Analysis of Adverse Environmental Effects of Water Supply Projects in Jos Metropolis, Nigeria

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Abstract

The increasing demands for water resulting from economic growth, climate change, pollution, and concurrent population growth exert additional pressure on available resources. Consequently, this leads to escalated costs of water treatment, which has adverse effects on the environment. This study investigates the environmental impacts of water supply projects in Jos metropolis, including dams, reservoirs, tanks, pipelines, and treatment plants. It examines the effects on both government and individual water users, considering factors such as economic growth, climate change, pollution, and population growth. The study utilizes a combination of primary and secondary data, collecting primary data through questionnaires, interviews, and field observations, and secondary data from the Plateau State Water Board and other sources. Using a sample size of 378 respondents determined from a population of 23,453, structured questionnaires were administered, and the results were analyzed using frequency tables. The findings reveal negative consequences for communities located along floodplains, as well as adverse effects on the government, including environmental damage, the risk of dam breaches and breakages, flooding, species loss, and increased salinity levels. It is concluded that the Plateau State Water Board should prioritize maintenance practices to reduce the occurrence of dam breaches and breakages, ensuring sustainable water supply and mitigating the negative impacts of these projects. The study recommends continuous facility maintenance, adherence to land use plans, and prevention of facility overstretching as effective measures to minimize adverse effects. Implementing these recommendations can help mitigate the detrimental consequences on the environment and society, promoting sustainable water management and resource utilization.

Keywords: Adverse effects, Environment, Water supply, Water projects, Jos metropolis

INTRODUCTION

Apart from the loss of plants and animal species at the times of initial dam construction and maintenance which has led to the loss of species of flora and fauna along the river banks, it has altered the ecosystem of the entire river channel (Cech, 2005). This further increase the erosion and deposition of downstream sediments and associated contaminants, inter-mixing of alien invasive aquatic species. Also, Hydrology downstream from dams and major diversions and pumping stations have been modified and extensive areas of Fadama, fisheries and wildlife habitats are wiped out (Das, 2006 and FAO, 2012). All these are the adverse environmental consequences of water projects that assessments do not reveal at the planning and execution stages of most water supply projects.

Fahim (1981) and DFID and UKAID (2009) maintain that in spite of the recognized financial, ecological and social costs very often associated with the construction of dams, water projects and the creation of lakes, this worldwide phenomenon is expected to continue as the gust for water increases to meet the demands for food, energy, potable water and industry. He also,

pointed out that ecological and environmental side effects of the Aswan High Dam and their short-run implications have been identified as follows: water loss through seepage and evaporation, sedimentation of the Nile silt in the lake and its impact on productivity; water logging and the level of soil salinity; the problem of disease menace through the expected increase in the incidence of schistosomiasis.

Apart from the multipurpose dams provided to provide water for multiple uses, some dams are built to control flood and avert its consequences on settlements, farmlands and other human activities, but recently, the excess water from dams are the cause of floods they are supposed to control. Cech (2005) also explained that dams cause changes in the character of river systems as water released from behind a dam can have different temperature from native river water which can be extremely stressful to the aquatic species downstream.

In a study by Araral and Holmemo (2007) of water supply projects, it was discovered that there were no identifiable environmental costs associated with small projects due to their highly localized impacts. But that in bigger projects, in spite of the serious environmental audit carried out; there exist very high risk of flooding and inundation of lands along flood plains mostly due to dam breach and subsequent breakages, devegetation, salinization, loss of plants and animal species among other issues. The flora and fauna of the natural water bodies are affected adversely during the construction and or maintenance activities, example abound in the current rehabilitations of Bukuru and Lamingo water works. The use of heavy machines and equipment to strip the natural vegetation of the surface of the land is destructive to the natural ecosystem.

Inadequate access to potable water is a serious challenge to most residents in Jos metropolis of Nigeria in spite of heavy monetary expenditures made by government and other stakeholders to provide sufficient water to guarantee social and economic wellbeing of the people (Ali, 2018). The aim of this study therefore is to examine the adverse environmental effects of water supply projects in Jos metropolis.

MATERIALS AND METHODS

Study area

Jos metropolis is located between latitudes 9^{o} 54' N and 10^{o} 10' N and longitudes 8^{o} 48' E and 9^{o} 30' E. The study area comprises Jos South and Jos North local government areas with their headquarters in Bukuru and Jos respectively. The area is situated within the northern senatorial zone of Plateau State, and is bounded by Barkin-Ladi and Jos East to the east, Riyom to the south and Bassa local government area to the west (see Figure 1). The areal extent from north to south is 104km while from east to west is about 80km on an elevation of 1,250m above sea level with Shere hills having the highest peak of 1,777m above sea level with an area of 1002.19 Km^2 (Mohammed *et al*., 2010).

Natural water resources

Most rivers in northern Nigeria owe their origins to the Jos Plateau due to its height above other regions in the northern Nigeria and is the source of Kaduna, Gongola, Korot, Shimanker, N'gell, Kassa, Delimi, Hadeija-Jama'are, Wase and Tenti rivers. The volume of these rivers are high during the rainy season and low during dry seasons due to the nature of rainfall and other climatic elements of the area (Bingel, 1978, Jiya and Musa, 2012). The presence of these rivers, streams, dams, hand dug wells, ponds and springs constitute very good water resource base for the area. Some of the rivers that the government has dammed and is harnessing for potable water supply to the metropolis are Nupis, Shen, Gwash, Rafin-Sanyi, Agog rivers and

Yelwa pond with Tolle Mache, Yakubu Gowon, Liberty (Laminga), Lamingo (Gwash),Kogin – giri and Yelwa Dams built on them (Ali, 2018).

Figure 1: Plateau State showing the LGAs

Climate

Jos metropolis experiences an AW climatic type and falls within the AW climatic sub-region according to the Köppen classification. The weather is generally warmer during the rainy season (April-October) and colder during the Hammattan period (December-February) (Ariyo, 2000). The mean annual temperature ranges from 20°C to 26°C, influenced by factors such as rainfall, relief, and cloud cover throughout different periods and seasons of the year. Relative humidity is lower during the dry season (November to March) and very high during the wet season, with peak values between 81% and 84% in July and August (Nyong *et al*., 2008).

Additionally, the area is rich in streams, ponds, mine pits, lakes, and smaller rivers that can complement other major water sources. If properly developed alongside dams, these natural water sources can contribute potable water to the piped water system (Daloeng, 2006; Ali, 2018).

The precipitation in the Jos metropolis varies from 700mm to 1000mm during the peak period. The region has distinct wet and dry seasons, with the wet season lasting approximately 8 to 9 months from mid-March to the end of October. This season is influenced by warm moist maritime southwesterly monsoon winds blowing from the Atlantic Ocean towards the southwest hinterland. On the other hand, the dry season spans about 3 to 4 months from mid-November to mid-March and is associated with the dry tropical continental northeasterly winds known as Harmattan, which bring cold, dry, and dusty conditions from the Sahara Desert (Ariyo, 2000).

METHODOLOGY

Data Collection

The major instrument of primary data collection used is the questionnaire. This was designed to elicit information on adverse environmental effects of water supply projects, and interview and exploration of database and personal observation on the other hand, was used to determine the geographic location of the water supply projects. Data for this study were derived from both primary and secondary sources. The primary data were generated from administration of questionnaire, author's personal observations and interview of relevant stakeholders. Secondary data on the other hand were obtained from Plateau State Water Board, Jos and Plateau State Budget office, Jos. Data on water supply projects like dams, pipelines, reservoirs, treatment plants, their capacities, year of construction and their locations were obtained from Plateau State Water Board data base, Federal Ministry of Water Resources' reports and these sources were complemented by interviews of stakeholders from Plateau State Water Board, Jos.

Information on adverse environmental cost of water supply projects which include erosion, dam siltation, flooding and the general ecosystem disturbance. These adverse environmental effects of water supply projects to individuals and the environment were obtained through questionnaire administration, personal observation of the researcher, focus group discussion and interviews of both water subscribers and Plateau State Water Board staff.

Jos metropolis has been designated into 21 water supply districts (Bukuru A - D) and (Jos A - O) by Plateau State Water Board. Each district has varied number of residents that are connected to piped water system as shown in Table 1 totaling 23,453.The sample size of 378 was determined using the Educational and psychological measurement table of Krejcie and Morgan (1970) at 95% confidence level. The research adopted a systematic sampling approach in the selection of some districts for questionnaire administration.

Sampling technique

This technique was used for selecting the 1st district and every third order district, out of 21 Water Board districts for questionnaire administration. This sampling technique is more convenient than simple random sampling as it ensured that each unit selected has equal probability of being included in the sample. It also ensures that selections are spread more evenly over the population; it ensures nearly evenly distributed spatial spread and achievement of fair representation. The districts were first listed alphabetically and after selecting the first district, each 3rd district was selected and this brought the number to seven districts with a connection population of 8,402.

To further arrive at the number of respondents in each of the seven districts, the population of piped connections of each of the districts was divided by total 8,402 and multiplied by 378 as

depicted in Table 1. A purposive sampling method was adopted in the administration of questionnaires on household heads from each of these seven selected districts. The choice of the sample type is due to the fact that most houses are not numbered and this approach has enabled the researcher to administer questionnaire to only houses that are connected to piped water system while household heads are selected because they pay and connect households to piped water system and would have more experience than other family members. Completed questionnaire were retrieved from 376 respondents representing 99.4% of the 378 household heads from the seven (7) districts sampled systematically from the 21 Water Board designated districts in Jos metropolis were retrieved (as shown in Table 1).

Table 1: Number of piped connections and water supply districts in Jos metropolis

S/N	Location (Name of District)	Number of Piped Connections	Sampled Size
1	Bukuru A (Fire Service)	1266	57
2	Bukuru B (Yelwa)	1089	
3	Bukuru C (Rahol Kanang)	1203	
4	Bukuru D (Metred)	487	22
5	Jos A (Main)	1415	
6	Jos B	1116	
7	Jos C (Lamingo)	1521	68
8	Jos D (Nassarawa)	2331	
9	Jos E (Kabong)	1049	
10	Jos F (Central)	2334	105
11	Jos G (U/Rogo)	1703	
12	Jos H (Kufang)	1636	
13	Jos I (Laranto)	957	43
14	Jos J (Fudawa)	853	
15	Jos K	883	
16	Jos L (Ali Kazaure)	597	27
17	Jos M (Federal Lowcost)	1299	
18	Jos N (Industrial)	35	
19	Jos O (Rikkos)	1240	56
20	Jos P (Utan)	249	
21	Jos Q (Rayfield)	189	
	TOTAL	23452	378

Source: PSWB (2012) and Authors' computation

The sample size is determined using the following formula developed by Krechcie and Morgan (1970):

$$n = \frac{X^2 * N * P(1-P)}{(ME^2 * (N-1)) + (X^2 * P * (1-P)} \quad 1$$

Where,
n= sample size
X^2= Chi square for the specified confidence level at 1 degree of freedom
N= Population size
P= Population proportion (.50 in the table)
ME= Desired margin of error (Expressed as a proportion)
Three methods were used to generate the data used for this research: the use of questionnaires, interviews and focus group discussion. Questionnaire administration is the major instrument for primary data collection for this study. Three hundred and seventy-eight (378) questionnaires were administered to purposively sampled respondents in seven (7) Water Board districts of

Jos metropolis, after two weeks 376 of the duly completed instruments were retrieved and analyzed. Interview method was adopted to generate information through personal dialogue with stakeholders of Plateau State Water Board Jos to get the data that will also complement those elicited through the use of questionnaires and documented sources.

To be able to fill the gaps in the questionnaires and also achieve fairness in coverage of research matrix for data integrity, the researcher has been able to identify water users in various locations for discussions especially households located near the dams who were not covered in questionnaire administration and interview. This has complemented the data generated through interviews and questionnaire administration.

In this study, descriptive statistics were used in data presentation and analysis. These descriptive statistics are frequency tables, bar graphs, pie charts, mean and standard deviation were used in presentation of data.

RESULTS AND DISCUSSION

Dams that supply potable water to residents of Jos metropolis are located mainly within Jos North, Jos South and parts of neighboring Barkin Ladi Local Government Area. These dams and their rivers are shown in Table 2 and Figure 2, the dams were built (constructed) on Rivers Rafin-Sanye,Nupis, Agog , Gwash, Shen River and Yelwa pond for mainly water supply purposes. Plateau State Water Board maintains a number of dams numbering six in Jos metropolis which supply raw water to treatment plants for processing. These dams as shown in Table 2 include Kogingiri, Laminga(Liberty) Lamingo (Gwash), Tollemache, Yakubu Gowon and Yelwa/ Bukuru dams.

Table 2: Location of Dams and their Rivers

Name of dam	Longitude	Latitude	River	Location
Yakubu Gowon	8.97324	9.76574	Shen/Yingi	Ratt B/ladi
Laminga (Liberty)	8.92374	9.8919	Rafin-Sanye	Jos North
Yelwa	8.8727	9.8	Yelwa pond	Bukuru
Lamingo (Gwash)	8.95011	9.89514	Rafin-Sanye	Jos North
Tollemache	8.96783	9.89574	Nupis	Jos North
Kogingiri	8.936189	9.929282	Agog	Jos North

These dams were constructed at different times and at different sizes with a combined daily capacity of 117,000m^3 to provide potable water for the teeming urban population in Jos metropolis. Out of the 23 dams in plateau state, six are located in Jos metropolis and were built by Plateau State and colonial governments mainly to provide potable water for the teeming population of the city. The remaining dams located outside Jos metropolis were built by NESCO, River Basin Development Authority and the Ministry of Agriculture for hydroelectricity generation, irrigation and water supply (FMWR, 2012). The three international rivers, the Niger, Benue and cross River and their tributaries draining the whole country provide ample sites for the construction of dams for all purposes (FMWR, 1991).

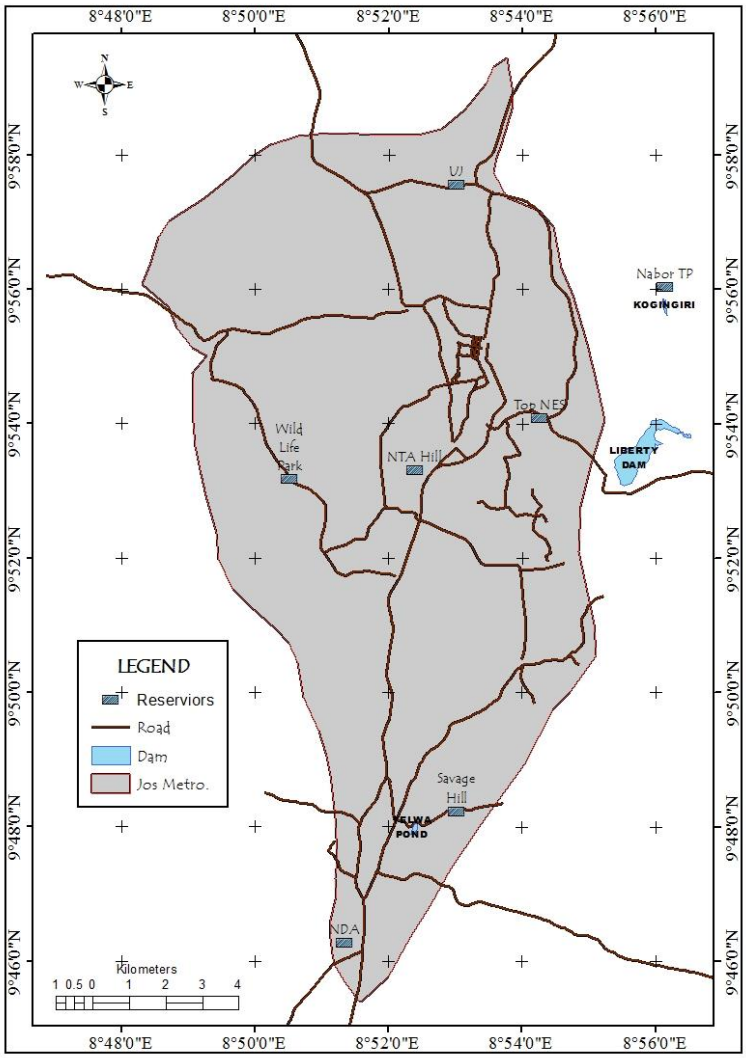

Figure 2: Jos Metropolis Showing Locations of Dams and their Rivers

Adverse Environmental Effects of Water Supply Projects

In every project targeted at delivering benefits to the populace, there are also some inherent associated negative environmental consequences. The effects of water supply projects execution in Jos metropolis such as loss of species of flora and fauna, risk of flooding, diversity loss, soil exhaustion and land degradation are apparent.

Table 3: Adverse Environmental Effects of Water Supply Projects

S/N	Variables	Classes	Frequency	Percent
1	Environmental problems associated with water supply projects			
		Flooding	153	40.7
		Biodiversity loss	79	21.0
		Land degradation	90	23.9
		Soil exhaustion and salinity	54	14.4
		Total	376	100.0

Associated with water supply project execution are serious adverse environmental effects that can negatively affect residents of the area. Over 40.0% of the respondents in same Table 3 said that when there is an occurrence of dam breach and eventual breakage there is risk of flooding. Twenty-one (21.0%) said that when water supply projects construction were embarked upon,

there was loss of species of flora and fauna, 23.9% also said that was land degradation while 14.4% said that the stillness of water has the tendency to lead to soil exhaustion and high level salinity.

This result disagrees with the findings of the study carried out by Araral and Holmemo (2007) on water supply projects which discovered that there were no identifiable environmental costs associated with small projects due to their highly localized impacts. But that in bigger projects, in spite of the serious environmental audit carried out, there exist very high risk of flooding and inundation of lands along flood plains mostly due to dam breach and subsequent breakages, devegetation, salinization, loss of plants and animal species among other issues.

Gallagher (2012) listed the following as potential adverse effects on surface water quality due to water supply project execution and dam construction to increased sediment loading during and post construction or rehabilitation of those water supply projects; on the hydrology and associated flood risk of surrounding water course due to increased surface water runoff post construction; adverse environmental effects on ground water from reduced recharge rates associated with the increased impermeable area on site post construction.

Environmental Cost of Water Supply Projects

Apart from the socioeconomic costs associated with water supply projects, costs such as flooding, biodiversity loss, soil exhaustion and salinity of still dam water are also prevalent in the area.

Table 4: Adverse Environmental Effects of WSPs

Variables	Classes	Frequency	Percentage
Environmental Challenges	Yes	242	64.4
	No	134	35.6
	Total	376	100.0
Environmental effects of Water Supply Projects	Dam breakage	61	16.22
	Risk of flooding	50	13.30
	Soil exhaustion/ salinity	55	14.62
	All of the above	210	55.9
	Total	376	100.0

During construction stage and even during maintenance of water supply projects and their existence so many years later result to myriads of environmental issues like risk of flooding, biodiversity loss, change in microclimate, soil exhaustion and high-level salinity. Over sixteen (16%) percent of the respondents are of the opinion that the risk of flooding is very high with the existence of water supply projects which may claim lives, property and farmlands located along flood plains. About 13.30% of the residents surveyed said that there is high level biodiversity loss resulting from water supply project execution and rehabilitation in Jos metropolis. Over 14.62% on their part said that there is soil loss and high-level salinity of dam water due to stillness of the water (see table 4).

Table 5 shows that 39.9% of respondents complained that the dams overflow the banks of their rivers during the peaks of rainy seasons and bring about phenomenal losses to farmlands and households and that at such times render members of households homeless. A number of respondents representing 29.0% said that at points of construction and rehabilitation of these water supply projects, the natural ecosystem is adversely affected and led to loss of plant and animal species, 2.1% also assert that these construction and rehabilitation activities have

severely led to soil loss in their immediate environment which also tampered with the original terrain and topography of the areas. While 18.9% said that these activities have brought about concentration of heavy metals and high level salinity (water pollution) due to stillness of water and only 10.1% said that all of the environmental issues are the costs that the residents are made to live with as a result of the development of water supply projects and other human activities in Jos metropolis (Vivan, Ali and Adamu, 2015).

Table 5: Analysis of Environmental Costs of Water Supply Projects (WSPs)

	Challenges	Frequency	Percentage
Environmental Cost of WSPs	Washing of farmlands	150	39.9
	Loss of nature	8	2.1
	Destruction of ecosystem	109	29.0
	Water pollution	71	18.9
	All of the above	38	10.1
	Total	376	100.0

CONCLUSION

The study has shown that apart from the cost incurred in the development of water supply projects in initial construction, operations, maintenance and replacement, there are adverse environmental issues associated with these projects also. It concluded that the Plateau State Water Board (PSWB) should imbibe serious maintenance culture to curb high rates of dam breaches and breakages and become efficient in constantly maintaining their equipment to ensure sustainable water supply and prevent the negative effects of these projects in the area. The recommendations are:

a) The PSWB should set up task force for maintenance to prevent dam breach and breakage to prevent flooding and other disastrous occurrences.

b) Due to rising population, urbanization and economic activities in Jos metropolis, the Plateau State Water Board should expand its capacity by building new water supply projects from the highly available potentials in ponds, springs, rivers and ground water to prevent the overstretching of the existing facilities leading to losses.

c) The landuse plan of the area should be strictly adhered to in order to prevent losses associated with farmlands, homes and crop losses.

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