THE FAILURE OF ALAU RESERVOIR TO FILL A LEGACY OF UNCONFINED, LEAKING BASIN ON THE MEGA-CHAD FLOOR

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Abstract

The Alau dam was constructed with high hopes: to supply potable water to the Maiduguri metropolis, and to supply water to irrigate the Jere bowl for the production of rice. This study, based on field observation and literature search, confirms that several years after its construction, the reservoir behind it fails to fill up to an expected level, precluding the achievement of the two objectives. It is discovered that the reservoir loses water to the unconsolidated sands at its floor, and to the Bama ridge, the outermost beach of the Mega-Chad, on its northeastern margin. field observation also reveals that a topographical divide exists between the Alau reservoir and the Alau (natural) lake which prevents the two to function as one body of water at a low level as envisaged by the planners. Finally, it is found that the reservoir basin is not adequately confined and a small rise would flood extensive areas in the region (the restraining dykes notwithstanding) and thereby compounding the problems of seepage and evaporation both of which are considerable in the area.

The preoccupation of the planners is to divert water from the larger Yerdzeram river to fill the reservoir and make it possible to release water for urban and irrigation needs. In fact, some water was diverted this way during 1992 as an experiment, while an elaborate dyke construction to divert more water to the reservoir is going on in the Sambisa swamps. However, it is contended that while additional water might improve the level of the reservoir, it would not solve the inherent problems which is largely a legacy of the processes associated with the Mega-Chad. These are:

- excessive seepage into loose sand at the floor, side and along any canal that may be built;
- flooding of an extensive area should the water level rise more than the current level, another metre may be more than enough; and
- the topographic divide between the Alau reservoir and lake.

An additional problem is the excessive evaporation from water surfaces which is characteristic of the region. Unless these problems are tackled effectively, Alau dam may never achieve the objectives for which it was built.

Key-words: reservoir, unconsolidated sediments, unconfined basin, (artificial) dykes, evaporation, topographic divide.

1. INTRODUCTION

The Alau dam was conceived and built on the Ngadda floodplains at a place known as Lokojeri, a few kilometres outside the Maiduguri metropolis on the Maiduguri-Bama Road (Figure 1). Its reservoir was envisaged to have a water head of at least 3 metres (head elevation of between 302 and 303 m above a bed elevation of 299 m). From this reservoir, water was to be extracted to a treatment plant to be situated immediately below the dam on the Bama ridge from where potable water would be piped to the metropolis. It was also planned to release water through the natural channel of the Ngadda below the dam to the Jere bowl in a controlled manner to support the irrigation of rice in the bowl. It should be remembered that before the inception of the dam, the Jere bowl had always been flooded by the Ngadda and local runoff to support the production of rice, using the residual moisture utilization technique. It was also envisaged that the reservoir water would merge with that of the (natural) lake Alau on the Alau river (Figure 1) to serve as one source of water for the projects.

However, more than five years after the construction of the dam, the reservoir has not achieved the expected water head on a regular basis; the treatment plant has not been completed because there is no sufficient water to run it; no water has been released to flood the Jere bowl; and the people of the metropolis could only comment on the adverse effects of the dam -- a white elephant.

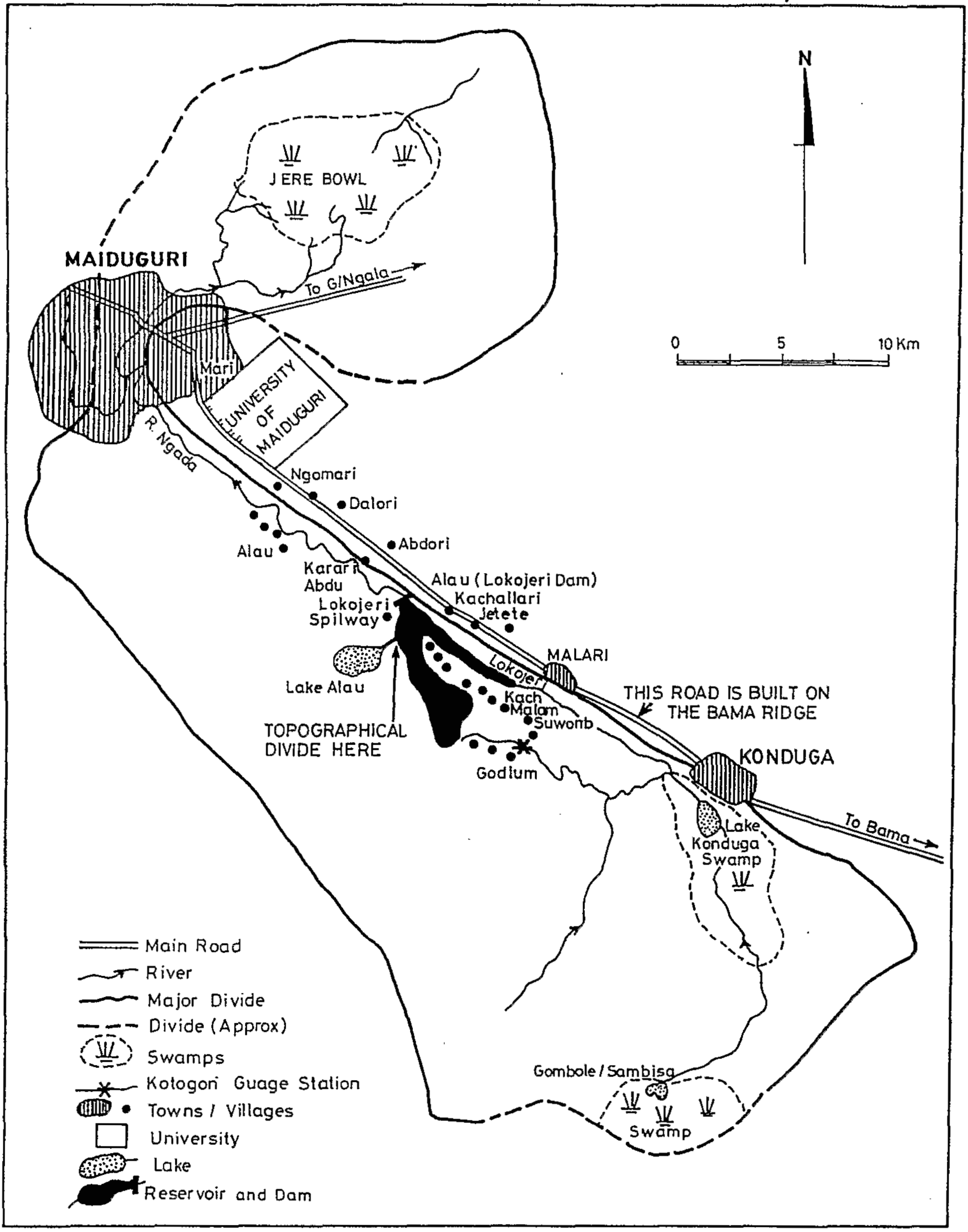
This paper examines the factors (which are closely linked with the nature of the site morphology and lithology) that are responsible for this colossal failure. To this end, the environmental conditions of the Lower Ngadda in which the reservoir basin is located, as well as those of the reservoir site itself, are described and site factors are advanced for the failure of the reservoir to fill to capacity.

2. ENVIRONMENTAL CONDITIONS OF THE LOWER NGADDA

2.1. The Ngadda catchment

The Ngadda catchment may be considered in three broad sections: the source region; the upland section; and the lower course. It must be stated that in the first two regions, the river is known as the Gombole and many researchers do not see it as the headstream of the Ngadda. To them, the Ngadda is only the lower

FIG. 1 : THE NGADDA CATCHMENT (LOWER COURSE)



Source : Modified from H.M.M.B. Seneviratne, 1979.

section, below the Sambisa swamps. In any case, about 150 km from its source, the Ngadda (or Gombole) flows into the Sambisa swamps (Figure 2) where its waters mix with those of the Yedzeram river. The Ngadda emerges from these swamps weak and meandering and unable to cut through the Bama ridge. It is the Ngadda below these swamps which is our concern here. The entire Ngadda catchment is about 2,600 km^2 of which the lower course constitutes less than 600 km^2.

2.2. The Lower course

In the lower course the Ngadda flows along the Bama ridge (the outermost beach of the Mega-Chad trending NNW-SSE in the study area as shown in Figures 1 and 2) for 50 km before it breaks through the ridge within the Maiduguri metropolis and flows into one of the numerous depressions on the bed of the Mega-Chad known as the Jere bowl where it loses its defined channel, and its waters to evaporation and seepage. It is believed that the river loses about 50% of its waters within the 50-km stretch along the Bama ridge to evaporation and seepage to its unconsolidated bed and banks, especially the Bama ridge itself. It is known that part of the water that infiltrates the ridge usually emerges on the other side to the ridge to cause extensive flooding on parts of the floor of the Mega-Chad.

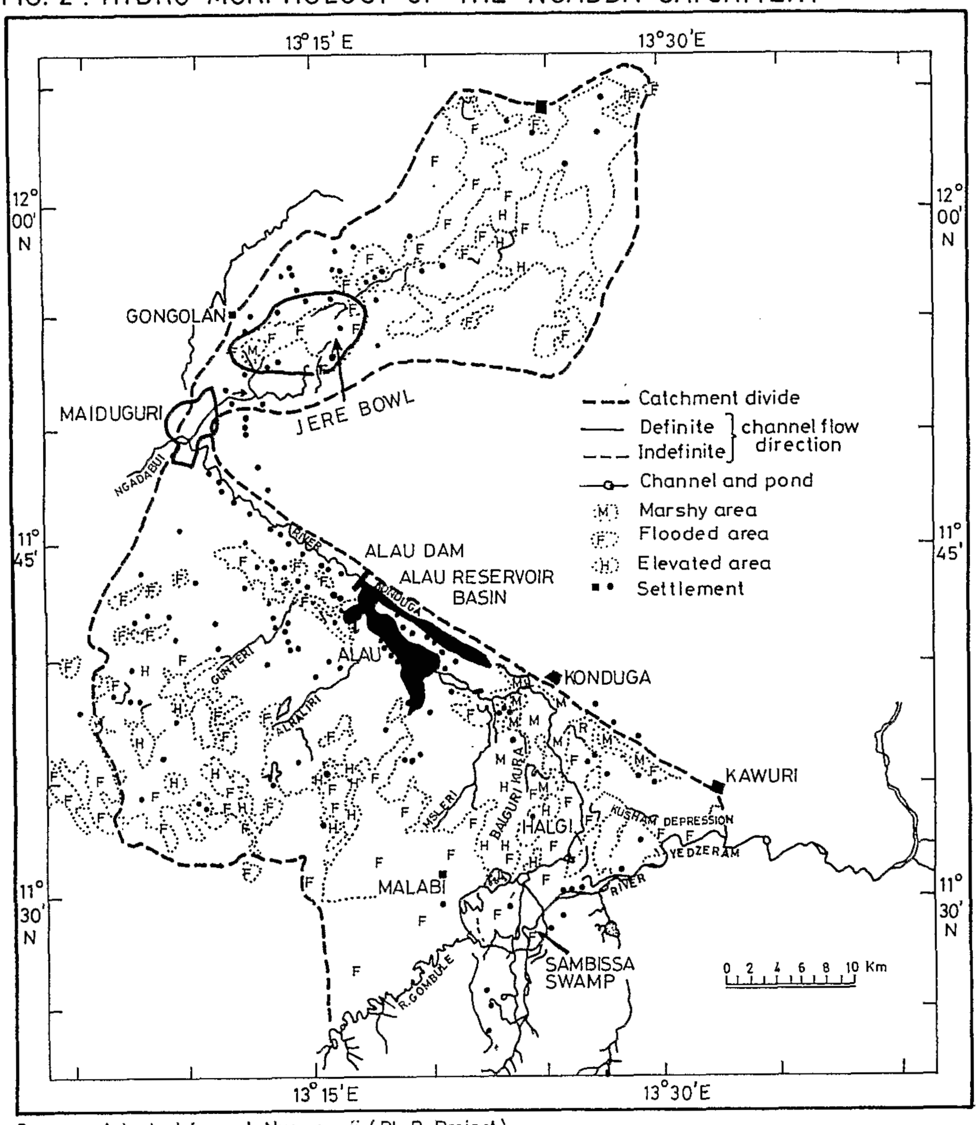
This lower course occupies plains formed by terrestrial and marine sediments of the Chad formation on the periphery of the ancient lake. Part of the terrestrial sediments must have been deposited in lagoons behind the beach. The sediments are very porous and encourage substantial seepage into the upper aquifer of the Chad basin. The plains are also characterized by sand ridges and shallow basins most of which are not confined. The Alau reservoir occupies one of such shallow, unconfined and "leaking" basins.

3. THE RESERVOIR BASIN

3.1. The setting

As stated above, this is one of the shallow, unconfined and porous basins developed at the edge of the ancient Mega-Chad as inflowing rivers attempt to discharge into the lake. The Ngadda seemed to have found it difficult to break through the beach and had to meander along it, creating an extensive open floodplains into which it later incised, deepening its channel to a depth of about three metres along the Bama ridge. But the outer edge of the depression remains unconfined, low and open. The Ngadda, before its impoundment, floods this outer edge frequently including lake Alau. It seems that it is the addition of the

FIG. 2 : HYDRO MORPHOLOGY OF THE NGADDA CATCHMENT



Source . Adapted from J Nyanganji (Ph D Project) waters of another river to those of the Ngadda in the metropolis that provides the energy that enables the Ngadda to break through the ridge as mentioned earlier.

3.2. Morphology

As stated before, the Alau dam reservoir occupies an area of undulating topography, consisting of low sand ridges and linear depressions. The reservoir water is contained within some of the depressions, the edges of some of which have to be closed by earth-dykes to prevent outward flow of water from the reservoir. Figure 2 illustrates the general morphology of the reservoir basin before the impoundment. Currently, the reservoir is characterized by sharp headlands and islands whose sides slope at between 5 and 10°. Also, the reservoir slopes (some of which are inhabited) incline at angles of 3 to 5°.

A study of existing maps of the reservoir basin suggests that none of them matches actual field conditions. For example, a contoured map of the area at one metre interval suggests that the bed elevation of the depression which the (natural) lake Alau occupies is about 297 m, rising to 305 m on the western, northern and southern rim, but opening on the east to the Ngadda channel at between 298 and 299 m. The map further depicts that the bed of the Ngadda at the site is about 299 m (i.e. at par with the opening of lake Alau), but rising to 305 m at both the Bama ridge and Lokojeri ends (Figure 1), suggesting that an impoundment of the Ngadda at the site should easily spill over to the Alau lake. In fact, it was envisaged that a reservoir with a head elevation at between 302 and 303 m should logically merge with the Alau river and lake system, allowing for a withdrawal of between 3 and 4 m depth of water from the combination. Such a head elevation should also flood the entire Ngadda floodplain upstream to Kimeri (Figure 1). However, while the floodplain has been flooded even beyond Kimeri, the Alau basin has not been flooded for any length of time, and the lake remained separated even when a head elevation of about 301 m was achieved on September 4, 1991. The flooding was only for a while in 1992 when diversion of water from the Yedzeram achieved a reservoir head elevation of approximately 302 m. Another map used by Jacob Nyanganji (personal communication) has shown that a divide of about one metre high lies between the reservoir and the lake.

3.3. Sediments

As already repeated before, the sediments of the site are unconsolidated and very sandy. Thus, seepage is very high. Seepage from the reservoir to its bed and banks should match the original seepage from the Ngadda to the beach ridge, its bed and other banks, if not more. Also, evaporation from the surface is excessive, especially since water is available for the process throughout the year. An estimate of over two metre per annum is given for this region, and the more the surface area of the exposed water, the greater is the total volume of water lost to evaporation (OLOFIN, 1985).

Another source of danger to the reservoir capacity is the potential rate of siltation which is already increasing due to the nature of the soils and human activities within the reservoir basin.

The surface soils of the reservoir area before the impoundment ranged from loamy sand on the raised grounds such as the ridges, through sandy loam at the footslopes to silty and clayey loam in the depressions. At the bottom of the depressions were hydromorphic clayey soils. Now only some of the raised grounds with their loamy sand texture rise above the water level as headlands, islands and bounding ridges. The soils are very fragile and highly susceptible to slope wash and rill erosion.

Soil erosion is rather serious on the exposed headlands, islands, bounding ridges, and the earth-dykes as well as on the cultivated margins of the relatively gentler reservoir slopes. The headlands and the dykes are the worst. One such headland studied during the field visit protruded into the reservoir for about 50 m. This headland was riddled with rills some of which were more than 50 cm deep. The headland had been eroded into a sharp-crested (two to three centimetres wide) densely rilled form. At the rate observed, and based on the fact that the texture is very fragile, it would not be long before it would be removed completely, if nothing concrete were done to control the process. Other headlands, ridges and dykes stand the same fate.

Secondly, the cultivation of the reservoir slopes, particularly the risk zone (draw down area) has resulted in a great deal of slope wash, evidence of which consists of sandy beaches at the base of the cultivated plots on the water margin. Finally, footpaths and other land use practices associated with settlements on the islands and bounding ridges also aid soil erosion. Small gullies recede headwards along such footpaths.

One result of the observed rate and magnitude of soil erosion is rapid reservoir siltation. There is little wonder that the reservoir is heavily silted-up. The sandy beaches, the numerous alluvial fans, some emerging low-water islands and pockets of vegetation clusters, coming so soon after the establishment of the reservoir, attest to this rapid siltation. The siltation is compounded by pollution arising from dumping of domestic refuse in the reservoir, wash down of chemical fertilizers from the cultivated plots, bathing and clothe-washing activities and aerobic particulates from rotting dead tree trunks left within the reservoir.

The second result is the lowering of the crest of the elevated bounding headlands, ridges and dykes. Should the heights be reduced below high-water level, there would be excessive spillage resulting in a widespread flooding as the lake would lose its water to an undefined and extensive area in view of the morphology of the region (see Fig. 2). The process of soil erosion must be stopped.

4. THE FAILURE OF THE RESERVOIR TO FILL

From all of the above, it is quite clear why the reservoir has not been able to fill up since the inception except during periods of temporary flash floods. Even when it appears to fill, the capacity is no longer as much as at inception. The main reason is traced to the highly porous bed and bank materials which is put at over 14% (NYANGANJI, interim report). The materials constitute a legacy of the ancient lacustrine activities of which the Bama ridge is the best example. Part of the legacy is also a topographic divide between the reservoir and the Alau system which has not allowed river Alau to contribute any water to the reservoir. In a class of its own, and of a greater dimension is the rate of evaporation of surface water in the region which may run to more than 70% of stored water in a year. Another hazard is the silting up of the reservoir bed owing to increased soil erosion within the basin as a result of increased human activities.

It is clear, therefore, that the reservoir cannot fill from local sources. And for the same reasons, in addition to the occurrence of a depression between the reservoir and the Jere bowl, it is not advisable to release water into the natural channel below the dam to serve the bowl. Of course, if water runs through the channel, serious urban pollution within the metropolis cannot be ruled out.

5. PLANNERS' SOLUTION

The planners' solution to the problem of an un-filling Alau reservoir has been the import of water from other sources. The Yedzeram river provides the nearest target, and an experimental diversion was undertaken in 1992 (FACU Director, personal information, and field visit). But it only increased the level of the reservoir temporarily and failed to flood the Jere bowl. It has not achieved a measurable success. Now there is an elaborate plan to transfer more water from the Yedzeram. To this end, a very long earth dyke is being built across the Sambisa swamps to impound the waters of Yedzeram and Gombole rivers on one side and release water to the Ngadda on the other side through a chain of gates (field visit). But the outcome of the 1991 experimental diversion should have taught a lesson: unless the local problems, identified above, are solved more water diverted into the reservoir, would mean more water available for seepage, evaporation and unfruitful flooding, particularly as the restraining dykes holding the reservoir in check can easily give way.

6. CONCLUSION AND SUGGESTIONS

It is doubtful if the Alau reservoir would ever fill to fulfil all the objectives of its planners because of the inherent local problems of seepage, evaporation, topographic divides and unconfined extensive plains. While detailed micro-relief study could help to solve the problem of the topographic divide, restraining walls built to solve that of unconfined depressions, and human activities controlled to minimize the rate of reservoir siltation, the problem of seepage and evaporation would seem to defy effective solution. Therefore, it seems wise to limit the function of the reservoir (with the assistance from the Yedzeram) to that of potable water supply to the Maiduguri metropolis. Other means should be found to make the Jere bowl productive.

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