Deficit is estimated as the difference between the seasonal crop water requirement and effective rainfall for each crop in a given location in the season. Effective rainfall is given as

$$S_{j,d} = \alpha_j * P_{j,d} \ldots (1)$$

In Eq. (1), $P_{j,d}$ is the rainfall for a day d in any given year at a location j. α_j is the parameter that determines the fraction of rainfall that can be utilized by the crops for location j. It accounts for losses to direct runoff, evaporation and groundwater infiltration. In our study, we set α_j = 0.7 (Devineni et al, 2013).

The water use for a given crop is estimated based on the expected growth stage and daily evapotranspiration as

$$D_{j,d} = {k_{c,d}}^{(j)} * ET_{0\ j,d} \ldots (2)$$

In Eq. (2), ${k_{c,d}}^{(j)}$ is the crop coefficient, which is the ratio of actual evapotranspiration (ET_a) of a given crop under non-stressed conditions to reference crop evaporation (ET_0). It represents crop-specific water use at various growth stages of the crop and is typically derived empirically based on local climatic conditions (Doorenbose and Pruitt, 1977). The accumulated deficit over a season is then given as

$$deficit_{j,d} = \max(deficit_{j,d-1} + D_{j,d} - S_{j,d}, 0) \text{ where } deficit_{j,d=0} = 0 \ldots (3)$$

$$CDI_{j,t} = \max\left(deficit_{j,d(y)} : d = 1 : n_s ; t = 1 : n\right); \text{ where } deficit_{j,d(0)}=0, \text{ y=1,…,n} \ldots (4)$$

In equation (3), $deficit_{j,d}$ refers to the accumulated daily deficit for any given year with a crop growth period of n_s days in the year, $D_{j,d}$ to total daily water demand, $S_{j,d}$ to the total daily effective rainfall, for geographical location j, and day d; t refers to a calendar or cropping year; and n is the total number of years in the analysis. For an n-year record, seasonal water stress is evaluated as the maximum cumulative deficit each season and defined here as $CDI_{j,t}$.