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Short Communication

Assessment of spatial climatic water balance over Uttarakhand using GIS

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Water balance techniques have been widely used to make quantitative evaluation of water resources and and their change under the influence of man's activities. It is the comparative study of precipitation and evapotranspiration that plays an important role in many fields like agro-meteorology, micrometeorology and applied climatology. Thornthwaite and Mather (1955) method have been widely used for assessment of water balance components viz. soil moisture storage (SMS), actual evapotranspiration (AET), water surplus and water deficit etc. Spatial distribution of water balance appears to be very important in spatial management of agriculture and hydro-climatological modeling. Many studies used water balance approach in climatic studies and crop planning for a particular location (Singh *et al.,* 2004, Jat *et al.,* 2004 and Salam *et al.,* 2006).Therefore considering all these aspects, an attempt has been made to study the water balance over Uttarakhand following Thornthwaite and Mather (1955) method and applying the remote sensing and GIS techniques.

The state of Uttarakhand is having two regions *i.e.* Garhwal comprised of 7 districts (Uttarakashi, Chamoli, Tehri, Pauri, Dehradun, Haridwar and Rudraprayag) and Kumaon comprised of 6 districts (Almora, Nainital, Pithoragarh, Champawat, Bageshwar and Udham Singh Nagar). Uttarakhand has diverse climate and vegetation which vary greatly with elevation from the sub-tropical humid climate of the Terai region to the tundra-like climate of the Great Himalaya ridges. The climatic data (viz. minimum temperature, maximum temperature and precipitation)were collected from different weather stations located in Uttarakhandviz.VPKAS, Almora; ARIES, Nainital; GB Pant University of Agriculture & Technology, Pantnagar; College of Forestry and hill Agriculture Ranichauri; IIT Roorkee and FRI Dehradun. The data of some other stations were taken from published IMD periodicals, UPROBE project of IIT Roorkee and were also downloaded from the website of www.ncdc.noaa.gov, www.worldclim.org and www.weatherbase.com. The soil maps of the region were acquired from National Bureau of Soil Survey & Land UsePlanning (NBSSLUP), Nagpur.

The state receives maximum precipitation during June to September, with their peak values in August. Maximum annual rainfall is received in Dehradun and parts of Tehri up to 2468 mm. In districts like UdhamSinghNagar, Haridwar, Nainital and parts of Pauri amount of rainfall varies between 1635 to 1916mm annually. Similarly large variation was observed in annual potential evapotranspiration (PET) at various locations over Uttarakhand. The highest annual PET up to 1377mm is observed in low lying areas of the state viz. parts Udham Singh Nagar, Nainital, Haridwar, Pauri, Almora, Dehradun, Chamoli and TehriGarhwal.

The water balance components viz. actual evapotranspiration (AET), water surplus and water deficit of Uttarakhand state are presented in Fig. 1 to 3. The annual AET (Fig.1) was as high as 620 to 766 mm in low lying areas of the state and monthly AET values were high from March to September due to high sun period. The lower AET values were observed from November to February with sharp decrease in January. This may be due to the drop of precipitation so the soil started to dry out. Thus decreasing soil moisture content led to reduce the rate of evapotranspiration.

Uttarakhand has considerable spatial variability of annual water surplus caused by both precipitation and soil conditions (Fig 2). The annual water surplus was found maximum in some parts of Udham Singh Nagar, Nainital, Haridwar, Pauri, Almora, Chamoli and Tehri Garhwal ranged between 685 to 825mm. On an average, upper hilly area of the state has maximum monthly surplus in July ranged between 159.6 to 341.4mm while middle and low lying region has maximum water surplus in the month of August, ranged up to 705.8mm. This surplus water is the result from the summation of rain water in the soil system during monsoon

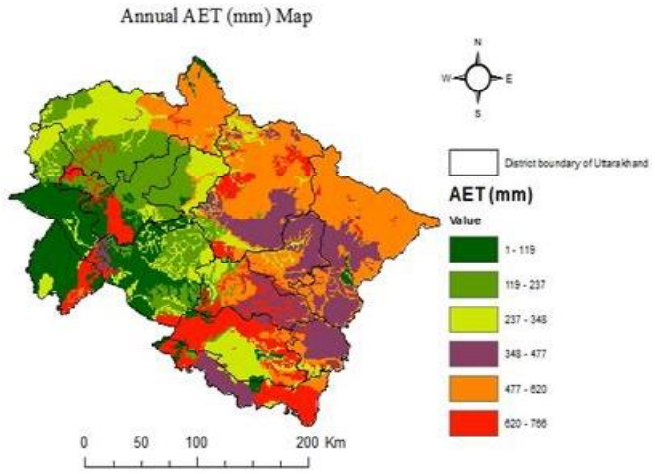

Fig. 1: Thematic map of annual actual evapotranspiration over Uttarakhand

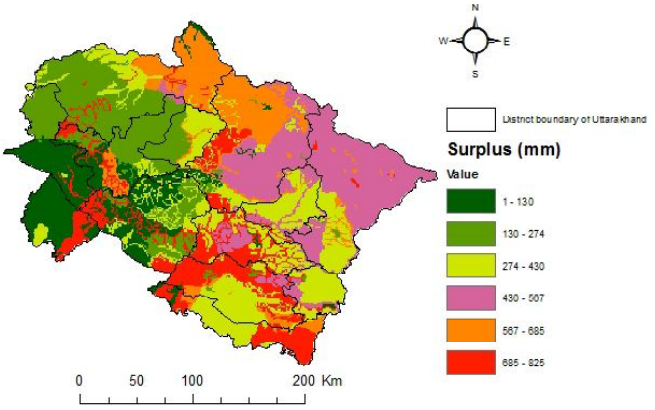

Fig. 2: Thematic map of annual water surplus over Uttarakhand

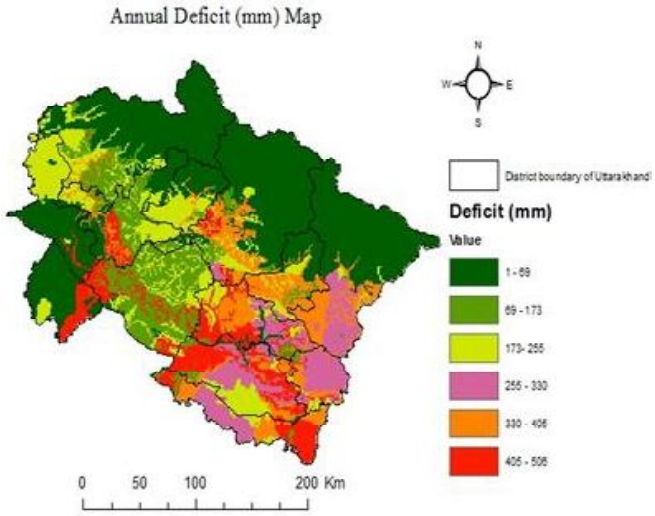

Fig. 3: Thematic map of annual water deficit over Uttarakhand

months. The surplus water first satisfies the soil moisture storage and then adds into groundwater recharge or generates run-off. The water holding capacity at the root zone is achieved in the month of July and continues till the month of September. This signifies that the surplus water in the month of July is required to satisfy the soil moisture storage in the study area. Therefore the surplus water in the months of August and September either adds as groundwater recharge or runoff.

The water deficiency represents the amount by which precipitation fails to meet the demands of evapotranspiration after all the available soil moisture has been used up. The water deficit months require irrigation facilities for agricultural practices. In the study area, the actual evapotranspiration exceed the rainfall in the months from March to May and again from October to November which makes them water deficit months. Monthly water deficit was found maximum in the month of May over the state ranged up to 262 mm. Annual water deficit (Fig.3) was found maximum in some parts of Udham Singh Nagar, Nainital, Haridwar, Pauri, Almora, Chamoli and TehriGarhwal ranged between 406 to 506mm. However in upper hilly portion, annual deficit was least or almost zero because precipitation in these regions was always more than PET. This study is very beneficial for deciding the crop calendar and irrigation requirements based upon the periods of deficit or surplus.

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