



Environmental Impact Assessment of the Proposed Earth Dam at Nigerian Defence Academy (NDA) Permanent Site

S. Ahmed¹, Batagarawa², R. L., Hassan³, I. I., Etim⁴, C.
Department of Civil Engineering,
Nigerian Defence Academy, Kaduna, Nigeria

ABSTRACT

Dams and reservoirs provide regular water source supply for human activities. It is a structure built across a river channel that drains a larger system of the river basin and has positive and negative effects. Environmental Impact Assessment evaluates the possible positive or negative impacts that a proposed project may have on the environment; consisting of the environmental, social and economic aspects. The rapid impact assessment matrix (RIAM) method was adopted to evaluate the environmental impacts of the proposed dam. RIAM uses a structured matrix to allow for judgments to be made on a like-by-like basis, with specific assessment components to be defined through a process of scoping. The environmental components fall into Physical/Chemical (PC), Biological/Ecological (BE), Sociological/Cultural (SC) and Economic/Operational components. The results of the assessment process for the proposed Nigeria Defence Academy (NDA) Earth Dam project revealed that 58.824% of the impacts are positive against 41.176% that are negative. Most of the positive impacts are of class (+D) type, and most of the negative impacts are of class (-D) type. Thus; the assessment indicates the implementation of the dam construction will significantly improve water supply in the Nigerian Defence Academy and its immediate surrounding environs. However, mitigation methods must be proposed as class D type indicates significant negative or positive impact.

ARTICLE INFO

Article History

Received: March, 2022

Received in revised form: March, 2022

Accepted: May, 2022

Published online: June, 2022

KEYWORDS

Impact assessment, earth dam, Rapid Impact assessment, Rapid Impact assessment matrix.

INTRODUCTION

Dams are engineering structures that are built to impede river flow and the resultant reservoir formed is used as potential water resource for diverse human activities that include agriculture, industrial applications, domestic use and hydro-electric power generation. This multi-dimensional function of dams describes their continued importance in sustaining growth and development of various ancient and human civilizations evolution and demise. Nigeria is very dependent on its water resources with dams and reservoirs providing a regular source supply. However, a dam is a structure built across a river channel that drains a larger system of the river basin. The river basin is exposed to other forms of human activities especially those that may not conform to the land use development planning in the upper basin regions.

Dams have been constructed for millennia, influencing the lives of humans and the ecosystems they inhabit. Remnants of one such man-made structure dates back 5,000 years and is still standing in northeast Africa (UNESCO-WWAP, 2003). Around 2950-2750 B.C., the first dam known to exist was built by the ancient Egyptians, measuring 11.3 m tall, with a crest length of 106 m (348 ft) and foundation length of 80.7m (Yang, et al, 2005). The dam was composed of 100,000 tons of rubble, gravel, and stone, with an outer shell of limestone. The immense weight was enough to contain water in a reservoir estimated to have been 570,000 cubic meters [m³] (20 million cubic feet [ft³] or 460 acre-feet) in capacity (Yang, et al, 2005). Dams have been built for years over the world to manage flood waters, for hydropower, to supply water for



domestic, industry or indeed primarily for irrigation.

Evapo-transpiration and delay in rain occurrences witnessed in recent years has further made rain fed farming in some areas unsustainable. Most farmers have resorted to constructing water retaining structures such as weirs and canals and dams aimed at harnessing excess runoff water for irrigation during the dry periods of the year. Therefore, dams enhance productivity and contribute effectively to the growth of the country's economy.

The Yali Falls dam project in Cambodia on the Se San River has resulted in serious downstream socio- economic and environmental impacts due to dramatic changes in annual natural flows and sudden flooding caused by irregular, large-scale releases of water from the dam's reservoir. It also appears that water quality downstream of the dam has worsened considerably. Consequently, the thousands of indigenous people living along the SeSan River downstream from the Yali Falls dam have experienced significant losses since 1996, when construction of the dam first required manipulation of the Se San River's flows. Studies have shown that the livelihoods of about 3,434 households (roughly 20,000 people) in this area have been severely affected by the dam (McKenny, 2001).

The upper Gotvand Dam is the highest earth dam in Iran which is located on Karoon River about 10 km from Gotvand city. It was found that Gachsaran salted formation in the reservoir made the reservoir water and consequently Karoon River salty (Mahmood, 2015). Gotvand dam with considerable environmental impacts was reviewed based on geophysical factors. Factors related to river and reservoir water, vegetation and animal effectable factors, social, economic, and cultural effecting factors and factors due to pollution made by human mentioned impacts.

According to studies on the Gotvand dam area, the nearby salt mine and salty Gachsaran formation were not considered in study phase of the dam. The mine, 5 km distance from the dam, made it (with hundreds of millions of tones reserves) completely drown in the water after dam impounding and therefore the salt amount of Karoon River reached its highest level (Farshchi, et. Al., 2014).

In Nigeria, Environmental Impact Assessment (EIA) must be carried out prior to the construction of a dam, irrigation and agricultural projects. The Federal Ministry of Environment of Nigeria has laid down procedures for conducting the Environmental Impact Assessment, it enforces the EIA decree, sets out the requirements and methods for conducting EIA (Biogeochem Associate Limited, 2004).

The Nigeria's Environmental Impact Assessment (EIA) decree provides that all projects of certain scales and locations must have an EIA study carried out so as to ensure the attainment of the country's environmental objectives. EIA is a tool for decision-makers to identify potential environmental impacts of proposed project, to evaluate alternative approaches and to design and incorporate appropriate prevention, mitigation, management and monitoring measures (Food and Agriculture Organization of United Nation. FAO 2011). The eight guiding principles governing the entire process of EIA are: participation, transparency, certainty, accountability, credibility, cost-effectiveness, flexibility and practicality (Economic and Social Commission for Asia and the Pacific. ESCAP 2012).

The environmental parameters to be evaluated may include biophysical, social and economic parameters. Major categories within a broad environmental checklist would include air, water, geology, soils, natural vegetation, wildlife and fisheries resources, heritage resources, land use on adjoining property, community conditions with the potential to be affected by the environmental aspects of the project (Government of Saskatchewan, 2000). The main purpose of EIA is to facilitate the systematic consideration of environmental issues as part of development decision-making, it does so primarily by assembling and analysing information on the potential environmental effects of specific development proposals and how they can be best prevented or mitigated (Hussein et al., 2004). There is a danger that the advances in environmental protection and enhancement achieved through the use of EIA in developed nations will prove inadequate on a global scale unless a similar level of attention is given to the

application of EIA in developing countries (Christopher, 2008).

Study Area

Kaduna has seven months of rain annually; the wet season last from April through to mid- October with a peak in August; while the dry season extends from mid-October of one calendar year to April the next year (Abaje et al, 2016). The annual average rainfall in Kaduna State is about

1323mm (Abaje et al, 2015b). With this kind of rain pattern, it is necessary that excess water during the wet months is harnessed to sustainably support agriculture production. This strategic approach would ensure maximum utilization of water resources for increased livestock and crop production.



Figure 1: South view of River Gora

The study area is located at the South Wing of Nigerian Defence Academy permanent site under Igabi Local Government Area of Kaduana State. It is approximately bounded by latitude 10°35'28" and longitude 7°22'44" of Greenwich Meridian. The project area is located

close to old Kaduna- Birnin Gwari road. The site is made up of fairly flat land with some sloping ground into valleys of some seasonal streams. The main streams located on the site are Rivers Gora, Debu, Doka and Moshi.



Figure 2: view towards the Tail of River Gora

MATERIALS AND METHOD

The materials used for this research includes: Environmental score sheet checklist, a structured questionnaire survey. The rapid impact assessment matrix (RIAM) method was adopted for this research, where the impact assessment was limited to the scoping phase of

the technique. The RIAM is a new tool for execution of an environmental impact assessment (EIA). RIAM uses a structured matrix to allow for judgments (both subjective and those based on quantitative data) to be made on a like-by-like basis, and provides transparent records of the judgments made. RIAM requires specific



assessment components to be defined through a process of scoping, and these environmental components fall into one of four categories, which are defined as follows:

1. Physical/Chemical (PC): Covering all physical and chemical aspects of the environment.
2. Biological/Ecological (BE): Covering all biological aspects of the environment.
3. Sociological/Cultural (SC): Covering all human aspects of the environment, including cultural aspects.
4. Economic/Operational (EO): To identify the economic consequences of environmental change, both temporary and permanent.

The scoping exercise requires determining the important environmental components in each of the four categories, and allows for decisions on these components to be made and recorded, by assessing the beneficial or negative impacts against defined criteria and scales. Not all criteria can be given the same weight, and so the criteria are considered in two groups:

- a. Criteria that are of importance to the condition, that individually can change the score obtained,
- b. Criteria that are of value to the situation, but should not individually be capable of changing the score obtained.

The value ascribed to each of these groups of criteria was determined by the use of a series of simple formulae. These formulae allowed the scores for the individual components to be determined on a defined basis. Using this simple formula, the values ascribed to these criteria were combined and produced a score for the component being assessed. Scores by themselves were not used to separate, or scale impacts, as they still attributed to subjective judgments. Thus, ranges have been defined, with set conditions for the maximum and minimum scores in each range, and the final result is represented by the range value derived.

The scoring system requires simple multiplication of the scores given to each of the criteria in group (A). Multiplier for group (A) was used and weight of each score is expressed,

summation of the scores provided identical results for different conditions.

Scores for the value criteria group (B) are added together to provide a single sum. This ensures that the individual value scores cannot influence the overall score, but that the collective importances of all values group (B) are fully taken into account.

The sum of the group (B) scores are then multiplied by the result of the group (A) scores to provide a final assessment score *ES* for the condition. The process for the RIAM can be expressed:

$$\begin{aligned}
 A1 \times A2 &= AT \quad \dots\dots\dots i \\
 B1 + B2 + B3 &= BT \quad \dots\dots\dots ii \\
 AT \times BT &= ES \quad \dots\dots\dots iii
 \end{aligned}$$

Where: *A1 and A2* are the individual criteria scores for group (A); *B1, B2 and B3* are the individual criteria scores for group (B); *AT* is the result of multiplication of all (A) scores; *BT* is the result of summation of all (B) scores; and *ES* is the environmental score for the condition.

Assessment Process:

RIAM is a very powerful tool used in EIA. It is imperative to understand the assessment process. Hence, an impact was taken from each of the four components and analysed as follows:

The Physical/Chemical (PC): Impact of the dam on surface water status. It is important to the area immediately outside the local condition $A1 = 2$. It significantly improves the status quo $A2 = +2$. This change is permanent as the long life of dam $B1 = 3$. This change is irreversible till the dam exists $B2 = 3$. There is cumulative change in factor $B3 = 3$ and its environmental score is 36 ($ES = 36$). Hence from the range band in table 2, the range band value (alphabetical) is "D" and range band value (numerical) is "4".

Biological/Ecological (BE): Impact of the dam on flora. It is important to the area immediately outside the local condition ($A1 = 2$). It significantly negative change ($A2 = -2$). This change is permanent as the long life of dam ($B1 = 3$). This change is irreversible till the dam exists ($B2 = 3$). There is single change in factor ($B3 = 2$) and its Environmental score is



$-32 (ES = -32)$. Hence from the range band in table 2, the range band value (alphabetical) is " - C" and range band value (numerical) is " - 3".

Sociological/Cultural (SC): Impact of the dam on migration. It is important only to the local condition ($A1 = 1$). Improvement in status quo ($A2 = +2$). This change is permanent as the long life of dam ($B1 = 3$). This change is irreversible till the dam exists ($B2 = 3$). There is no change in factor ($B3 = 1$), and its environmental score is $7 (ES = 7)$. Hence from the range band in table 2, the range band value

(alphabetical) is "+A" and range band value (numerical) is "1".

Economic/Operational (EO): Impact of the dam on access road. It is important only to the local condition ($A1 = 1$). It significantly improves the status quo ($A2 = +2$). This change is permanent as the long life of dam ($B1 = 3$). This change is irreversible if the dam exists ($B2 = 3$). There is no change in factor ($B3 = 1$), and its environmental score is $14 (ES = 14)$. Hence from the Range Band in table 2, the range band value (alphabetical) is "+B" and range band value (numerical) is "2".

Table 4.1: Assessment Criteria

Criteria	Scale	Description
A1: importance of condition	4	Important to national/international interests
	3	Important to regional/national interests
	2	Important to areas immediately outside the local condition
	1	Important only to the local condition
	0	No importance
A2: Magnitude of change/effect	+3	Major positive benefit
	+2	Significant improvement in status quo
	+1	Improvement in status quo
	0	No change/status quo
	-1	Negative change in status quo
	-2	Significant negative disbenefit or change
B1: Permanence	-3	Major disbenefit or change
	1	No change/ not applicable
	2	Temporary
B2: Reversibility	3	Permanent
	1	No change/not applicable
	2	Reversible
B3: Cumulative	3	Irreversible
	1	No change/not applicable
	2	Non-cumulative/single
	3	cumulative/synergistic

Table 2: Range Band

RIAM Environmental score (ES)	Range Band (Alphabetical)	Range Band (Numerical)	Description of Range Band
72 to 108	E	5	Major Positive Change / Impact
36 to 71	D	4	Significant Positive Change / Impact
19 to 35	C	3	Moderate Positive Change / Impact
10 to 18	B	2	Positive Change / Impact



1 to 9	A	1	Slight Negative Change / Impact
0	N	0	No change / status quo /Not Applicable
-1 to -9	-A	-1	Slight Negative Change / Impact
-10 to -18	-B	-2	Negative Change / Impact
-19 to -35	-C	-3	Moderate Negative Change / Impact
-36 to -71	-D	-4	Significant Negative Change / Impact
-72 to -108	-E	-5	Major Negative Change / Impact

RESULTS AND DISCUSSION

Table 4.3: Physical & Chemical impacts

Physical/Chemical Components	Code (PC)	A1	A2	B1	B2	B3	ES	RBA	RBN
Air quality	PC1	1	-1	2	3	2	-7	-A	-1
Noise	PC2	1	-1	2	2	2	-6	-A	-1
Ground water	PC3	2	+2	3	3	3	36	+D	4
Surface water	PC4	2	+2	3	3	3	36	+D	4
Land use	PC5	2	+2	3	3	2	32	+C	3
Subsidence	PC6	1	-2	2	3	3	-16	-B	-2
Visual impact	PC7	1	+1	2	2	2	6	+A	1
Soil Pollution	PC8	2	-1	2	3	3	-16	-B	-2
Risk of Natural hazards	PC9	2	-1	3	2	3	-16	-B	-2
Drought mitigation	PC10	0	0	1	1	1	0	N	0

RIAM results of the physical and chemical components such as ground water and surface water have significant positive impact of national interest on the environment, while developing a dam as the land use for the area would bring about moderate positive change with

major benefits. Risk of natural hazards and soil pollution will pose temporary negative impact. Air quality and noise will result in slight negative impacts important only to local conditions. Meanwhile, visual impact will be slightly improved at the local level.

Table 4.4: Biological/Ecological Components

Biological/Ecological Component	Code (BE)	A1	A2	B1	B2	B3	ES	RBA	RBN
Fauna	BE1	1	-1	3	3	1	-7	-A	-1
Flora	BE2	2	-2	3	3	2	-32	-C	-3
Terrestrial Ecosystem	BE3	1	-1	3	3	3	-9	-A	-1
Riverine Ecology	BE4	2	-2	3	3	3	-36	-D	-4
Biodiversity	BE5	2	-2	3	3	3	-36	-D	-4

The riverine ecology and biodiversity have a significant negative impact on the area of national interest while that of flora is moderate.

Fauna and terrestrial ecosystem will like result in negative impacts that are slight on the local population and environment.

Table 4.5: Sociological & Cultural impacts

Sociological/Cultural Component	Code (SC)	A1	A2	B1	B2	B3	ES	RBA	RBN
Tribal Culture	SC1	0	0	3	3	1	0	N	0
Living Standard	SC2	2	+2	3	3	2	32	+C	3



Education	SC3	2	+2	3	3	3	36	+D	4
Migration	SC4	1	+1	3	3	1	7	+A	1
Live-stock	SC5	1	0	3	3	1	0	N	0
Recreation	SC6	1	+1	3	3	1	7	+A	1

The sociological and cultural components generally indicate positive change at various levels with education having significant

positive impact. While tribal culture and livestock are not affected; living standard would significantly improve.

Table 4.6: Economic & Operations impacts

Economic/Operations Component	Code (EO)	A1	A2	B1	B2	B3	ES	RBA	RBN
Jobs	EO1	2	+2	3	3	3	36	+D	4
Access Road	EO2	1	+2	3	3	1	14	+B	2
Tourisms	EO3	0	0	3	3	1	0	N	0
Land Price	E04	0	0	3	3	1	0	N	0
Agriculture	EO5	2	+3	3	2	1	30	+C	3
Transportation	EO6	1	0	3	3	1	0	N	0

The economical and operational components such as jobs, agriculture has significant and moderate positive impact

respectively with positive change on the access road. Meanwhile, land price, tourism and transportation are not affected.

Table 4.7: Impacts of NDA Dam on the environment

ES	RBA	RBN	PC	BE	SC	EO	Total	Final
72 to 108	+E	5	0	0	0	0	0	0
36 to 71	+D	4	2	0	1	1	4	16
19 to 35	+C	3	1	0	1	1	3	9
10 to 18	+B	2	0	0	0	1	1	2
1 to 9	+A	1	1	0	2	0	3	3
0	N	0	1	0	2	3	6	0
-1 to -9	-A	-1	2	2	0	0	4	-4
-10 to -18	-B	-2	3	0	0	0	3	-6
-19 to -35	-C	-3	0	1	0	0	1	-3
-36 to -71	-D	-4	0	2	0	0	2	-8
-72 to -108	-E	-5	0	0	0	0	0	0

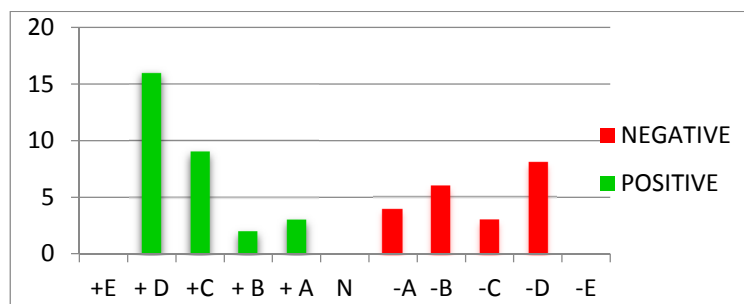


Figure 4.5: Collated Negative and Positive impacts of the RIAM analysis



Results of assessment process for the Nigerian Defence Academy (NDA) Dam project indicates a net positive impact on the environment - 58.824% of positive and 41.176% negative. Most of the positive impacts are of class (+D) type, and most of the negative impacts are of class (-D) type. This indicated a strong need for mitigation of the negative impacts to enhance to protect the environment and ensure health and well-being of the populace.

CONCLUSION

From the results obtained, it can be concluded that the benefits of the construction of the dam outnumber the negative impacts, meaning that construction of the dam would be beneficial in most respects to the Nigerian Defence Academy (NDA) and its environs. No mitigation is required as regards displacement of people, historical and cultural sites. Loss of agricultural land is expected, but the impact is slight. The project area has been subjected to years of human activities mainly agriculture and as such not much flora and fauna are left, hence the low impact. Dust during construction poses danger to human health. Ecosystems, biodiversity, flora and fauna are at a risk of destruction.

REFERENCES

- Abaje, I. B., Sawa, B. A., Igusi, E. O and Ibrahim, A. A. (2015b). A Quantitative approach to vulnerability assessment of rural communities to climate change in Kaduna State, Nigeria. *Nigeria Geographical Journal, New Series*, 10(2), 180-195.
- Abaje, I. B., Sawa, B. A., Igusi, E. O and Ibrahim, A. A. (2016). Impact of climate change and adaptation strategies in rural communities of Kaduna State, Nigeria. *Ethiopian Journal of Environmental Studies and management*, 9(1), 97-108.
- Biogeochem Associates Limited (2004). Impact Assessment of Proposed Obajana Earth Dam Project. 1, Omoku Street (By Ndashi Street). D-Line. Port Harcourt, River State, Nigeria. www.infobiogeochem.com
- Caleb W. Christopher "Success by a thousand Cuts: the use of Environmental Impact Assessment in Addining Climate Change" 9 *Vt. Entl. L.* 549 (2007-2008)
- Daryush Mahjoob Farshchi, Alireza Sadatifard, Hooshang Hassani, and Alireza Zia "Upper Gotvand Am and Hydro Power Plant Dealing with Salinity in Reservoir Challenges, Remedies and Evaluations" Conference: Proceedings of ICOLD Symposium, Bali, Indonesia. At: Indonesia, June 2014.
- Economic and Social Commission for Asia and the Pacific, ESCAP Virtual Conference (2012). Environmental Impact Assessment Principles and Process. Integrating Environmental Considerations into Economic Policy Making Processes. http://www.Unescap.org/drpad/vc/orientation/m8_1.html
- Food and Agriculture Organization of United Nation, FAO (2011). Environmental Impact Assessment Guidelines for FAO field projects. Food and Agriculture Organization of United Nation, Rome, Italy
- Government of Saskatchewan (2000). Assessment Process. Saskatchewan Agriculture, Food and Rural Revitalization. www.agr.gov.sk.ca/.../Environmental Impact
- Hussein, A., Ron, B., and Barry, S. (2004). EIA and Strategic Environmental: Towards an Integrated Approach. United Nations Environment Programme (UNEP), Geneva.
- Mahmood Mansournejad, (2015). The Investigation of Negative Effects of Salt Dome on the Quality of Water in Gotvand Olya Dam and the Use of Cut-off Wall as Treatment.
- McKenny, B. (2001). Economic Valuation of Livelihood Income Losses and other Tangible Downstream Impacts from the Yali Falls Dam to the Se San River Basin in National Irrigation Board (NIB) (2013). Mwea Irrigation development project. Retrieved at: <http://www.nib.or.ke/mweairrigationboard> on 09 March 2014.
- S. L. Yang, J. Smith, J. Zhu, J. P. Li, S. B. Dai, A. Gao, and P. Li "Impact of dams on Yangtz River sediment supply to the sea and delta intertidal wetland response" *Journal of Geographical Research*, 110, F03006, doi: 10.1029/2004JF000271, 2005
- United Nations Educational, Scientific and Cultural Organization, World Water Assessment Programme (UNESCO-WWAP) >> Natural Science >> Environment >> Water >> WWAP >> World Water Development Report >> WWDR1 (2003)