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WATER REQUIREMENTS AND IRRIGATION SCHEDULING OF BAN KHAI IRRIGATION PROJECT USING GIS AND CROPWAT MODEL IN RAYONG PROVINCE THAILAND

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ABSTRACT

In the wake of changing climate the present water crisis seems to tighten its hold on the Mankind hence water resources estimation is integral part of planning, development and management of water resources of the country and the estimation of water resources is based on several hydrological and meteorological parameters. Due to overexploitation of available water resources, it has become very important to define appropriate strategies for planning and management of irrigated rice paddy field and farmland. In this paper, Ban Khai area located in Rayong province of Thailand, was chosen as our case study area for its special political and economic status and its severe water problem. To achieve effective water allocation and planning, the information about crop water requirements, irrigation withdrawals, soil types and climate conditions were gathered in the study area. In the meantime, a GIS-based method was adopted, which extends the capabilities of the crop models to a regional level.

Keywords: CROPWAT; Crop Water Requirement; Evapotranspiration; Effective Rainfall; Irrigation Schedule

The main objectives of the study area

1) to estimate the spatial distribution of water requirement (i.e., evapotranspiration) in Ban Khai study area

2) to estimate climatic water deficit

3) to estimate the yield reduction of Ban Khai under different rainfed and irrigated conditions.

Based on the water deficit analysis, recommended supplemental irrigation schedule can be developed ising CropWat model to reduce water stress. Compared to the rainfed control, the two or three times of supplemental water irrigated to Ban Khai area at the right time reduced the loss of yield, under a wide spectrum of scenarios for future management of water resources.

Introduction

CROPWAT is a decision support system developed by the Land and Water Development Division of FAO for planning and management of irrigation. CROPWAT is meant as a practical tool to carry out standard calculations for reference evapotranspiration, crop water requirements and crop irrigation requirements, and more specifically the design and management of irrigation schemes. It allows the development of recommendations for improved irrigation practices, the planning of irrigation schedules under varying water supply conditions, and the assessment of production under rain fed conditions or deficit irrigation (FAO 1992). Water use requirement for same crop varies under different weather conditions. To achieve effective planning on water resources, accurate information is needed for crop water requirements, irrigation withdrawal as a function of crop, soil type and weather conditions. However, a detailed study by comprising all the data on water requirement and availability is also not available under humid tropical conditions.

Materials and Methods

Study Area

We select Ban Khai irrigation project as our study area. It covers 30,000 rai of Ban Khai weir located in Bang Boot subdistrict, Ban Khai district, Rayong province, in the Eastern part of Thailand. Ban Khai weir construction was completed in 1952 with the purpose to serve as a local water resources storage and irrigation for agricultural sector.

Hydro-Meteorological Data Collection

The main important data for analyses in this study are composed of climate data, local agricultural data, crop types, crop growth periods, and water allocation scheme in the study area. Meteorological parameters used for calculation of ET_0 are latitude (12.38 Deg. North), longitude (101.21 Deg. East) and altitude of the station (3 m above M.S.L.), maximum and minimum temperature (°C), maximum and minimum relative humidity (%), wind speed (km/day), and sunshine hours which was collected from TMD and local authorities (between year 2007-2010). ET_0 was calculated for every 10 days (defined as 'decade' by FAO) and then cumulated to monthly data. Soil characteristics considered for estimation of crop water requirement are available water content (mm/m) and depth of soil (cm).

Materials and Methods

Crop Water Requirement (CWR) Estimation

FAO (2005) defines crop water requirement (CWR) for a given crop as:

$$CWR_i(mm) = \sum_{t=0}^{T} \left(kc_i \cdot ET_0 - P_{eff} \right)$$

where kc_i is the crop coefficient of the given crop i during the growth stage t and where T is the final growth stage; $ET_c = K_c \times ET_0$; K_c = crop coefficient; ET_0 = reference crop Evapotranspiration (mm/day), which may be defined as follows:

$$ET_0(mm/day) = \frac{0.408\,\Delta(R_n - G) + \gamma\left(\frac{900}{T+273}\right)u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}$$

Where ET_0 = reference evapotranspiration (mm/day); R_n = net radiation at the crop surface (MJ m^{-2} d^{-1}); G = soil heat flux density (MJ m^{-2} d^{-1}); T = mean daily air temperature at 2 m high (°C); u_2 = wind speed at 2 m high (m s^{-1}); e_s = saturation vapor pressure (kPa); e_a = actual vapor pressure (kPa); e_s-e_a = saturation vapor pressure deficit (kPa); Δ = slope vapor pressure curve (kPa $°C^{-1}$); γ = psychrometric constant (kPa $°C^{-1}$).

Materials and Methods

Crop Evapotranspiration (ET_c)

ET_0 is multiplied by an empirical crop coefficient (K_c) to produce an estimate of crop evapotranspiration (ET_c) as follows:

$$ET_c = K_c \times ET_0$$

Crop Data

The major cultivated crops in the study area are rice, pineapple, cassava, Long Kong, durian, mango, rambutan, jackfruit, mangosteen, coconut, rubber, and palm. The salient details of crops considered for the study are as per FAO and package of practices of Rayon local authorities. Crop coefficient values (K_c) are taken from available published data. K_c values for initial, mid, and late growth stages of annual and seasonal crops are used. In the case of perennial crops, same K_c value is used for the whole year.

Results and Discussions

Reference Evapotranspiration (ET0)

The ET0 of different crops in the study area ranged from 1,481 to 1,555 mm/yr (from year 2007 to 2010). This indicated the differences observed in the meteorological parameters (from relatively dry to relatively wet year) within the study area and stress the need for having scientific water requirement assessment.

Water Resources Assessment

1)Water Demand (Total Water Requirement)

The total water requirement (m3) was calculated by multiplying crop water requirement (mm) by crop area (m2) for both sides of the canal as illustrated in Figure 1. The results obviously indicate that the total water requirements are fluctuating all year long with the highest value in Jan-Feb and Jul-Aug of the year.

Results and Discussions

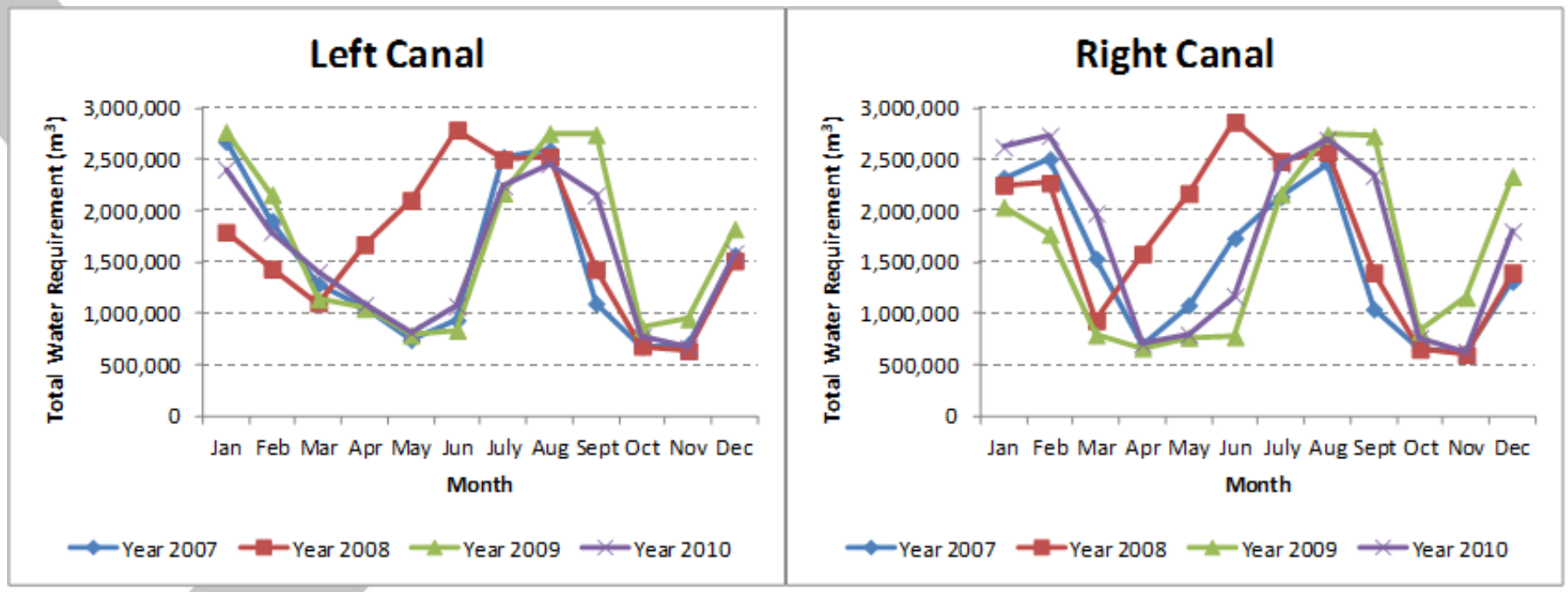
2) Irrigation Water Requirements

Based on the effective rainfall data in the study area, irrigation water requirements can be calculated from the difference between effective rainfall and the total water requirement. The results are presenting in Figure 2.

Status of Water Allocation for Irrigation

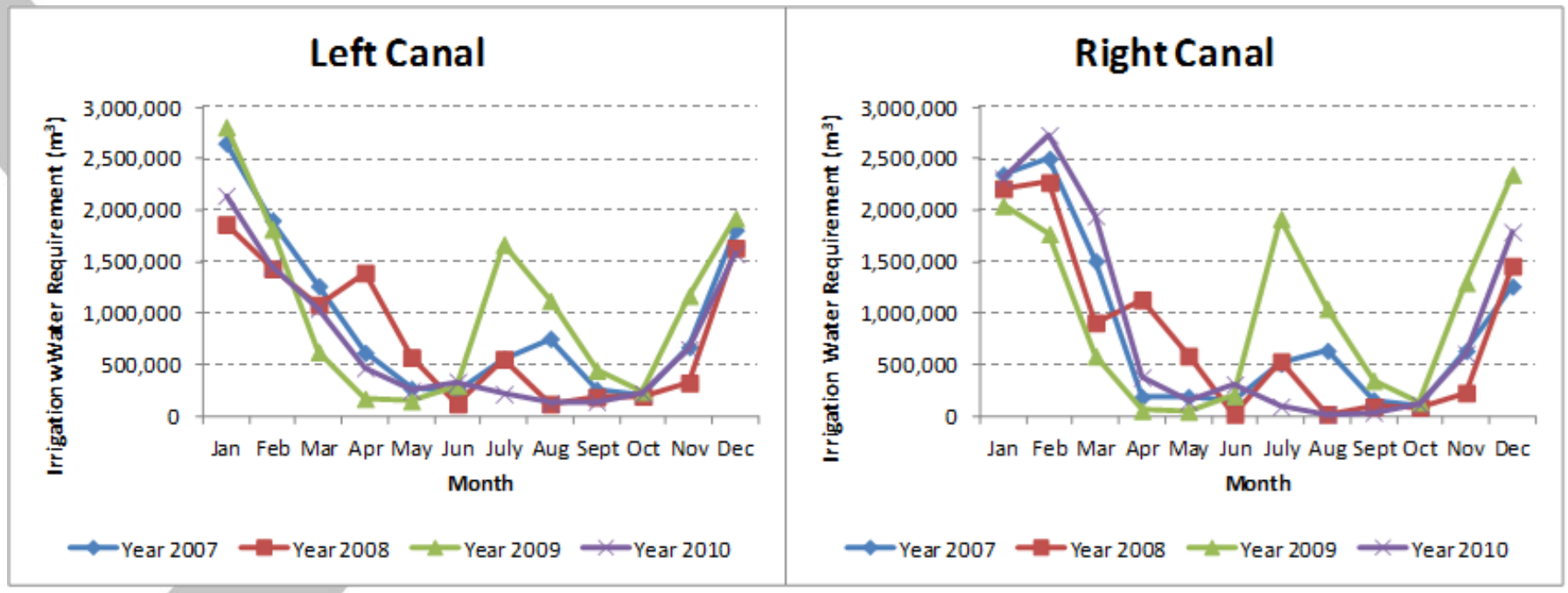
Based on the irrigation water requirement on both sides of the irrigation canals, and the water allocation schedule provided by Ban Khai weir, the results can be tabulated in Figure 3. It is noticeable that water was over-allocate to Ban Khai irrigation project most of the time year round, while some area has experienced some water shortage and could result in low irrigation efficiency

Results and Discussions



"Figure 1 Total Water Requirement in the Study Area"

Results and Discussions



"Figure 2 Irrigation Water Requirement in the Study Area"

Results and Discussions

Season	Month	2007		2008		2009		2010	
		Left	Right	Left	Right	Left	Right	Left	Right
Winter	January	✓	✗	✓	✓	✗	✗	✓	✗
	February	✓	✗	✓	✓	✓	✗	✓	✗
Summer	March	✓	✓	✓	✓	✓	✓	✓	✗
	April	✓	✓	✓	✓	✓	✓	✓	✓
	May	✓	✓	✓	✓	✓	✓	✓	✓
Rainy	June	✓	✓	✓	✓	✓	✓	✓	✓
	July	✓	✓	✓	✓	✓	✗	✓	✓
	August	✓	✓	✓	✓	✓	✓	✗	✗
	September	✓	✓	✓	✓	✓	✓	✓	✗
	October	✓	✓	✓	✓	✓	✓	✓	✓
Winter	November	✓	✗	✓	✓	✓	✓	✓	✓
	December	✓	✗	✓	✓	✓	✗	✓	✓

✓ = Field Water Supply > Irrigation Water Requirement
✗ = Field Water Supply < Irrigation Water Requirement

"Figure 3 Current Status for Irrigation Schedule"

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