Evaluating the Technical Performance of the Koga and Gomit Reservoirs in the Blue Nile under Existing Conditions and Possible Climate Change

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Introduction

Water storage is widely posited as a key adaptation strategy for climate change. However, climate change will also have impacts on water storage, affecting both the effectiveness and suitability of different storage options. The aim of this study was to evaluate the possible impacts of climate change on the technical performance of two reservoirs in the Blue Nile basin of Ethiopia.

- **The Koga dam** is new dam built to irrigate 7000 ha and provide water for electricity generation. The storage capacity of the reservoir is 83.1 Mm^3.
- **The Gomit dam** is a community dam built to irrigate 90 ha. The storage capacity of the reservoir is 0.74 Mm^3.

Koga Reservoir

Gomit Reservoir

Method

Daily rainfall runoff modeling and reservoir simulation were conducted using HEC-HMS. The performance of the reservoirs was evaluated in terms of Reliability, Resilience and Vulnerability (RRV) criteria (Hashimoto et al., 1982) under both existing and hypothetical future climate conditions.

- **Reliability** is a measure of the frequency of the reservoir to fail to supply water for all demands
- **Resilience** is a measure of the speed of recovery of the reservoir from failure
- **Vulnerability** is a measure of the cumulative maximum extent of failure (i.e. days)

A Digital Elevation Model was used to extract the physical characteristics of watersheds using Arc-Gis, Arc-Hydro and HEC-GeoHMS. Simulation of inflow to each reservoir was conducted using rainfall, evaporation, watershed characteristics. The model was used to simulate reservoir water levels and releases. After calibrating the model (Figure 1), the Koga and Gomit reservoirs were simulated on a daily time-step for 20 and 10 years of historical data respectively. This was done, to determine the availability of water to meet irrigation, hydropower (only Koga) and environmental flow requirements. RRV characteristics were determined.

a) b)

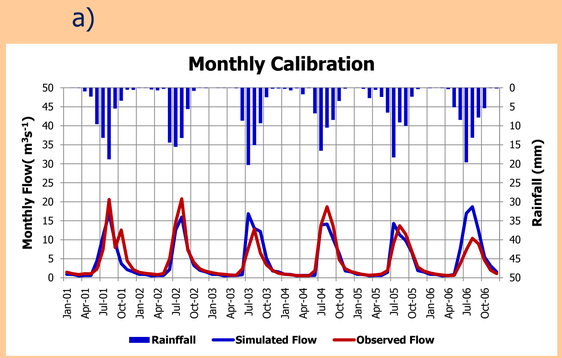

Figure1: Calibration results for a) Koga and b) Gomit Reservoirs

There is considerable uncertainty about the possible impacts of climate change, particularly with respect to rainfall. Previous studies indicate that future rainfall changes in the area are likely to lie within range of -20% to +20 %. Hence, the effect of hypothetical rainfall changes over this range were determined. RRV values were recalculated with the reservoir inflow generated with these changes in rainfall.

Results

Tables 1 and 2 show the RRV results for Koga and Gomit reservoirs under the historic conditions and with the hypothetical changes in rainfall. Although there are sometimes trade-offs in RRV terms (e.g. a reservoir that is highly resilient maybe less reliable), the results indicate that:

- Under all conditions, the larger Koga reservoir is more resilient and reliable and less vulnerable than the smaller Gomit reservoir
- Higher rainfall in the future will increase resilience and reliability and decrease the vulnerability of both reservoirs
- Reduced rainfall in the future will decrease resilience and reliability and increase vulnerability of both reservoirs
- The magnitude of the impact of possible changes in rainfall on the RRV terms is greater for the smaller reservoir than the larger

	Resilience	Reliability	Vulnerability
Irrigation			
Historic	0.037	0.992	37
-20%	0.020	0.968	64
+20%	1.000	1.000	0
Hydropower			
Historic	0.023	0.948	66
-20%	0.020	0.927	76
+20%	0.033	0.975	60

Table 1: Koga Reservoir RRV results

	Resilience	Reliability	Vulnerability
Irrigation			
Historic	0.032	0.950	71
-20%	0.016	0.874	88
+20%	0.055	0.979	44

Table 2: Gomit Reservoir RRV results

Conclusions

Key to planning and management of water storage is making appropriate choices from the range of storage options available. In any given situation this requires an understanding of the possible implications of climate change on the technical performance of storage options. The RRV criteria are a useful tool for determining how the technical performance of reservoirs may alter as a consequence of climate change. They provide a starting point for building climate change into dam planning and management and as well as single reservoirs they can be used to assess the technical performance of reservoirs linked in systems.

Research is needed to determine how RRV terms can be extended to other storage types (e.g. groundwater and small ponds and tanks) as well as storage systems comprising more than one storage type. Such combined systems are more flexible and more likely to be effective under changed climate conditions. Furthermore, beyond assessments of technical performance it is also necessary to consider suitability of different storage options. This requires consideration of a wide range of socio-economic factors.

References

Hashimoto, T., Stedinger, J.R. and Loucks, D.P. 1982. Relibaility, resilence and vulnerability criteria for water resource system performance evaluation. *Water Resources Research* 18(1) 14-20.

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