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Hans H. Ruthenberg Award for Graduates 2003

Jens Liebe “Estimation of Water Storage Capacity and Evaporation Losses of Small Reservoirs in the Upper East Region of Ghana”

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Summary

Water is a scarce and valuable good in semi-arid regions, and the retention of water in reservoirs is an important tool to extent its availability over time. Especially in areas as the Upper East Region of Ghana, where the population is comparably poor and increased agricultural production is seen as the primary opportunity of economic development, further reservoirs are needed. Where water is scarce, its efficient use needs to be the primary guideline in water related planning. Also, the planning of dams needs thorough evaluation to achieve sound water use efficiency. The location and dimensions of planned reservoirs have an influence on already existing reservoirs, which has to be taken into account to avoid negative effects. The present lack of baseline data hinders proper decision making in this respect. Collection and evaluation of such baseline data was the objective of this study.

The aim of this study was to determine reservoir storage volumes in the Upper East Region of Ghana and to estimate the evaporation losses that occur from their surfaces. In order to make volume estimates for a large number of small reservoirs that are spread throughout the Upper East Region, the study combined two kinds of data. These are satellite images and data from reservoir field measurements. The Landsat ETM+ satellite images were used to conduct an up-to-date inventory of reservoirs. As satellite remote sensing may only give information on the extent of the surface area of reservoirs, a randomly selected set of 61 reservoirs was extensively measured during field trips. The field data served to find a function that allows the estimation of reservoir volumes by means of their remotely sensed surface areas. In the analysis of the reservoir measurements, the three attributes 'area', 'depth', and 'volume' were used to evaluate relations of the combinations area-volume, area-depth, and depth-volume. Due to the relatively similar geometric properties of the reservoirs, interrelations between these variables could be adequately described in terms of simple equations.

The possible uses of the dataset are manifold. In order to give an example, unproductive water losses were estimated that occur in terms of evaporation directly from the reservoir surfaces. Based on the evaluated relationships between area, depth, and volume, the reservoir data was therefore aggregated into a "super reservoir" that unites and resembles all of the Upper East's reservoirs properties. Using ten-year averages of monthly evaporation data, the evaporation loss from the super-reservoir were estimated. In the course of a year, the evaporation losses

sum up to a total of 175.7 Mio m^3 (or 0.1757 km^3), a figure that appears very small compared to the mean annual evaporation losses from Lake Volta, that are estimated at 10.2 km^3 (ANDREINEI et al. 2000, p. 16). In relation to the Upper East Regions' total reservoir storage capacity that was estimated at 185 Mio m^3, this amount of water loss is very high.

A full reservoir volume simulation model that takes into account additional water storage reduction through seepage, percolation, or withdrawal was beyond the scope of this thesis. Nevertheless, the results of this study may substitute the unknown 'storage' in the water balance for the Upper East Region and contribute to further reservoir related research. The reduction of volumes through evaporation can be observed throughout the year, yielding information that may be of use for efficient water use management or the selection of crops to cultivate that can securely be produced with the given resources.

The impact assessment of dam construction, however, also has to take into account increasing evapotranspiration from the adjacent developing irrigation and gardening schemes. Subtracting the evapotranspiration from the primary land cover, the surplus in evaporation from reservoirs and evapotranspiration from irrigation schemes resemble man-induced changes. The effects of these changes in land use, surface hydrology and atmospheric feedback would need to be evaluated more closely for a complete impact assessment.

Yet, the important point is that the reservoirs supply the poorest population of Ghana with up to 185 Mio m^3 of water every year for irrigation, livestock and fishing, and to use it for household and hygienic purposes. Studies like the one presented here may help safeguard continued social benefits of this technology while preventing over-exploitation of the scarce water resources.