukun	98.2	1.8
Kabala West	95.3	4.7

**Awareness on indiscriminate fishing and other Dam activities**

The opinion seem to be contradictory here as all of the respondents agreed that there are illegal users of dam such as fishing and draw water for

irrigation without prior permission from the dam management. The reason why contradictory is that, Table 8 shows that in Tudun Wada 61.5% responded to unaware of indiscriminate fishing or dam activities. In other zones it was even higher as the percentage respondents from Rigachikun is 74.4%, and though Kabala West is aware of indiscriminate dam activities with 53.2%.

Table 8: Responses to Indiscriminate fishing and other dam activities

Zone	YES	NO
T/Wada	38.5	61.5
Rigachukun	25.6	74.4
Kabala West	53.2	46.8

**Opinion on protection of dam on illegal activities**

Considered the value and importance of dam, every respondents indicated that the dam should be protected as shown in the Table 9. The percentage of agreed respondents to dam protection indicated the response percentage of between 98.9 – 100%.

Table 9: Opinion of respondents on protection of dam illegal uses

Zone	YES	NO
T/Wada	99.9	1.0
Rigachukun	100.0	0.0
Kabala West	100.0	0.0

**Form of protection and sustainability**

There is high opinion of protecting the dam. In view of that, the respondents provided the suggestion that will sustain the dam and ecosystem in it. As indicated in the Table 10, between 34.9 – 38.7% of the respondents vote for security beef-up around the dam, protection against the illegal fishing is between 27.3 – 29.3%, respondents that believe of fencing the dam is between 27.8 – 35.2%, while between 2.6 – 4.9% suggested proper legislation.

Table 10: Respondents reaction to protection and sustain ability of dam

Zone	Security	Illegal Fishing	Fencing	Legislation
T/Wada	38.7	29.3	27.8	4.2
Rigachukun	34.9	27.3	35.2	2.6
Kabala	36.0	28.8	30.0	4.9

**SCENARIO “A”: POLL ON DAM PROTECTION**

**Poll on proposal to transfer dam to State Government**

Table 11 presented the result on the opinion poll to transfer dams to State government. Virtually all respondents agreed generally to transfer dam to State government for proper management. The opinion poll for those respondents that support the proposal range from 78.3 – 97.8% while those not in support is between 2.2 – 22.7%.

Table 11: Opinion poll on transfer dam management to state government

Zone	YES	NO
T/Wada	78.3	22.7
Rigachukun	97.8	2.2
Kabala West	93.2	6.8

**Suggestion for Private Partnership (PP) for management**

Opinion shows that between 92.8 – 99.1% agreed that for the effective management of the dam there is needs to involve private ownership as indicated in Table 12. The oppose side is just between 0.9 – 7.2% which indicated that the proposal will work well if private partnerships are involved.

Table 12: Opinion poll on transfer dam management to state government

Zone	YES	NO
T/Wada	99.1	0.9
Rigachukun	96.3	3.7
Kabala West	92.8	7.2

**Do you go on vacation and leisure at the dam**

Table 13 shows that the vacation and recreational leisure attitudes of the respondents can not be significantly differentiated. The reason is that the percentage of “yes” to “no” are not particularly different as indicated 47.7 – 58.5% and 47.1 – 52.3% in the Table 13, respectively.

Table 13: Respondents answer to vacation and leisure

Zone	YES	NO
T/Wada	47.7	52.3
Rigachukun	52.9	47.1
Kabala West	58.5	41.5

**SCENARIO “B”: VALUE OF AN INCREASE IMPROVEMENT IN THE DAM ECOSYSTEM AND ENVIRONMENTAL CONDITIONS**

**Family readiness to make holiday visit to dam site**

Table 14 shows that between 98.3% to 99.8% are readily available to make holiday visit to dam site probably the set of attraction are provided, while between 0.2 – 7% objected to the visit. Kabala West has the highest of 99.8% followed by Rigachukun with 99.1% and Tudun Wada with 98.3%.

Table 14: Family readiness to make holiday visit

Zone	YES	NO
T/Wada	98.3	1.7
Rigachukun	99.1	0.9
Kabala West	99.8	0.2

**Visiting period**

Table 15 presents the result of likely visiting period the respondents indicated to visit the

dam. Majority agreed and preferred festivities time as indicated in Table 15 of result percentage of between 50.3 – 63%, while weekend indicated between 25 – 48%, monthly between 1.2 – 4% and yearly visit was between 0.5 – 8%

Table 15: Respondents of visiting time

Zone	Week-end %	Monthly %	Yearly %	Festivities %
T/Wada	43.0	3.0	2.9	52.1
Rigachukun	25.0	4.0	8.0	63.0
Kabala West	48.0	1.2	0.5	50.3

**Provision of attractive facilities**

Provision of boating activities shows that between 23 – 47.9% agreed to pay visit, the beatification as sign of aesthetics shows between 20.8 – 64.3%, while fishing and wildlife sight attraction shows between 6.3 – 46% and 0.6 – 10.2%, respectively as presented in Table 16.

Table 16: Provision of infrastructural facilities

Zone	Boating %	Aesthetic %	Fishing show %	Wildlife %
T/Wada	23.0	20.8	46.0	10.2
Rigachukun	47.9	43.0	8.5	0.6
Kabala West	28.2	64.3	6.3	1.2

**Willingness to pay (WTP) to visit the dam**

The maximally agreed and willingness to pay as presented in Table 17 is between ₦500 - ₦1000. The percentage of responds ranged between 95 – 98% which is at extreme. The WTP percentage between ₦1000 - ₦1500 is 1.1 – 3.4%, while 0.3 – 1.2% and 0.2 – 0.4% indicated to pay between ₦1500 - ₦2000 and ₦2500 - ₦3000, respectively.

Table 17: Respondents willingness to pay voluntarily

Zone (%)	₦500- ₦1000	₦1000- ₦1500	₦1500- ₦2000	₦2500- ₦3000
T/Wada	95.0	3.4	1.2	0.4
Rigachukun	98.0	1.1	0.9	0.0
Kabala West	97.0	2.5	0.3	0.2

**OTHER FOLLOW-UP QUESTIONS**

**Individual perception outlook of dam and ecosystem environment**

The beatification of dam site and its environment indicated percentage of between 35.8 – 37.7%, giving the environment land forming, indicated the following percentage result of between 17.3 – 21.4%. While some respondents goes for restore and hotel the environment which shows in Table 18 as percentage of between 13.2 – 39.4%. Other preference is colored (3 – 29.6%), the environment should be coloured in such away to attracts visitors.

Table 18: How the respondents want the dam site look

Zone	Terracing	Aesthetic	With Restore	Colourful
T/Wada	21.4	35.8	13.2	29.6
Rigachukun	17.3	37.7	29.0	16.0
Kabala West	20.3	37.4	39.4	3.0

**Level of individual satisfaction on the propose and economic values to be gain**

The level of satisfaction in all the zones compliment with strong hold of the proposal as shown in Table 19. The result shows that the respondent satisfaction will be achieved as level shows a strong satisfaction 73.2 – 84.3%. The other responds of satisfied (between 11.1 – 23.4%) gives a more confidence that hope of the proposal to succeed is high. The fairly satisfied

is between 0.4 – 3.2% and the weakly satisfied was 1.2 – 1.4%, while no respondents choose not to be interested.

Table 19: Level of individual satisfaction on dam recreation

Zone	Strongly satisfied %	satisfied %	Fairly satisfied %	Weakly satisfied %
T/Wada	73.2	23.4	2.2	1.2
Rigachukun	84.3	11.1	3.2	1.4
Kabala West	79.8	19.8	0.4	0.0

Willingness to pay more when income improved and expected satisfaction met

As shown in Table 20, more respondents wish to pay more if their expectation are met as indicated in the Table 20. A range of between 85.2 – 93.9% shows their willingness to pay more of between ₦1000 - ₦1500 as against the formal WTP. Only between 6 – 10.8% still could not go beyond ₦500 - ₦1000, while only 0.1 – 4% wish to pay between ₦1500 - ₦2000 and level of 0.2% willing to pay above ₦2500.

Table 20: Respondents willingness to pay when income improved

Zone (%)	₦500- ₦1000	₦1000- ₦1500	₦1500- ₦2000	₦2500- ₦3000
T/Wada	10.8	85.2	4.0	0.0
Rigachukun	8.1	91.1	0.6	0.2
Kabala West	6.0	93.9	0.1	0.0

**DISCUSSION OF RESULTS**

The second part of the questionnaire consists of general question about the main household size, education status, income and occupational level. This part fulfils the intention of gathered general information about household characteristics so as to elicit different factors that influence the valuation of dam reservoir. The average number in households was considered based on the

percentage of household that are majority in the range as observed in the survey. The range of between 5 – 10 and 11 – 20 persons were identified as majority and the range were further classified as between 5 – 20persons and the simple arithmetic average was found and 13.5persons per household averagely.

Within the third part of questionnaire termed “General questions about dam”, the intention here is to distinctively identify if the respondents aware of dam existence, infliction problems on dam and value of dam. As a supplement to the questions, some information was provided to the respondents. The respondents were in totality responded to existence of dam and very aware of infliction problems on dam

Subsequently, respondents were confronted with two hypothetical scenarios. The scenario is made to be the most basic component of the questionnaire in this work as it was organised in section, A and B.

Section A were designed to obtained information on the sustainability of hydro-habitat existence. The scenario presented the case that the current situation of the dam was highly emphasized upon on the illegal fishing, and exposition to evaporation, consequences that may lead to the lost of the dam value as the present situation progresses.

The result indicated that the respondents are of great opinion that there is needs to protect and sustain the existence of dam because of its value to the individual and the country at large. The respondents shows that they will in totality support the partnership with private company/organisation as to achieve the intended proposal.

In section B, economic benefit value were found to be viable as respondents responded to readily

available to visit the dam at festivities period and prepared to pay the maximum money of ₦750 averagely per trip per festival as majority agreed upon (95 – 98%).With about four prominent festivals in Nigeria (El-Ramadan, El-Kabir, Eastern, and Christmas), it is expected that ₦3000 per person per adult in the household per year will be realised, assuming they visit the dam.

The average number of households was 13.5 per person as was found in the survey, thus the expected visiting households is dividing total population of Kaduna metropolis (993,255 by 2015, NPC, 2006 projection). The annual economic value is estimated as indicated below on Table 21.

Table 21: Economic Valuation of Kangimi Dam

WTP per person per household per year	Number of Houses	Total Economic value per year
₦3000	73574.44	₦220,723,333:33

### Conclusion

The sustainability and economic policy of the study is to increase hydro-habitat value of dam reservoir, to protect its ecosystem and sought for economic value that will translate to naira value benefits. It was observed that most of the respondents have enthusiasm readiness to participate and visit the site when proper infrastructural are placed and agreed to pay to visit as demonstrated in the survey.

It was also observed that the individual people considered dam based on its importance as for water supply, fishing and agricultural uses only. Other uses are presented in the questionnaire to the respondents in which it arosed their awareness and attached so much importance to the dam as presented in their responses with highest weight number (5). The awareness on illegal uses of dam was also acknowledged



which was described by Berrens et al (1996) as distortion of inhabitat, extinction of certain fish in their locality, losses of storage to evaporation and pollution.

From this study, it can be concluded that the respondents attached so much interest and the values to the dam reservoir and ready to pay voluntarily to enjoying the visit. Though the payment is low less than \$3 (N1,092) compared with counterpart in the World. South Platte in US pay \$21 (N7,644) (Loomis *et al*, 2000), Middle Rio Grande \$28.73 (N10,457.72) (Berrens et al, 1996) and Montana instream \$23 (N8,372) (Brown and Duffield, 1995). The reason is not far fetch than the economic

dwindling of the country that's translating to individual and industries.

It is of the opinion from this survey for government to turn their search light toward dam recreational policy as to increase the internally generated revenue.

There is the need for further research on this area in this part of the world to ascertain the WTP level.

This work is an on-going research work, it is subject to objective criticism as to achieve the intended purposes and possibly applied to other areas.

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