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Estimation of small reservoir storage capacities in a semi-arid environment A case study in the Upper East Region of Ghana

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Abstract

In semi-arid regions at the margins of the Sahel, large numbers of small reservoirs capture surface runoff during the rainy season, making water available during the dry season. For the local population, small reservoirs are important water sources which help them cope with droughts. The lack of knowledge of the number of existing reservoirs, their distribution, and their storage volumes hinders efficient water management and reservoir planning. The authors have developed a simple method that allows the estimation of reservoir storage volumes as a function of their surface areas. This function is based on an extensive bathymetrical survey that was conducted in the Upper East Region of Ghana. In combination with satellite imagery, this function can be used determine and monitor the storage volumes of large numbers of small reservoirs on a regional scale.

Keywords: Small reservoirs; Drought mitigation; Water management; Dams; Ghana; Africa

1. Introduction

In the semi-arid regions of Northern Ghana, large numbers of small reservoirs dot the landscape. Reservoirs capture surface runoff during the rainy season making water available in the dry season. For the rural population in environments such as the Upper East Region of Ghana, the presence of a small reservoir is an important means of overcoming minor droughts. Efficient water management and sound reservoir planning are hindered by the lack of information about the functioning of these reservoirs. The reservoirs were built at different times by various agencies. Poor record keeping and the lack of appropriate institutional support result in deficiencies of information on the capacity, operation, and maintenance of these structures. As a first step towards understanding the impact these dams have on the availability of water in this area, the authors developed a simple method for estimating and monitoring the storage volumes of these reservoirs on the basis of their surface areas. The use of satellite imagery allows us to measure the reservoir surface areas and gives insight into the statistical (e.g. size, and frequency) and spatial distribution. The area based volume estimation is made possible because this region is morphologically and morphometrically regular. The reservoirs are located in the stream channels, and the morphometry of stream channels are a response to the surface runoff

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characteristics of this area (Windmeijer and Andriesse, 1993). Damming these streams results in characteristic relationships between volumes and surface areas.

2. The study area

The Upper East Region of Ghana is situated in the center of the Volta Basin (Fig. 1, van de Giesen et al., 2002). The Upper East is inhabited by approximately one million people and has a population density of 96.5 inhabitants/km^2 (Asenso-Okyere et al., 2000). With a poverty incidence of 88% in 1998/1999, the Upper East has the largest portion of poor people of Ghana's ten regions (Ghana Statistical Service, 2000). The residents incomes are generated from rainfed and some irrigated agriculture. Population growth places pressure on scarce land and water resources. The scarcity of usable water resources is mainly due to the climate, especially the mode of rainfall. The Upper East's semi-arid climate is characterized by a three month, monomodal rainy season. Ninety percent of the Region's total rainfall (986 mm) occurs as thunderstorms, originating from squall lines (Eldridge, 1957; Hayward and Oguntoyinbo, 1987; Friesen, 2002). Rainfall intensities often exceed the soil's infiltration rates causing surface runoff, without replenishing soil moisture and groundwater. Small reservoirs help make better use of the rainfall by capturing runoff. This water can be used for domestic purposes and agricultural production. The small reservoirs' proximity to places of demand is another advantage that makes them an appropriate tool for drought mitigation.

3. Reservoir inventory with satellite imagery

Due to the lack of baseline data, our inventory of reservoirs was conducted by means of remote sensing. The reservoirs were classified with four Landsat ETM images. Three images were acquired at the end of the

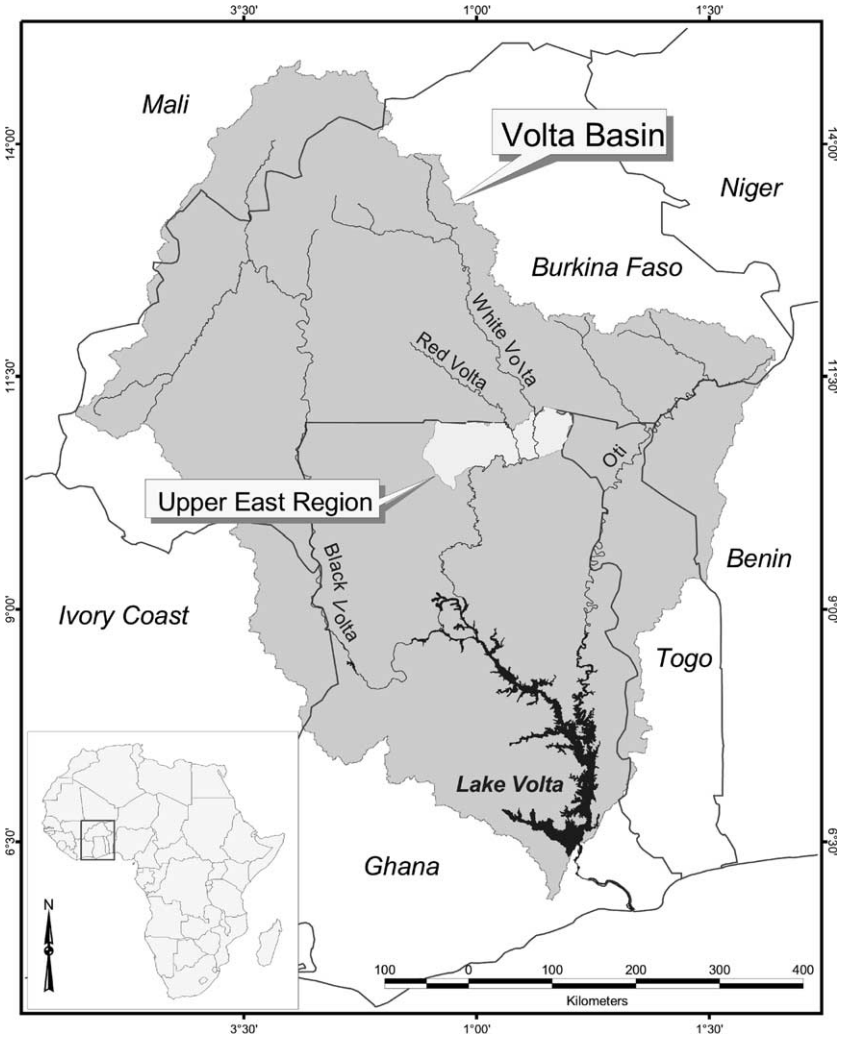

Fig. 1. The Upper East Region of Ghana within the Volta Basin, West Africa.