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Estimating the actual evapotranspiration and deep percolation in irrigated soils of a tropical floodplain, northwest Ethiopia

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A B S T R A C T

The deep percolation and actual evapotranspiration from flood irrigation in tropical floodplains were predicted using a numerical model, Hydrus-1D, and a bucket type water balance model. Field experiments were conducted on onion and maize crops grown from December 2015 to May 2016 in small irrigation schemes found in the Lake Tana floodplains of Ethiopia. Experimental fields were selected along a topographic transect to account for soil and groundwater variability. Irrigation volumes were measured using V-notches and irrigation depths (400–550 mm) were calculated, and daily groundwater levels were monitored manually from piezometers installed in the fields. The soil profiles were described at each field and physical properties (texture, *FC*, *PWP*, *BD*, and *OM*) were measured at each horizon which were used to derive model input parameters. Soil hydraulic properties (residual and saturated moisture content, saturated hydraulic conductivity, parameters related to: pore size distribution n, air entry α and pore connectivity *l)* were derived using KNN pedotransfer functions for tropical soils and fitted using Retention Curve Program for Unsaturated Soils, RETC. The seasonal actual evapotranspiration estimated by Hydrus and water balance models ranged from 320 to 360 mm for onion and from 400 to 470 mm for maize. The seasonal deep percolation estimated from both models was 12–41% of applied irrigation and with this flood irrigation management; the deep percolation is very high. Implementing precise irrigation and water saving practices that minimize deep percolation and unproductive excessive consumptive use are required to achieve the growing food demand with the available water. When less detailed information is available, the water balance model can be an alternative to predict deep percolation and actual evapotranspiration.

1. Introduction

Irrigated agriculture accounts for 70% of the global freshwater withdrawals and 90% of consumptive water uses (Siebert et al., 2010). Due to growing food demand for the 7 billion world population, irrigated areas more than doubled from 1961 to 2009 (FAO, 2010). Irrigation is used to get out of poverty, alleviate the effects of drought and improve livelihoods (Belay and Bewket, 2013; Makurira et al., 2007). Improving irrigation efficiency for sustainable water management is the major objective of irrigated agriculture. This is especially important in Africa south of the Sahara where undernourishment is prevalent (Clarke et al., 2017) and irrigated agriculture highly depends on the amount of nearby water sources (Belay and Bewket, 2013).

Most smallholders in Africa, south of the Sahara use surface irrigation methods with greater risks of failure (Kay, 2001) and irrigation water management in the region is generally poor (Belay and Bewket, 2013). The majority of Ethiopian farmers use traditional, short closed end furrow irrigation (Geremew et al., 2008; Mintesinot et al., 2004) and flooding like other poorly resourced farmers in Africa. Data scarcity is one of the challenges of water management in the country in general and Lake Tana Basin (LTB) basin in particular, where only 3% of the potential irrigable area (which is 11%) is irrigated with surface water

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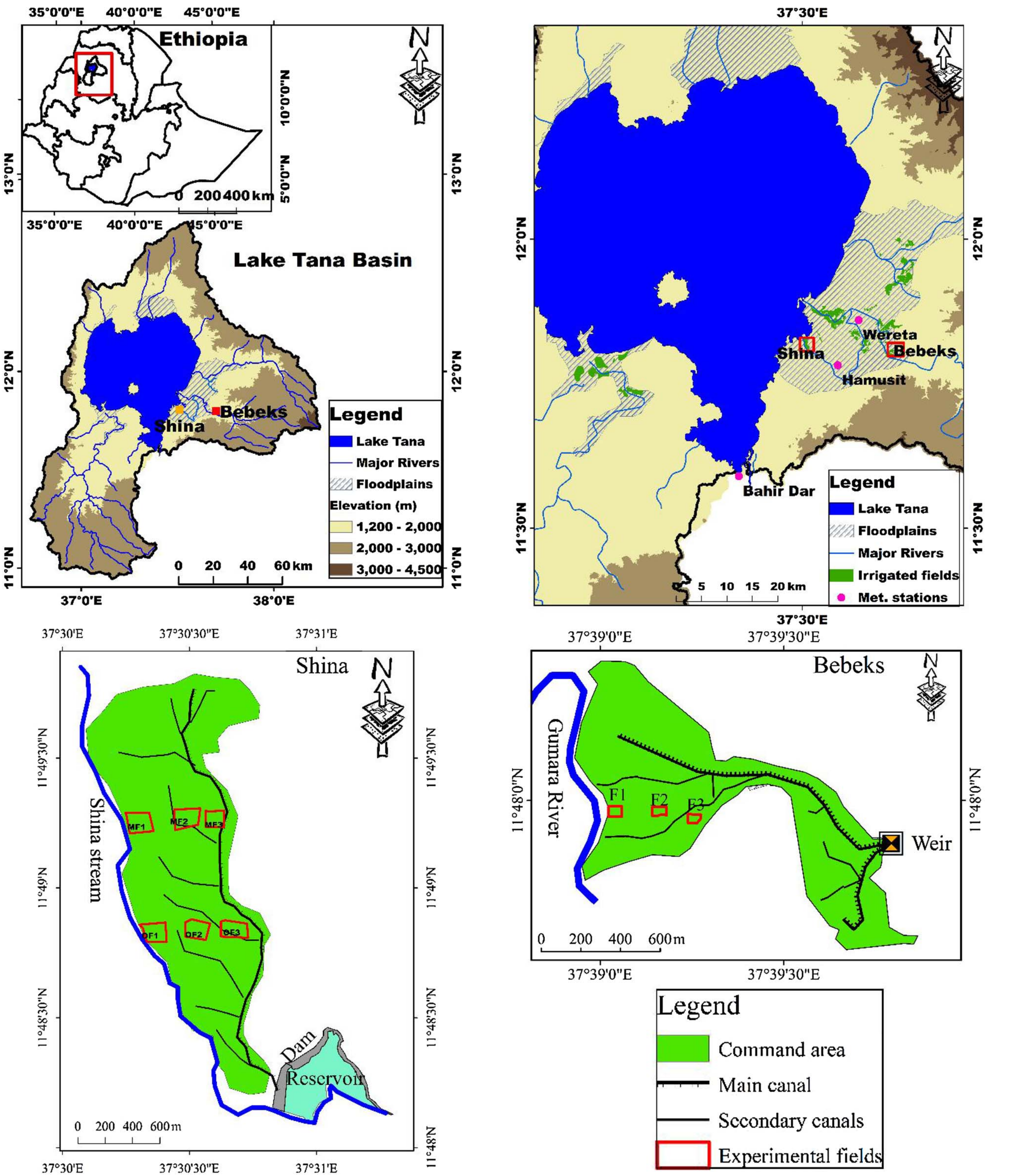

Fig. 1. Geographical location of the study area and irrigated fields in the floodplains. F1–F3 represent fields 1–3 and O and M indicate onion and maize crops.
Data Source: ASTER GDEM, MoWRs and field survey; Geographic Coordinate System: GCS_WGS_1984 and Datum: D_WGS_1984.

(Worqlul et al., 2015). In LTB resources scarcity is critical to agricultural productivity of small farms (Clarke et al., 2017) and its land and water resources are not properly utilized (Derib et al., 2010; Setegn et al., 2008). Although few researches were conducted in LTB to understand rainfall and runoff processes (Collick et al., 2009; Dessie et al., 2014b,c; Kebede et al., 2011; Setegn et al., 2008), the irrigated agriculture as an integral part of the systems, was not investigated well, despite its role in water resources as well as in rural livelihoods.

Floodplains are dynamic systems due to frequent erosion and sedimentation, flood inundations and complex groundwater–surface water interactions (Dessie et al., 2014a; Tockner et al., 2008). Floodplains have been exposed to intensive land use and management changes