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Assessment of Crop Water Demand in South-West Punjab

Chetan Singla, Samanpreet Kaur, Amina Raheja and Rajan Aggarwal

Department of Soil and Water Engineering,
Punjab Agricultural University, Ludhiana-141 004(Punjab)

ABSTRACT

The paper focuses on block-wise assessment of crop water demand for irrigated agricultural areas in South-West Punjab with aim to develop a GIS based system for supporting infrastructural for water resources management. The average seasonal evapotranspiration (ET) demand of the region was estimated to be 725 mm for kharif and 537 mm for rabi season for 2007 to 2013. Blocks namely Lambi (890mm) and Bhagta Bhai Ka (701mm) had the maximum crop water demand whereas blocks Mahal Kalan (482mm) and Phul (323mm) had the least crop water demand. The ET maps derived in the study are useful in determining high water demand areas and can be helpful for planners to adjust the cropping pattern as per the micro level water availability in South-west Punjab.

Key Words: Assessment, Crop, Water, Demand, Punjab.

INTRODUCTION

Water is considered to be an inexhaustible natural resource but the quantum varies from place to place. Punjab is endowed with good surface water resources and also has underground water reservoirs. More than 85 per cent of the state water resources are being used for the production of food grains and fiber. Therefore, water management assumes great significance in agriculture. The evapotranspiration (ET) is defined as the combination of two separate processes, in which water is lost on one hand from the soil surface by evaporation and on the other hand from the crop by transpiration. Accurate estimation of evapotranspiration is important in hydrological modeling, irrigation planning and water resources management. Farquhar and Roderick (2007) noted that changes in evaporative demand affect fresh water supplies and have impact on agriculture which is the biggest consumer of fresh water. Proper irrigation scheduling, based on timely measurements of soil moisture content and crop water needs, is one of the most important management practices for irrigation management.

Of the total geographical area of Punjab (82.2%) is irrigated with the cropping intensity is more than 190 per cent (Anon, 2016). It contributes more than 50 per cent food grain in the central pool Tiwana *et al* (2007). The rainfall in the South-West Punjab is less in comparison to the Central and North-East Punjab but the cropping pattern is cotton, wheat and rice. As rice required large quantity of water for irrigation which is not fulfilled by rainfall, so irrigation in this area mostly depend on groundwater. Hence, in order to utilize water resources efficiently for ensuring long term sustainability in agriculture and food security, there is a need to compute regional crop water demand. Geographic Information System (GIS) has capabilities to integrate database, statistics, remote sensing, maps with advance graphics for visualization and analysis. With its powerful capacity for management and analysis of spatial data, GIS becomes an important tool in irrigation management as reported by Lin *et al* (2004). Keeping this in view, the present work was done with an objective to determine crop water demand and mapping it using GIS.

MATERIALS AND METHODS

Description of the Study Area

The total area of Punjab is 50,362 sq km. The

Corresponding Author's Email:chetan_singla@pau.edu

state is divided into three zones namely North-East, Central and South-West Punjab. South-west Punjab covers the tehsils of Abohar, Fazilka, Muktsar, Bhatinda, Mansa, Faridkot and some parts of Ferozepur. The climate of the south-west Punjab on the whole is dry and characterized by very hot summer, a short rainy season and with a cold winter. The winter season is from middle of November to the early part of March. The succeeding period up-to the end of June is the hot season. July, August and half of September constitute the south west of monsoon, the period of mid September to about the middle of November may be termed as post monsoon or transitional period. June is generally the hottest month. Hot and scorching dust laden winds blow during summer season. December and January are the coldest months.

Calculation of Reference Crop Evapotranspiration/PET (ETo)

The Reference ET (ETo) represents the potential evaporation of a well-watered grass crop. The water needs of other crops are directly linked to this climatic parameter. Although several methods exist to determine ETo, the Papa Dakis Method has considered the most appropriate method for arid and semi-arid regions,Papadakis, (1965).

$ETo = 0.5625*(e_{max} - e_{min-2})*(10/N)$

$e_{max} = (33.8639*(0.00738*T_{max}+0.8072)^8)-(0.000019*(1.8*T_{max}+48)+0.001316)$

$e_{min-2}=(33.8639*(0.00738*(T_{min}-2)+0.8072)^8)-(0.000019*(1.8*(T_{min}-2)+48) +0.001316)$

where, ETo = reference evapotranspiration; T_{max} = average maximum temperature; T_{min} = average minimum temperature; emax = saturation water pressure corresponding to average maximum temperature; e_{min-2} = saturation water pressure corresponding to dew point temperature ; N = Number of days in a particular month.

Papadakis concluded that dew point temperature is roughly equal to daily minimum temperature minus 2 degree. The district wise climate and rainfall data was obtained from Indian Meteorological Department (IMD) and was used to compare the effect of maximum/ minimum temperature and rainfall on the evapotranspiration of the crop.

Calculation of Crop (ETc)

Area under different crops of each block of South-West Punjab was collected from village directory from website www.esopb.gov.in and analyzed. ETc for a specific crop was estimated by multiplying the reference ETo by a crop coefficient Kc for kharif and rabi crops respectively. Kc is dependent on crop type, stage of growth, canopy configuration and regional climate. Throughout the growing cycle, Kc will depend on the stage of growth of a crop. Initially, it will increase as the leaf area of the crop increases to a plateau when "Leaf Area Index" (LAI) > 3, then decreasing during senescence as the area of green leaf decreases Thaman *et al* (2001). Crop growth stages (days) and stage wise crop coefficients for different crops were used for the study Kaushal (1988). Based on crop coefficient and reference ETo, annual ET in hectare-meter for Rabi and Kharif crops were computed for south-west zone. For spatial mapping of ET demand in South-West Punjab, Arc GIS 9.3 software was used and classified maps were created.

RESULTS AND DISCUSSION

The variation in annual ETc for the study period is shown in Figure 1. The average annual volumetric crop water demand for the South-West Punjab was 21.97 lakh ha-m out of which 12.49 lakh ha-m (56.80 %) was in kharif season and 94.90 lakh ha-m (43.20%) was in rabi season. Rainfall analysis of the region showed that average ET was much higher than the average rainfall in both rabi and kharif season indicating the need of creating additional water resources in the region (Fig. 2). The maximum ETc was in the year 2012-13 (24.88 lakh ha-m) which may due to reason that the amount of rainfall was minimum increasing the atmospheric temperature as compared to other years under study and the least ETc was in the year 2011-12 (20.06 lakh ha-m). In terms of depth, the average seasonal ETc demand of the region was estimated to be 725

mm for kharif season and 537 mm for rabi season for 2007 to 2013.

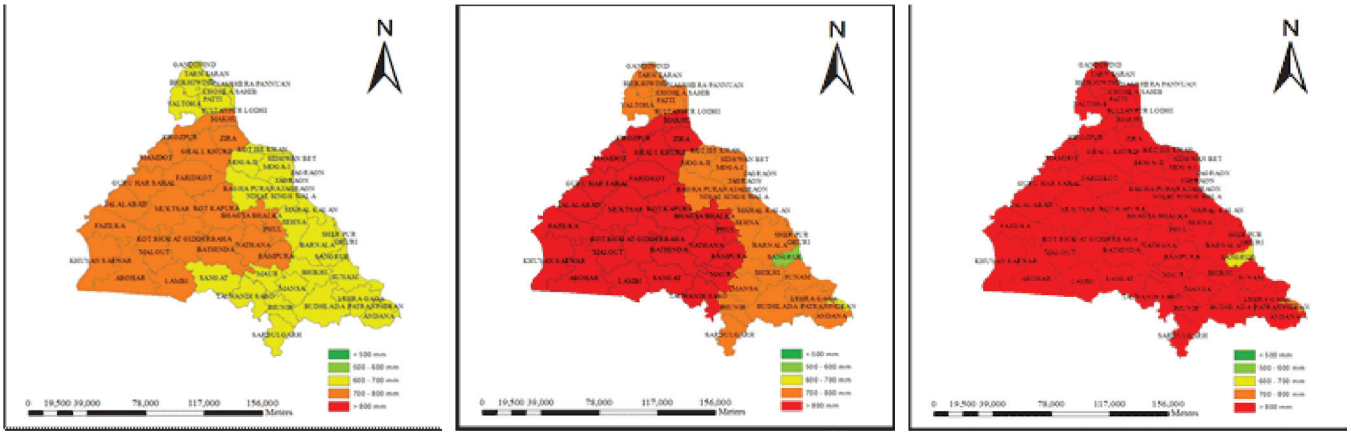
Figure1. Annual ET (lakh ha-m) of South-west Punjab

Fig 2. *Rabi and Kharif* average rainfall and evapotranspiration analysis of South-west Punjab

A perusal of ET maps for a time period from 2007 to 2013 (Figure 3) revealed that in the year 2007-08 and 2008-09, ET of kharif crop of all blocks of South-West Punjab varied from 600-800mm. But in the year 2009-10, the maximum blocks of South-West Punjab were in the range greater than 900 mm except Sangrur block. In 2011-12, maximum area had ET demand in the range of 600-700 mm except some parts of Sangrur block. It is pertinent to state here that the monsoon rainfall was good and equally distributed in all the blocks of Punjab. The maximum average ET range of kharif season consisted of 674 mm in Fazilka in the year 2011-12. In 2012-13, almost all the area was above the range of 800 mm ET except Sangrur. It is mainly because 2012-13 was a monsoon deficit year. The high ET demand in various blocks may be due to the majority of cultivated area under paddy. The paddy crop requires about 24000 cu. m of water per ha. This is about 6 times more water than maize, almost 20 times more than groundnut and 10 times more than kharif pulses. Similarly in rabi season, the ET demand of all blocks of South-West Punjab ranged from 400–700 mm (Figure 4). The maximum area lies in the range of 400-600 mm and in this range in all blocks of South-West Punjab except in some parts of Moga , Ludhiana, Sangrur district and also Kot Bhai block which had ET demand of more than 600 mm in year 2009-10.

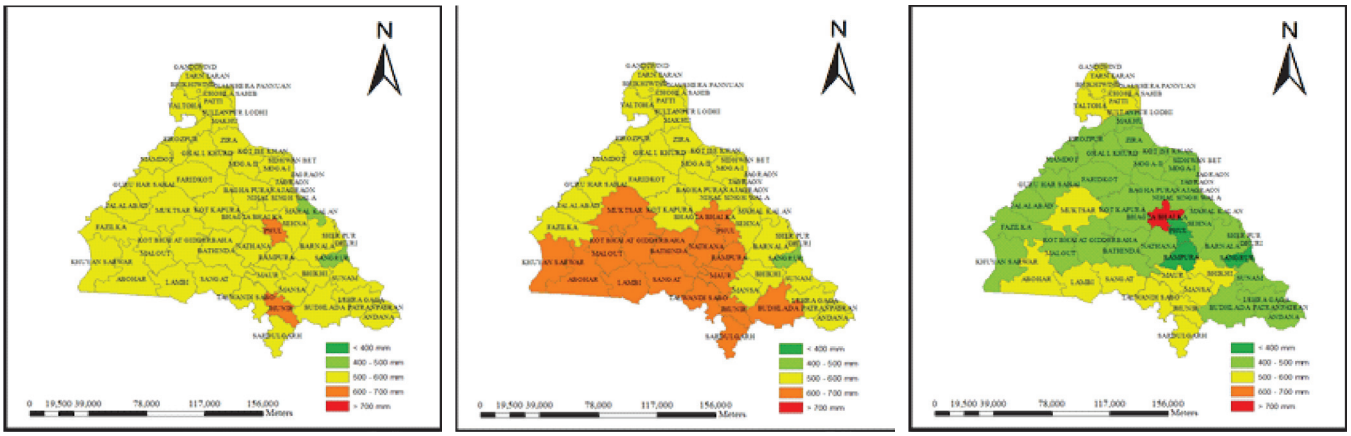
CONCLUSION

This study concluded that average annual water demand of South-Western region of Punjab is 21,96,967 ha-m. Maximum water required both in kharif and rabi season is in Lambi and Bhagta Bhai



2007-08 **2009-10** **2012-13**

Figure 3. Trends of variation in ET *Kharif* season from 2007-2013



2007-08 **2009-10** **2012-13**

Figure 4. Trends of variation in ET *Rabi* season from 2007-2013

Ka blocks. But these blocks have inherent problem of water-logging and salinity. So effects should be made to reclaim this area and judicious by supply surface law. It is suggested to diversify some of the area in the South-West districts from irrigation water intensive rice-wheat system to less water intensive cropping system. From ET maps, we can easily identify high water demand regions and help the planners to transmit the precious resource in most judicious way to these regions to meet their demand or to adjust the cropping pattern as per the micro level water availability in South-west Punjab. Also these maps will be helpful in creating awareness among the farmers for understanding the irrigation requirement of their region.

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