Environmental Impacts of Kashimbilla Multipurpose Buffer Dam and Associated Structures, Taraba State, Nigeria

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Abstract- People keep struggling for decades in order to shape the ecosphere in a manner they wants since the first day. The period in which this struggles was observed most intensively was the period covering the transition from a migrant and primitive hunter society to a resident life and farming. The most deep-seated environmental modification against the nature that had been realized in the history of the human being has started at this time. Even the development and downfall of civilizations are correlated to this interaction between the people and nature. One of the most important roles in utilizing water resource by dams were started to construct long years before gaining present information about hydrology and hydro-mechanics. Dams have a great deal of impact on the environment besides their benefits like controlling stream regimes consequently preventing floods, obtaining domestic and irrigation water from the stored water and generating energy. The environmental impacts of Kashimbilla dams are classified according to different criterions as long term and short term impacts, the impacts on the close area and the impacts on the regions where the dam services, social and unsocial impacts, beneficial and harmful impacts. These effects may be ordered in an intensive and complicated manner like climatic, hydraulic, biologic, social, cultural archaeological etc.

Keywords: Dam, Environmental, Impacts, Kashimbilla

I. INTRODUCTION

Most of the primary civilizations of the world emerged in or near river valleys. The construction of dams and other hydraulic structures is, therefore, one of the oldest branches of engineering. Dams are not ordinary Engineering buildings, they are useful in meeting the demand for water in desired times and in regulating stream regimes, besides their benefit of controlling stream regimes, they have also a great deal of positive and negative impacts on the environment.

Dams have been constructed in order to prevent floods, to supply drinking and domestic water, to generate energy and for irrigation purposes since the old-times. The earliest dams were probably built for the purpose of irrigation, flood control and water supply.

Later, water was impounded so that its subsequent controlled release could provide a source of energy, first by the use of water wheels and later by the use of hydroelectric generators. Other purpose includes the maintenance of an adequate river flow through the year for navigation and provision of facilities for recreation.

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Most modern reservoirs are designed for two or more of these purposes. Usually "the role of water storage reservoir is to impound water in periods of higher flows so that it may be released gradually during periods of lower flows, but sometimes the sole purpose of impoundment is to provide a new body of standing water for use as such example for fishing or boating or for water-heat dissipation from a thermoelectric generating plant (Baxter, 2005).

Dams hold possibilities of considerable harm for living beings in addition to their advantages such as meeting basic requirements of the society and increasing living standards. Nearly 700 dams were built every ten years up to 1950s. This number grew rapidly after 1950s. while the dams were built and completed it was observed that, there was something missing and detrimental although the effects of water on human life and the development of civilizations are well-known all over the world, it is claimed that the economical benefit expected from the projects designed to utilize water resources could not be gained and also necessary precautions to decrease the environmental, economical and social losses were not taken. Even some studies aiming to block these water supply projects of the developing countries are carried out by some international organizations. Because of this, in the sustainable management of the water, taking into account the economical, social and cultural development and the environmental impacts which came out as a result of the mentioned studies, has gained an increasing importance (Sait et al, 1995).

The earliest dams were probably constructed by blocking the stream with earth. Kashimbilla multipurpose buffer Dam in Takum Local Government Area of Taraba State was constructed to serve mainly as buffer against the eminent flood that will occur as a result of the collapse of the upper reaches of Lake Nyos situated up in the hills of Cameroon, upstream of the Kashimbilla River. The Dam which also includes an irrigation scheme covering an area of about 3,286ha, water supply network to Takum, Kashimbilla and other neighbouring villages.

Kashimbilla Multipurpose Buffer Dam is an earth-fill dam with a pile of compacted earth composed of quarried rock or natural boulders extending across river Kashimbilla with a fairly gentle slope both upstream and downstream. The long rock fill embankment has a length of 1.585km at a maximum height above river bed of 35m. The Dam has a ground exploration, a hydropower infrastructure with a reservoir capacity of about 500 million cubic meters of water, stepped concrete ogee spillway, spillway-bridge, inlet and outlet structures, water treatment plant of 60,000 cu m/Day, associated pipe and water distribution network to about 400,000 people per day.

It has Hydro electric power generation structures with 40MW Hydropower capacity.

Aircraft landing strip, River and water way crossing structures, access road of 11km etc.

The stepped concrete ogee spillway has a provision for safe discharge of excess water and also a provision is made to control the rate of discharge. There is also a discharge of water through a penstock to the turbines.

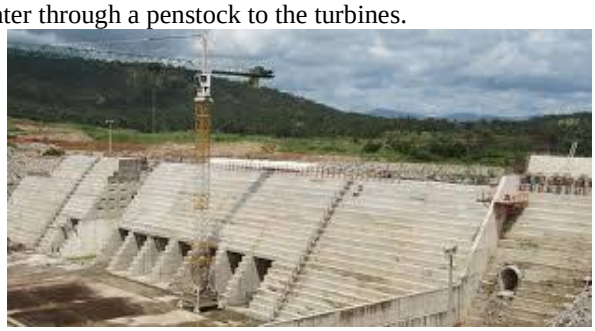

Fig.1: Kashimbilla Multipurpose Buffer Dam in Takum LGA Taraba State, Nigeria

II. REVIEW OF EXISTING DAMS

Dams have been to known to have a great deal of positive and negative impacts on the environment and capable of altering the harmonious interrelationship between the environment and human activities. This is particularly so in most developing countries where proactive precautional measures are either ill provided or is entirely absent. The concept of living in harmony with nature dated back into antiquity. As a follow-up on this, in the 1960s to early 70s, the concept of sustainable development came into timelight, with the view that any development that meet their own needs (WCED, 1987). The emphasis of sustainable development is on the interplay between 3 dimensions of sustainability namely: social, economy and the environment. Two school of thought exist in this discussion, these are: the weak and the strong sustainability schools (Beckernan 1995 and Niemeger, 2003). The strong school of thought is the radical type which believes that pursuit of development must not lead to disastrous consequences on the environment. The weak school on the other hand is premised on the effect that poverty eradication for example, cannot be realized without modification to the ecosystems. Therefore trade-off show development to a limit that permits coexistence between the social, economic and the environment without unwarranted damage to lives and properties.

It has been estimated that there are about 45,000 large dams in the world. Hydropower account for 11% of the world total energy production and 80% of Nigeria energy production, its inception in Nigeria dated back to 1898. Criticism of the hydropower project has increased since the 1190s, but the hydropower industry too has risen to these challenges, by taking various types of measures. The hydropower technology in itself does not impede the ability of future generations in meeting their needs. This explains why it is recommended by Millennium Development Goals (MDGs) as a medium of eradicating poverty. Sustainable development and the way hydropower has sometimes been developed have not always been in harmony. The problem of hydropower development has recently been complicated with the climate change issues since 2000. Meanwhile, irrespective of the perspective it's viewed, hydroelectric power will have negative and positive consequences. Some of the expected consequences may include the provision of low operating and maintenance costs, possession of long life span (50 – 100 years), water storage and release flexibility, provision of reliable service and proven technology.

It also instigates and fosters regional development, makes water available for other uses, provides highest energy efficiency rate (pay back ratio and conversion process), instigation of revenue generation for other water uses such as tourism, irrigated agriculture, leisure, sports etc. It creates employment opportunities particularly during the construction phase, avoids fossils fuel use and cost, provides energy independence by exploiting natural resources, and optimizes power supply of other generating options (thermal and variable renewable). It also have positive social cost such as creating opportunities for capacity building by local/indigenous governments, companies and individuals, often provides flood protection, may enhance navigate conditions, often enhance, recreational facilities, enhance accessibility of the territory and its resources (access roads, ramps and bridges), provides opportunities for construction and operation with high percentage of local man power, may improve living conditions through sustained livelihoods (fresh water, food supply). The positive environmental implications may also include: production of no atmospheric pollutants and only very few Green House Gases emissions, enhances air quality, produces no waste, and avoids depleting non renewable fuel resources (coal, gas and oil). It can also create new freshwater ecosystem with increased productivity, enhances knowledge and improves management of valued species due to study results. Finally, it neither consumes nor pollutes the water it uses for electricity generation purposes.

On the other hand the negative implication can be seen in the following respects: high upfront investment, hydrology dependency, in some cases, the storage capacity of reservoir may decrease due to sedimentation, requires long term planning and require long term agreement. Also, it often requires foreign contractors and funding and conflicting water users can occur. It social negative implication includes: involvement in resettlement, local land use pattern may be modified, water borne diseases vector may need to be checked, requires management of competing water uses, many impact local people's livelihood (Usman & Ifabiyi, 2012).

III. SOCIO-ECONOMIC IMPACT

The concept of water and development has been changing in recent decade. Water for life energy, agricultural and domestic sectors are widely managed between upstream and downstream sides. The water management mitigates the socio economic impact of the area. The notion of economic impacts refers to the effects, on the local and regional economy of project construction and subsequent operating activities. Those include: direct and secondary demands for labour and services, as well as effects on local resources and thus on a very structure of the local economy. Such economic effects also cause significant social impact which impinge on economic parameters. Also, various social impacts stem directly from project activities and these also have economic implications.

The overall socio-economic impacts engender a complex dynamic which is not easy to predict accurately. Impacts are most conveniently evaluated and managed when this

dynamic is seen in terms of issues, but it is essential to remember that such issues are not discrete problems; mitigation, like the impact analysis and project planning must take into account the inter-relationships between the various social and economic considerations.

Because the Kashimbilla dam is often seen as essential for national economic development (served as a buffer against the effect that may be cause by the collapse of the lake Nyos in Cameroon), the macro-economic benefit tend to be highlighted while environmental considerations and especially local economic impacts and social impacts may be less adequately evaluated.

The construction of the dam has been responsible for the relocation of large numbers of people, from Birama, a lot of people moved to Hanki village, some even to Mango, Alahu, Tandun and so on. The economic and human cost of resettlement are huge, the financial costs of resettlement includes surveying people and property, rebuilding of settlements and infrastructure and the actual translocation. There is also the human cost of the stress caused by uprooting.

IV. SPREAD OF DISEASES

Newson, 1997 states of schistosomiasis and other communicable diseases. He also notes that devastating water borne diseases are introduced by reservoirs and their associated irrigation works. Furthermore, he argues that dams have reduced the quality of drinking water for hundreds of millions of people. Clarke (1991) states that when large new volumes of water are created, the risk of disease in tropical countries rises sharply. The diseases associated with dams includes schistomosiasis, yellow fever, malaria, river blindness and liverfluke infections. Adams (1992) argues that, although water borne diseases are widespread in African floodplains, dam construction can increase their prevalence. According to Turcker (1983) water resource development projects creaste additional habitats for disease vectors beyond those already present.

The Kashimbilla Dam caused a lot of devastating diseases among the people of Jinagbanshin, Lukpo, Shibon igba and bariki lisa. The empowerment of the water at the upstream increased the prevalence of schistomomiasis, malaria and yellow fever in the region.

V. LOSS OF SITES OF HISTORICAL AND ARCHAEOLOGICAL IMPORTANCE

Valeys between hills/mountains and river valleys are important sources of recreational activities and history of the area as the valley between “Kuna bête” and “Kuna Kashinbilla” is a site for Takaciyawa festival in the area. The Takaciyawa is one of the prominent historical events in Nigeria and the site is relevant in Nigeria where local indigenous people were seen as inferior and culturally static by the European colonizers. Nigerian governments are also playing an active role in attempting to discover more about the cultural history of the indigenes as a way of promoting nationhood.

Fig.2: Showing Loss of Site for Takaciyawa festival at Kashimbilla

VI. CONSTANT SUPPLY OF WATER

The kashimbilla dam provide a balanced supply of water for all seasons and condition in Takun LGA of Taraba State. The dam ensures a constant supply of water for domestic, industrial, energy production and irrigation purposes. It is of great significance as most part of Southern Taraba have relatively underdeveloped surface water while most of the population lacks access to improve water supply. Infact 45% of the population of Southern Taraba has no access to potable water. The dam also provide constant supply of water for irrigation purposes and livestock which is important in the face of increased incidence of droughts in Nigeria. These drought result in the death of livestock thereby devastating the fragile economy of the country.

VII. JOB CREATION AND INCOME IMPROVEMENT

The construction of the dam results in creating employment to so many people in that area. A lot of people were employed during the construction of the dam, though there are changes in the employment and production systems starting before the construction of the dam including expropriation of the land, employment of construction workers and the transport of construction materials with the machines to the site. Unqualified workers were employed from the site; however the technicians and experts came from other places.

VIII. IMPACTS OF THE DAM ON HYDRAULIC SYSTEM

The main hydraulic impact is the discharge of the collection basin to a stationary reservoir instead of a stream bed. Therefore, changes started at the downstream; downstream of the river dries partially whenever the reservoir begins to accumulate water. During this temporary or periodically repeating time interval, the hydrological balance can collapse; irreversible death, disappearance and structural jumps are observed in the water dependent ecosystem. Decay of dead flora and fauna in the new coming water body speeds up. So, upstream water flows polluted, without oxygen in deeper parts, dark coloured for a long time and usually smells rotten because of sulphurous hydrogen disposal. Although after this process the stream forms a new and healthy ecosystem in this part of it, neither this new aqua balance nor the terrestrial ecosystem and even the sea environment that the stream joins the sea have the chance to join their previous health. It is possible to correlate these changes to different factors listed below.

- Flow speed of the river becomes stationary in its downstream part since the water level in the stream bed does not change significantly. Therefore, energy flow characteristics modify in the living ecosystem.
- Positive variations may occur as a result of the increasing leakage into the groundwater.
- As the reservoir works like a big settlement basin, turbidity in the water flowing downstream decrease and erosion around the lake deceases slowly.
- Increases in the evaporation losses because of the enlargement in the water surface can be observed.
- The various in the temperature regime of the water environment can be classified in two groups:

1. Thermal variations that may end in seasonal thermal layer formations depending on the water depth in the dams,

2. The variations that happen in the water temperature inside the reservoir related to the water depth that was able to leak trough the downstream gates and the exchange of water with constant temperature. The river will behave like a cold climate river from chemical and biological qualifications point of view, as the water will always cold even in dry season, if the gate depth lies below the thermocline of the reservoir. On the contrary, it will behave like a hot climate river if the flowing water is at surface water temperatures. Effects similar to these can continue kilometers along the downstream.

- Serious changes occur in the chemical qualifications of the river water similar to temperature variations. Depending on the reservoir depth, water that is suffering from oxygen and even includes sulphurous hydrogen may take part in the deeper parts of river. When water flows downstream, very important vital changes may occur in the downstream part, related to the depth of dam gates. The decomposition products of the organic matters accumulated in deeper parts of the river where oxygen is in limited amounts may come up to the surface accompanied by sudden gas releases. This results in a sudden addition of different chemical nutrient substances to the biosystem and besides a frequently fluctuating water quality. Furthermore, it has been observed that nitrogen in the air was dissolved in extreme saturation levels in the downstream part of the falling water. By this way, water that is saturated approx. 150% to nitrogen can be fatal for fishes.

IX. IMPACTS OF THE DAM ON THE ATMOSPHERIC SYSTEM

Variations in moisture percentage, temperature and air body movements of air caused by the big stationary water body differentiate microclima related to region topography. In addition, regional scaled climatic changes can be observed. These alterations may seem not very harmful for human health, but they are notable from many plants and animals. Their secondary effects influence human beings.

X. IMPACTS OF THE DAM ON THE EARTH'S CRUST

Even though it is claimed that the dam reservoirs have some seismic effects, it must be stated that this is not proven scientifically.

XI. IMPACTS OF THE DAM ON TERRITORIAL BIOLOGICAL SYSTEMS

Biological life of the river changes fast both in the reservoir and in downstream. The parts of the biosystem that are affected from the dam are the watered parts on the shore.

During the filling works of the dam, while the lands remain under water the land part of the region decreases. However, the water-land boundary extends. Thus, plant, animal or human being settlement areas change. Forests, agricultural areas may come under water.

As the water level differentiates periodically, some species begin to live under water from time to time, in the tide zone. This area may turn to marshy land or reed bed depending on the soil structure.

Water-soil-nutrient relations, which were settled after floods in the downstream of the dam, change in a long period of time. Furthermore, compulsory changes occur in flora, fauna and the agricultural traditions of people in the region. This effect can extend for kilometers.

XII. IMPACTS OF THE DAM ON AQUATIC ECOSYSTEMS

At the beginning, the decomposing organisms cause an increase in the nutrient substances in water in a short period of time. Therefore, BOD (Biological Oxygen Demand) value of water rises. An anaerobic decomposition media is performed with the help of the stationary layers along the reservoir depth.

Ecological Impact/Mitigation Measures

Ecological Impacts	Mitigation Measures
Sedimentation in the reservoir.	• Ensure regular penstock releases • Increase frequency of releases when sediment load of inflowing water increases. • Ensure catchment protection and watershed management
Release/accumulation of bye-products of anaerobic decomposition	• Ensure regular penstock releases • Monitor water quality, including penstock releases.
Migration and productivity of fish species.	• Ensure spillway is free from any blockage. • Seed fish, if necessary, to maximize fisheries productivity.
Changes in primary productivity due to biochemical reactions.	• ensure penstock releases (from the lower depth of the dam). • Spillway shall release water from the surface.
Risk of eutrophication/growth of non-native and/or invasive species.	• Monitoring of in-stream water quality • Partner in enlightenment for increased environmental awareness in surrounding communities.
Opportunistic growth of aquatic macrophytes in the littoral and sub-littoral zone of the reservoir.	• Monitor for any presence of disease species • Remove such species when seen.
Creation of favourable habitats for the growth and proliferation of diseases vectors.	• Monitor the presence of disease vectors • Contribute to strengthening of local health facilities through public enlightenment. • Contribute public health programmes to eradicate/protect against malaria, schistosomiasis &, etc. • Direct contributions in terms of drugs, provision of infrastructure, etc. • Spillway ensures continuous flow; hence the likelihood of creation of habitats for bilharziasis is remote.
Altercations in the flow of water and changes in water quality during the construction of the dam embankment.	• Adequately divert the river away from construction areas. • Ensure good practices.
Obstruction of flow of the River Oinyi during dam filling.	• Carry out commissioning at the peak of the rainy season • Ensure penstock releases if flow is critically below expectations.
Changes in downstream water quality.	• Ensure regular penstock releases, • Monitor quality of penstock releases • Increase frequency if necessary.
Impacts due to air emissions/noise, and dust generated during earthwork/construction	• Ensure that emission levels of machinery are within permissible limits. • Ensure that there is no night work.
Enhanced erosion/changes in topography due excavation.	• Put erosion control measures • Obtain earth fill from flooding zone. • Re-vegetate with native species.
Risk of accidental drowning. Injuries during dam construction and/or due to vehicular traffic.	• Keep unauthorized persons away from dangerous zones. • Put warning signs (written in English and local languages) at strategic sites • Ensure regular monitoring of embankment, penstock and spillway.
Changes in downstream ecology.	• Ensure minimum ecological releases • Monitor seepage/penstock release volumes.
Possibility of creation of mosquito breeding grounds due to the alternation of the natural flow pattern of river Oinyi through penstock releases during dry season.	• Minimize penstock releases during the dry season and monitor and control the possible creation of mosquito breeding sites.
Loss of terrestrial habitats due to impoundment.	• To put in place catchment protection and watershed management plan.

Socio-Economic & Health Impact/Mitigation Measures

Socio-Economic/Health Impacts	Mitigation Measures
Loss of control/income of land to be inundated by the reservoir	• Compensate for farm crops and/or economic plants. • Liaise with chiefs to allocate alternative land to farm. • Subsidise clearing new farmlands and assist affected farmers.
Risk of introduction of new diseases as schistosomiasis	• Monitor for the presence of snails of *Bulinus* species • Contribute to strengthening of local health facilities.
Changes in downstream water quality.	• Monitor water quality. • Provide appropriate alternative source of water for downstream settlers.
Gender disparity in the adverse effects of landtake	• Gender equity in compensation • Ensure payment is to affected women.

Massive influx of people during dam construction.	• Strengthen basic facilities • Avoid actions that could cause or escalate tension. • An influx management plan being prepared to address influx related issues.
Changes in sexual behaviours leading to the spread and/or escalation of sexually transmitted diseases (including HIV/AIDS) and unwanted pregnancies.	• Enlighten personnel about STDs (HIV/AIDs) and use of condoms. • Partner with NGOs in campaign to stop the spread of HIV/AIDs. Help strengthen healthcare system.
Conflict resulting from insensitivities of dam construction personnel to the local culture, traditions and lifestyles.	• Educate workers on the cultural sensitivities in the host communities. • Identify with the host communities during festivals.
Rescued availability of river water, downstream (especially during dry season) to downstream users.	• Ensure penstock releases during dry season to mimic minimum ecological flows.

XIII. COMPENSATION MEASURES

Some measures of compensation are considered as part of the environmental management plan. This is considered as some form of repayment for residual adverse effects, or impacts that can neither be avoided nor adequately mitigated. These include the following:

- Compensation in the form of direct monetary payment of people affected by land-take and/or loss of crops has been put in place.
- Ensure the preservation of the dam catchments area especially the hills to the northeast of the dam site.

XIV. CONCLUSION AND RECOMMENDATIONS

The study has revealed that Kashimbila Multipurpose Buffer Dam has both positive and negative impact in Takum LGA of Taraba State. However, there is need to enhance the beneficial impacts and minimize the adverse impacts of the dam.

The beneficial economic impact of the dam is the development of the irrigation scheme and the supply of water to Takum, Kashimbilla and other villages. Lack of proper management and funding will possibly be the major hindrance to the development of the irrigation scheme; funds should be made available for this purpose. Irrigation has the potential to boost local agricultural income through ensuring constant supply of water for crops throughout the year. The development of irrigation scheme is also an important mitigation measure against climate change.

The benefit of Kashinmbilla Multipurpose Buffer Dam can be enhanced by using its water resources for the development of the hydroelectric power plant project. The hydroelectric power plant project would augment the national power grid and contribute to the production of clean energy. The project could be beneficial from carbon trading as this will be one of the alternatives to achieving net carbon sink status. This will be a plus for combating global climate change and achieving sustainable development. Local communities should also participate in water resources development planning. This empowers local people so that they regard the development projects as their own. The kashimbilla community did not actively participate in the development planning of the dam. This has largely contributed to failure by authorities to ensure the local communities reap maximum benefit from the dam. Community involvement in the dam construction also reduces the impact of uncertainties and stress caused by uprooting and resettlement. Thus, bottom up planning is necessary for the achievement of sustainable development.

Fishers should also be provided with increased access to capital resources in order for them to purchase modern fishing gear. This will help them to reduce the incidence of drowning and being attacked by wild animals in the water among fishes. Further, aquaculture should be developed as away of diversifying economic activities in the area. Aquaculture will also increase access to fish protein for the community. This will result in an expansion in income generating activities and help improve community health thereby contributing to the achievement of the Millennium Development Goals, (MDGs).

REFERENCES

1. Adams, W.M. (1992). Wasting the rain: Rivers, People and planning in Africa. London: Earthscan publications.
2. Barrow C.J. (1995). Impacts of Large Dam in Developing the environment. Pp. 226 -0 233, longman Singapore.
3. Baxter R.M. (2005). Environmental Effects of Dams and Impoundment. Journal of Annual Review Ecological Systems.
4. Boycen K.M. (2012). An Assessment of Socio-Economic Impacts of the construction of Siya Dam. Journal of Sustainable Development in Africa. Volume 14. No. 4.
5. Baba K. and Toshio H. (2000). Water Storage Transport and Distribution E/A of Dams and Reservoirs. UNESCO Eohss sample chapters.
6. Carteledge B. (1993). Energy and the Environment. Oxford Press UK.
7. International Hydropower Association (2003). The role of Hydropower in sustainable Development. UNESCO International hydrological Programme.
8. John T.H. and Salas J.D. (1995). Environmental Effects of Extreme Floods. US-Italy Research workshop on the Hydrometeorology, Impacts and management of extreme Floods. Perugia.
9. Sait et al (1995). Positive and Negative Impacts of Dams on the Environment. International Congress on River Basin Management.
10. Usman A. and Ifabiyi I.P. (2012). Socio-Economic Analysis of the operational impact of Shinroro Hydroelectric power Generation in the low land Area of middle River Niger. Research in Business and social science vol. 2 no. 4.