Modelling of Irrigation Water Movement in a Distributed Runoff Model
分布型流出モデルにおける灌漑用水のモデル化

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Introduction

The study area is Thiba catchment in Central Kenya (with drainage area of 2,600 km^2) (Fig.1). The Thiba catchment distributed runoff model is a two-layer distributed-parameter, catchment-scale model. The catchment was sub-divided into cells of 500m by 500m for simulating runoff. The model consists of eight sub-models (components), which represent the various hydrological processes with governing equation for each process. These components are, 1) Snow accumulation/ snowmelt, 2) Interception, 3) Evapotranspiration (ET), 4) Infiltration, 5) Surface flow, 6) Irrigation area surface flow, 7) Sub-surface saturated flow, and 8) Channel flow. The results of simulation of the calibrated model prior to the inclusion of irrigation component shows good agreement with the observed one in the Thiba river gauge (4DA10) which is above the major irrigation area in the catchment. Mwea Irrigation Scheme (MIS) with a command area of 5,890ha is the oldest and major irrigation scheme in the catchment (Fig. 1).. MIS has two diversions one from the Nyamindi river and one from the Thiba river. The scheme is divided into 60 independent units of irrigation and drainage. Presently the irrigation component is designed to account for paddy irrigation water movement. The combined effect of diversion, irrigation, and drainage is observed in the river gauging station 4DD02 downstream of the MIS.

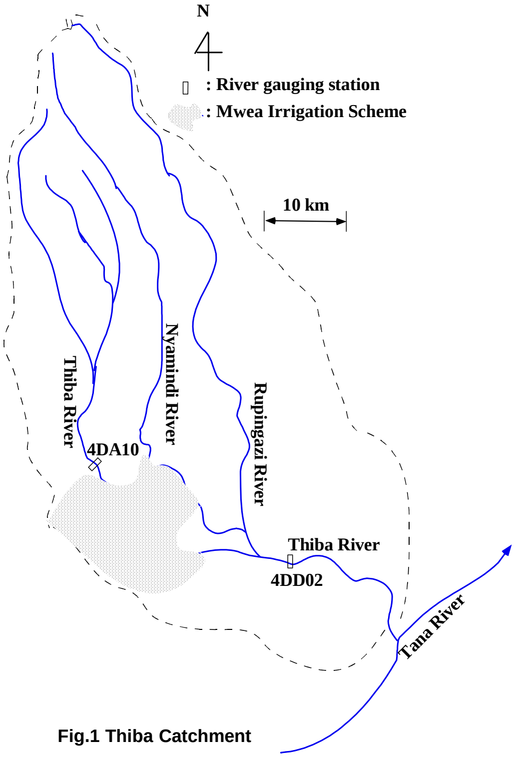

Fig.1 Thiba Catchment

Objective

To model irrigation water movement in a distributed runoff model.

Methodology

Since the distributed runoff model is cell based, it was necessary that the irrigated cells also be on cell basis. The beneficiary area map was superimposed on the runoff model grid map and the fraction of irrigated area in each cell visually estimated. A threshold fraction of irrigation area in a cell was set for selection of irrigated cells with the objectives of maintaining the total beneficiary area under each headworks. The selected irrigated cells were excluded from overland flow modelling and water balance modelling was carried out instead. The other processes are same as the runoff model. Irrigation inflow data at the two headworks is available for six years (1972-1977) but this data is incomplete as such the maximum inflow in a specific day of the year was selected. The 10-day moving average of the maximum inflow was used for simulation.(Fig. 2). The irrigation inflow was subtracted from the respective river discharge at the headworks

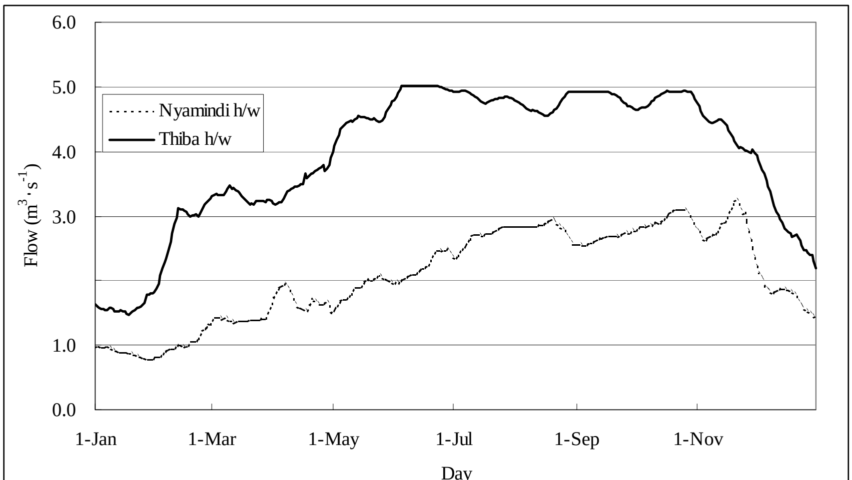

Fig. 2 Irrigation diversion at headworks

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gauge. The drainage from an irrigated cell is added to the nearest stream cell discharge (downstream). The equation for water balance at cell level re-arranged to solve for the ponding depth is shown below

$$PD_i = PD_{i-1} + I_i + R_i - ET_i - DP \quad (1)$$

If $PD_i > MPD$

$$DR_i = PD_i - MPD \quad (2)$$

where PD_i : ponding depth on i^{th} day (mm), PD_{i-1} : ponding depth on day i^{th}-1 (mm), I_i : irrigation on i^{th} day (mm), R_i: rainfall on i^{th} day (mm), ET_i : evapotranspiration on i^{th} day (mm), DP : deep percolation on i^{th} day (mm), DR_i : drainage on i^{th} day (mm), MPD : maximum ponding depth (mm). For simplification purpose, irrigation water was distributed to each cell equally and canal loses was not considered. Evapotranspiration was calculated by the Priestly-Taylor method in the Evapotranspiration component. A deep percolation value of $0.3 mmd^{-1}$ was used (Van Gessel; 1982). Farmers in MIS maintain different depths of irrigation water in their fields. The main reason being the availability of irrigation water and the rice plant growth period. Since equity was maintained in distributing the irrigation water to cells, a single value *MPD* was assumed to apply to all the cells. This value is a calibration parameter. Due to limited irrigation water and machineries for land preparation the MIS management staggers farm activities such as irrigation for puddling, drainage for transplanting and harvesting for one month. The management sets a period (about two weeks) for a certain area for transplanting (and harvesting), but it is upon the farmer when to carry out the transplanting. This actually depends on farmer's financial ability and labour availability. In order to reflect the effect of staggering activities in MIS, a one month difference was maintained between the first and last cell's activity. 1972-1974 data was used for calibration and 1975-1977 data was used for validation.

Reference: J.M van Gessel, 1982. Mwea water use study (water management part). Irrigation and Drainage Research Project report no.27 National Irrigation Board.