IMPLICATIONS OF THE DAM IN THE BULBULA RIVER FOR LAKE ZIWAY

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May, 2009

Construction of a dam in Bulbula River

Currently (May 2009) a check dam is being constructed in the upstream portion of the Bulbula River (just downstream of the outlet of Lake Ziway). The temporary detour channel and the temporary dam in the Bulbula River, both aimed at creating a dry construction site, are already in place (Figure 1 and Figure 2, respectively). The foundation of the dam is also being made. Building material and heavy equipment are on site (Figure 3).

Figure 1. Temporary detour of the Bulbula River

Figure 2. Temporary dam in the Bulbula River

Figure 3. Excavation works in the previous streambed of the Bulbula River.

Although the obtained information on the project and parts of the underlying report (Water Works Design & Supervision Enterprise / Concert Engineering & Consulting Enterprise, 2007) are somewhat ambiguous, it is understood that the dam will principally be constructed to increase the water level of Lake Ziway by approximately 1 metre and thus create additional storage capacity. The report concludes that the net evaporation of fresh water resources will be reduced by the new dam and that an additional 5000 ha of land can then be irrigated "without significant impacts on Lake Ziway and Lake Abyata".

The project is not in line with the recently issued Master Plan for the Rift Valley (Halcrow and GIRD, 2008) and also contradicts with recommendations from other studies of the area (e.g. Legesse and Ayenew, 2006; Jansen et al, 2007; Ayenew and Legesse, 2007). Because of the concerns about the sustainability of the project, this discussion note has been composed. The note addresses some of the critical issues and aims to create awareness and contribute to sustainable development of water resources in the area.

Expected impacts of the dam

The expected hydrological and environmental impacts of the dam in the Bulbula River are:

- Reduced net outflow towards Lake Abyata, resulting in the further shrinkage of Lake Abyata and the associated environmental degradation;
- Reduced (net) availability of water in downstream sections of the Bulbula River;
- Increased salinity levels of Lake Ziway;
- Increased evaporation losses from Lake Ziway.

Potential social impacts are:

- Increased competition and potential conflicts between the upstream farmers (around the Meki and Ketar Rivers and around Lake Ziway) and downstream water users such as the farmers along the Bulbula River and the citizens of Bulbula Town, if no proper water allocation / prioritization protocol for times of scarcity is established;
- Deterioration of the water quality of the public drinking water supply of Ziway Town;
- Reduced revenues from fishery at Lake Ziway.

This note provides a conceptual framework for further discussion and research on the impacts of the dam in the Bulbula River. The focus is on the water quantity and water quality issues, particularly the risk of salinization of Lake Ziway. The impacts on ecosystems and the impacts on Lake Abyata are not addressed in this note. This note is thus principally aimed as scoping paper to identify some of the main hydrological issues, which should be followed-up with additional information.

Water quantity

Water storage in Lake Ziway

From the bathymetrical survey by (Calorie et al., 1999) it can be concluded that the average additional storage in Lake Ziway would be in the order of 350 – 450 million m^3 if the average water level of the lake would be increased by 1 metre (see also Ayenew, 2007). This estimated volume is based on limited data and can be quantified more precisely if more recent and more accurate bathymetrical data were made available.

Additional evaporation losses

From the available bathymetrical data in combination with the digital elevation map it can be concluded that the increase of the average water level in Lake Ziway by 1 metre will result in an extension of the average inundated area of 50-75 km^2. This would result in additional evaporation from Lake Ziway in the order of 75-100 million m^3 per year. This volume of water can be considered as being lost for agriculture and ecosystems in the Central Rift Valley.

In the 1990s the average annual discharge by the Bulbula River was in the order of 300 million m^3. Since 2000 the average annual discharge has been in the order of 150 million m^3, with annual discharges of less than 50 million m^3 in 2003, 2004 and 2005. Data of 2006, 2007 and 2008 were not available for this assessment, but indications are that the discharges have continued to be very low in the past years.

This means that at least half of the present discharge by the Bulbula River would be lost by additional evaporation from Lake Ziway because of the new dam.

Unless the Bulbula River would be completely closed, it is expected that Lake Ziway will not reach its envisaged water level in most of the years.

Water quality

Activities leading to the further reduction of discharge by the Bulbula River (such as water abstractions from Lake Ziway or in the catchments of the Meki and Ketar River) can result in the salinization of Lake Ziway, as the lake may become a terminal lake (Jansen et al, 2007). Also in the case that the lake will not become a terminal lake there is a risk that the discharge by the Bulbula River may not be sufficient to "flush" the lake, i.e. that the *environmental flow* in the Bulbula River is insufficient to maintain Lake Ziway fresh. It is unlikely that this environmental flow can be guaranteed against the background of the reducing discharges since 2000 and the plans for further expansion of the irrigated area.

Lake Ziway is the largest fresh water reservoir in the area and a critical resource for the drinking water supply of people and livestock. Lake Ziway is the resource base for many livelihoods and ecosystems. If Lake Ziway salinizes this will have dramatic consequences for many people, livestock and the ecosystems.

Process of salinization

Together with water there is a permanent inflow of salts into Lake Ziway. Salts originate from the interaction between water and soils (geological formations) and -to a lesser extent- from human activities. Lake Ziway's main source of salts are the tributaries (particularly the Meki and Ketar Rivers). Also surface runoff and groundwater inflow are associated with salt load.

The Meki and Ketar Rivers contain excellent quality water, yet they do contain a (low concentration of) salts. The average salt concentration is approximately 200 mg/l, the annual discharge of the two rivers is approximately 700 million m^3. This means that these two rivers together discharge annually 140 000 tonnes of salts into Lake Ziway. This is the equivalent of *more than 10 000 truck loads with salt that are dumped into Lake Ziway every year*!

If these salts are not removed Lake Ziway will salinize, similar to Lake Abyata. Lake Abyata is a terminal lake (with no outlet for water *and salts*), hence this lake has become saline. The discharge of salts from Lake Ziway through the groundwater is limited, whereas there are (virtually) no salts discharged through evaporation. The Bulbula River is the principal outlet of salts from Lake Ziway. The discharge of the Bulbula River should be sufficient to "flush" Lake Ziway and keep it fresh.

Environmental flow

The minimum discharge of the Bulbula River to keep Lake Ziway fresh can be considered as one of the components of the required "environmental flow". The ecosystem requirements of the area downstream of the dam (including Lake Abyata) should also be incorporated in the environmental flow. This note will only focus on the portion of the environmental flow that is required to avoid the salinization of Lake Ziway.

Assessment of salinization risk

The risk of salinization has been assessed with preliminary calculations, based on the available information. The following data and assumptions were used:

- Average volume of Lake Ziway: 1.7 billion m^3;
- Salinity of the water from the Meki and Ketar River: 200 mg/l;
- Annual discharge of Meki and Ketar River: total of 700 million m^3;
- Present (initial) salinity of Lake Ziway: 300 mg/l;
- Inflow and outflow of groundwater are not considered (this is an order of magnitude less than surface water fluxes, however the salt concentration is higher);
- No soil salinization occurs and drainage water flows back to the surface water system.

The risk of salinization also depends on the flushing characteristics of Lake Ziway, i.e. whether full mixing of the lake's water occurs or if only partial mixing occurs. If the mixing is partial then the fresh waters from the Meki and Ketar River "push" the more mineralized water ahead, resulting in a salinity gradient between the upstream and downstream section of Lake Ziway. The salinity gradient over Lake Ziway depends on the outflow by the Bulbula River. In the case of low outflow the average time that water resides in Lake Ziway will increase and more mixing will occur.

Figure 4 shows the development of the salinity level of Lake Ziway for various quantities of outflow through the Bulbula River in the case that full mixing of the water occurs.

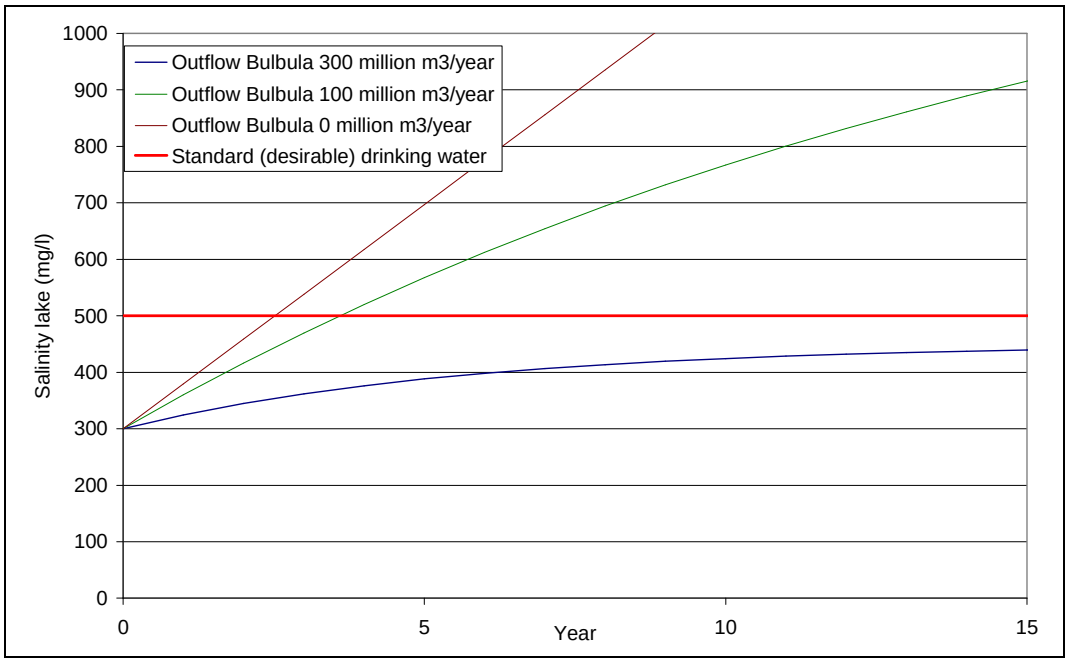

Figure 4. Salinity development Lake Ziway for various outflow scenarios

If the annual discharge of the Bulbula River is 300 million m^3 (approximately the natural/historical outflow) no salinization is expected. However, the lake will salinize to concentrations above the desired drinking water standard (500 mg/l) within 5 years, if the discharge of the Bulbula River reduces to 100 million m^3 per year or less. If the Bulbula River stops discharging water critical salinity levels (1500 mg/l) will be reached after about 15 years. If the annual discharge is 50 million m^3 per year this will take approximately 25 years. It can thus be concluded that the hydrological system is very sensitive to (human) interventions.

Salinity measurements show, however, that there is a slight salinity gradient over Lake Ziway in the downstream direction (Haile, 2008), hence no complete mixing occurs presently. As a result the salinization process can be somewhat slower, although this effect is small for discharges of less than 150 million m^3 per year. The calculations presented in Figure 5 explain that the observed (historical) salinity levels of Lake Ziway are below 400 mg/l (because of this gradient).

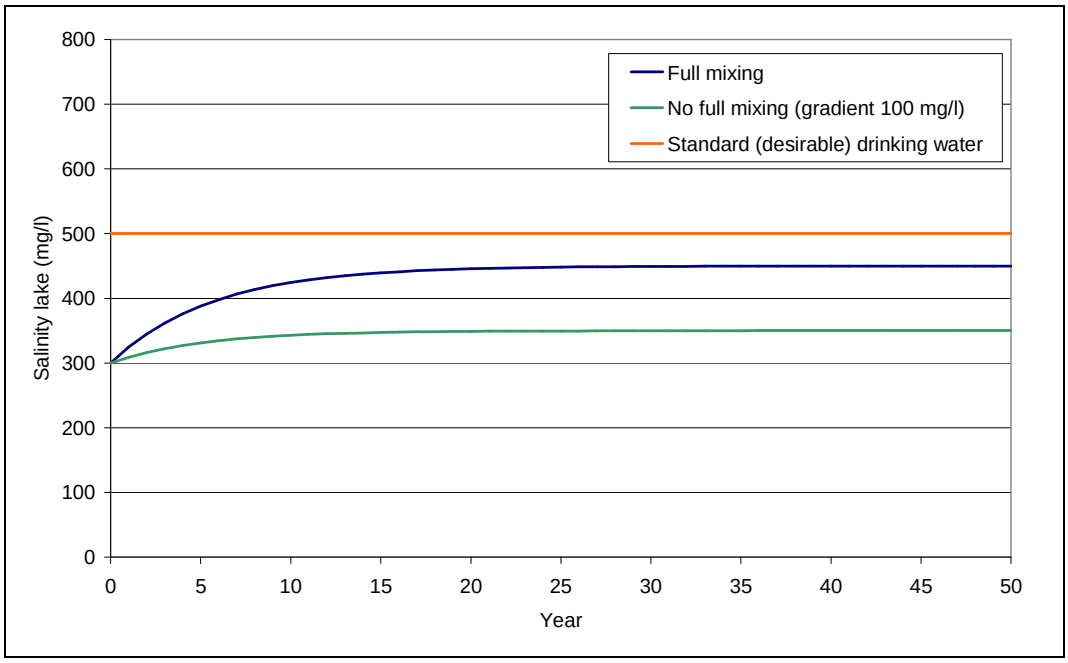

Figure 5. Salinity development of Lake Ziway (discharge Bulbula River of 300 million m^3/year)

The calculations presented in Figure 6 show that the required environmental flow in the Bulbula River, required to maintain the salinity below the desirable drinking water standard of 500 mg/l, is more than 200 million m^3 per year, even with the assumption that in the future a gradient of 100 mg/l over the lake will continue to exist.

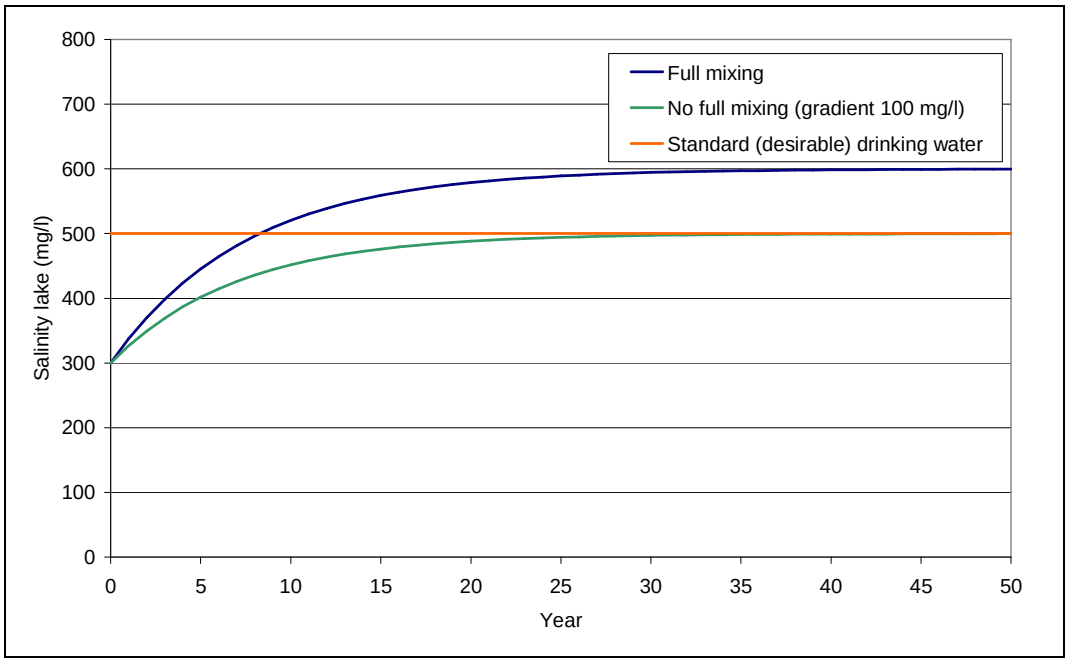

Figure 6. Salinity development of Lake Ziway (discharge Bulbula River of 225 million m^3/year)

It can therefore be concluded that the current abstractions from Lake Ziway and the upstream catchments are already unsustainable and that the construction of the dam will deteriorate the situation.

Soil salinization and drainage
The above calculations assume that no salt accumulation in the soils occurs, i.e. that the soils are adequately leached. Moreover it is assumed that the salts are discharged back into the surface water system (by the drainage water). In reality salts may be also be discharged through the groundwater, which would retard (not avoid!) the salinization process. Salt accumulation in the soils would have the same effect.

Conclusions

1. The increase of the average water level in Lake Ziway by 1 metre will result in additional evaporation losses in the order of 75-100 million m^3 per year. This volume of water can be considered as lost for agriculture and ecosystems in the Central Rift Valley.

2. The (potential) additional storage capacity of Lake Ziway will be in the order of 350 – 450 million m^3 (note that this is *not* an additional resource). It is, however, expected that this storage cannot be realised without entirely closing the Bulbula River;

3. There are strong indications that the current discharge of the Bulbula River is already insufficient to maintain Lake Ziway fresh and that the existing developments around Lake Ziway and the upstream catchments are not sustainable;

4. The dam in the Bulbula River is expected to further reduce the net outflow by the Bulbula River to discharges that are well below the critical environmental flow, which is required to keep Lake Ziway fresh.

5. Lake Ziway is, therefore, at great risk of salinization, which may already occur at relatively short notice.

Recommendations

1. Liaise with the Ethiopian Ministry of Water Resources and experts in the water and environmental sector to:
    - Start a dialogue and exchange views;
    - Make a more detailed assessment, incorporating all available information.

2. Suspend the construction of the dam until there is more consensus on the hydrological and environmental impacts.

References

Ayenew, T, 2007. Hydrological System Analysis with Emphasis on Recent Environmental Changes in the Lake Ziway Basin, Central Ethiopia. Addis Ababa University, Department of Earth Sciences.

Ayenew, T, Legesse, D, 2007. The changing face of the Ethiopian rift lakes and their environs: call of the time. Lakes & reservoirs: Research and management 12: 149-165.

Haile, Brehanu, 2008. Temporal Water Quality Trends in Lake Ziway with Respect to Salinity and Sodicity. MSc thesis Environmental Science. Addis Ababa University.

Halcrow Group Limited and Generation Integrated Rural Development (GIRD) Consultants, 2008. Rift Valley Lakes Basin Integrated Resources Development Master Plan Study Project.

Jansen H, Hengsdijk H, Legesse D, Ayenew T, Hellegers P, Spliethoff P, 2007. Ecosystems for water, food and economic development in the Ethiopian Central Rift Valley. Land and water resources assessment in the Ethiopian Central Rift Valley. Wageningen, Alterra-report 1587.

Legesse, D, Ayenew, T, 2006. Effect of improper water and land resource utilization on the central main Ethiopian Rift lakes. Quaternary International 148: 8-18.

Water Works Design & Supervision Enterprise in Association with Concert Engineering & Consulting Enterprise, 2007. Hydrology Draft Final Report. Ziway Irrigation Project. Feasibility Study, Design Works and Tender Document Preparation.