Conference Proceedings Paper

Satellite Based Temporal Analysis of Local Weather Elements Along N-S Transect Across Jharkhand, Bihar & Eastern Nepal

Shanti Shwarup Mahto [1,*], and Arvind Chandra Pandey [1]

[1] Centre for Land Resource Management, Central University of Jharkhand, Brambe, Ranchi-825205, India; shantishwarup185@gmail.com, arvind.pandey@cuj.ac.in

* Correspondence: shantishwarup185@gmail.com; Tel.: +91-7050780959

Published:
Academic Editor:

Abstract: The study shows the variation in the most important climatic variables i.e. Net Surface Radiation (Rn), Temperature, Rainfall, Evapotranspiration (ET) etc. during 2000-2016 along North-South transect across Jharkhand, Bihar & Eastern Nepal. The TRMM monthly average precipitation (0.25° X 0.25°), MODIS-Terra 8 day average LST product (1km X 1km), MERRA-2 radiation (0.5° x 0.625°) and GLDAS reanalysis model data (0.25°X0.25°) has been used to study and analysed the spatial variability and distribution of rainfall, surface temperature, energy fluxes and evapotranspiration, respectively. The results have shown that the overall annual average rainfall has a gradual decreasing trend. Results have suggested that the regions with low rainfall (<1000mm) have to witness warmer temperature conditions (>43°C). East-west central line of the Bihar, along the river Ganga is found to be the line of division for the comparatively higher (towards south) and lower (towards north) temperature zones. The results for Rn have shown an overall increasing trend over the period of time. The Nepal has a wider stretch of Rn concluded by its mountain topography followed by the Jharkhand (plateau) and Bihar (plain). ET values have also shown an increasing trend and the results are noticeable for western Bihar-Jharkhand. There is an upward latitudinal shifting of the low rainfall bands in both the pre-monsoon and monsoon conditions. Due to the lack of availability of ground truth data, we have to restrict with the remotely sensed dataset only.

Keywords: Climate change; Net solar radiation; Evapotranspiration; Temperature; Rainfall; Topography; Monsoon.

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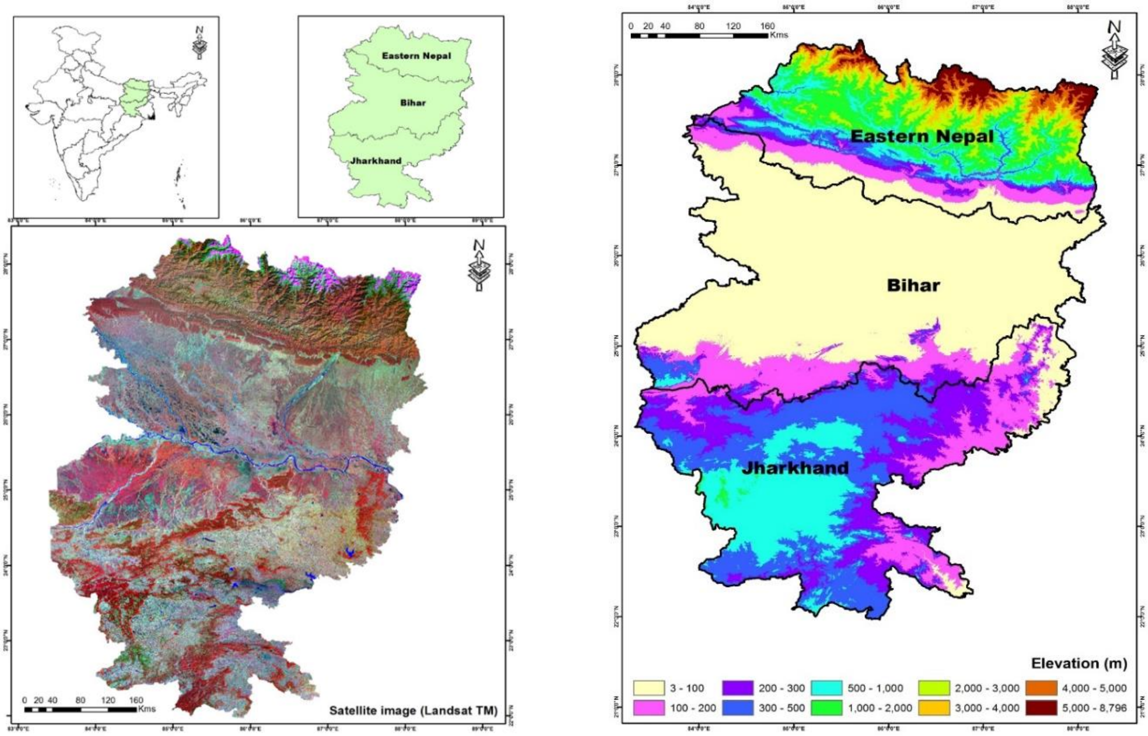
1. Introduction

During the past century especially after the industrial revolution, human activities have impacted a lot in a regional level which are mainly attributed to greenhouse gases, aerosols, and land use activities [5]. It has been seen that the global climate variability is the major phenomenon occurring worldwide which has caused the major changes in climate variables such as precipitation, air temperature, relative humidity, and solar radiation [2, 4, 12]. Study have shown that the analysis of seasonal and annual surface air temperatures over the central east India has a significant warming trend of 0.57°C per hundred years [11]. The climate variability has also led to increased evapotranspiration rates, decline in soil moisture, and socio-economic consequences with longer dry periods, and greater number of extreme events which is governed by the variation in the solar insolation [3, 7]. Evapotranspiration (ET) Higher or lower rainfall or changes in its spatial and seasonal distribution influences the spatial and temporal distribution of runoff, soil moisture and groundwater reserves, and thereby affects the frequency of droughts and floods [8, 9, 10]. Therefore, this study has carried out to know the actual rate of alterations of the climatic variables along with their spatial variability. ET study has been carried out to determine the impact of climatic variability on trends of annual and seasonal rainfall and its intensity during the pre-monsoon and post-monsoon season. The topography has taken as a controlling factor to study the latitudinal distribution of ET and Rn.

2. Experiments

2.1. Study Area

The study has been conducted for the region enclosed by 20°N to 30°N latitude & 80°E to 90°E longitude. The study area basically consists of the entire Jharkhand, Bihar and eastern Nepal i.e. the North/South transect across the Himalaya, Gangetic plains and Chotanagpur plateau. It is having a total geographic area of around 230204 sq.km and has a total perimeter of 4137 km (Figure 1a). Topography



is one of the major factor which governs local climatic variability. Three major different topographic region within studyarea have shown below (Figure 1b).

(a) **(b)**

Figure 1 : (a) Location map of study area (FCC) prepared using Landsat TM dataset, Acquisition date 8th Feb 1988, and **(b)** Relief map of study area; prepared using SRTM DEM (90m)

2.2. Materials used

The TRMM monthly average precipitation (0.25° X 0.25°), MODIS-Terra 8 day average LST product (1km X 1km), MERRA-2 radiation (0.5° x 0.625°) and GLDAS reanalysis model data (0.25°X0.25°) has been downloaded for the duration of 2000-2016, which has been used to study and analysed the spatial variability and distribution of rainfall, surface temperature, energy fluxes and evapotranspiration, respectively (Table 1).

Table 1. Details and specifications of the data used

Sl. No.	Sensor	Resolution	Purpose	Source
1.	TRMM RAINFALL	0.25° X 0.25° monthly 3B43v7	Rainfall analysis	http://www.geovanni.nasa.gov/
2.	MODIS-Terra LST	1km X 1km, 8 day average	Temperature analysis	http://www.geovanni.nasa.gov/
3.	GLDAS ET PRODUCT	0.25°X0.25°, monthly average	Radiation analysis	http://disc.sci.gsfc.nasa.gov/mdisc/
4.	SRTM DEM	90m	Relief analysis	http://www.jpl.nasa.gov/srtm/
5.	MERRA-2 RADIATION	0.625°×0.5° monthly	Radiation analysis	http://gmao.gsfc.nasa.gov/

2.3. *Method adopted*

Temporal mapping of precipitation (rainfall) and land surface temperature has done for the desired years and spatial distribution and variability has been observed. The amount and distribution pattern of precipitation have further analysed by putting a temperature threshold of 35°C and more in summer. The Surface Energy Balance Algorithm for Land (SEBAL), (Equation 1) has been used to extract the net surface radiation (Rn), which quantifies the energy balance using satellite data as an input [1, 6]. The distributional pattern and amount of net solar radiation (Rn) received and evapotranspitation (ET) has been mapped in GIS environment and linked with the pre-monsoon and monsoon rainfall events. Detailed work flowchart has given in Figure 2.

$$\mathbf{Rn = (1 - \alpha)\, RS{\downarrow} + RL{\downarrow} - RL{\uparrow} - (1\text{-}\varepsilon o)\, RL{\downarrow}} \quad \mathbf{(1)}$$

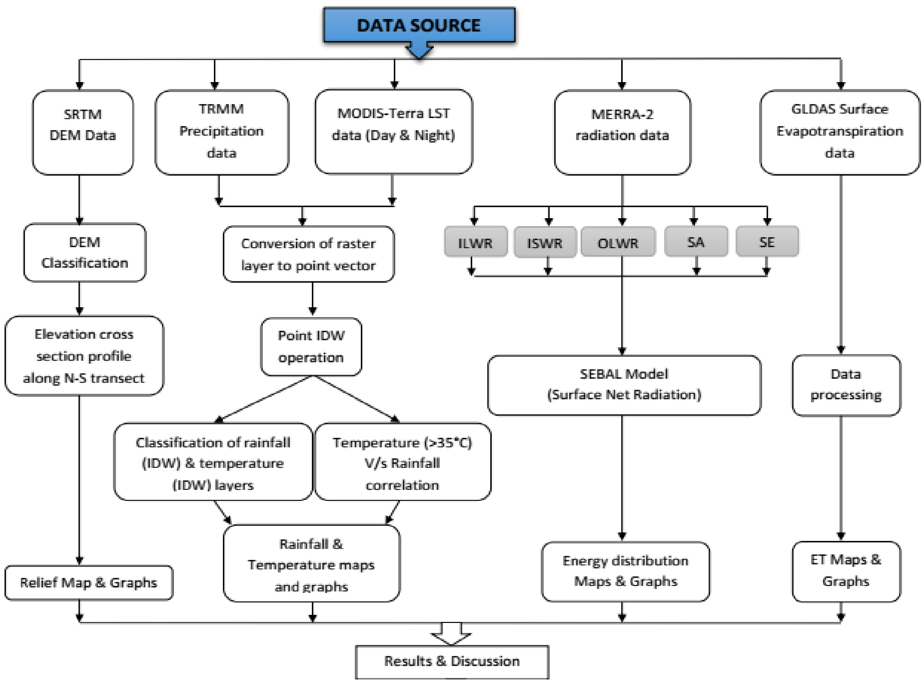


Figure 2. Mothodology flowchart

Where, RS↓= incoming short wave radiation (W/m2); α = surface albedo (dimensionless); RL↓= incoming long wave radiation (W/m2); RL↑= outgoing long wave radiation (W/m2) and εo = surface thermal emissivity (dimensionless). (dimensionless); RL↓= incoming long wave radiation (W/m2); RL↑= outgoing long wave radiation (W/m2) and εo = surface thermal emissivity (dimensionless).

3. Results

3.1. Rainfall analysis

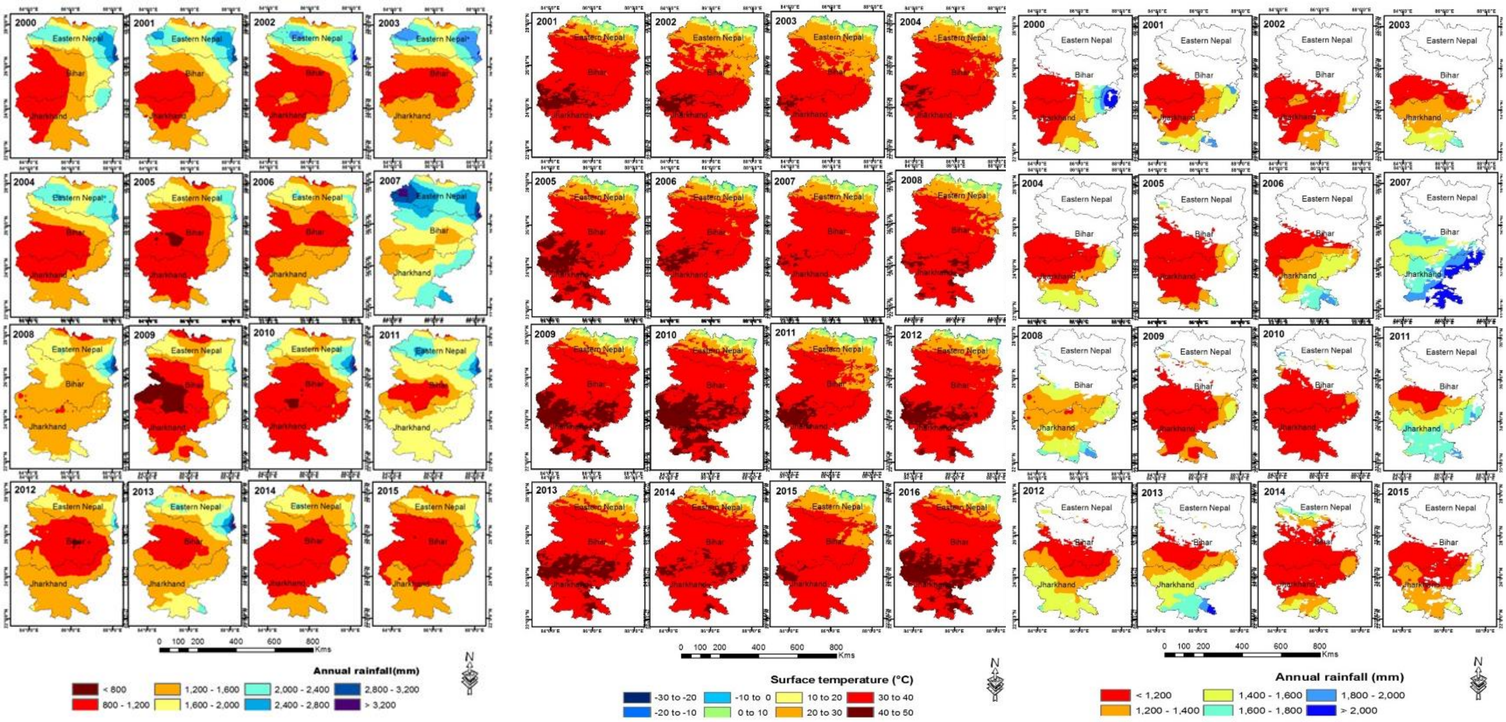
The prepared maps for the above mentioned period have shown that the average annual rainfall of the study area has decreased over the past three pentad, mainly over the E-E Nepal and N-E Bihar region (Figure 3a).

3.2. Temperature Analysis

The trend has shown a maximum-minimum temperature difference of 64°C for the duration of years from 2001 to 2006. It has reached to 65°C in the next five years, 2007 to 2011, and further increased to 66°C in the years from 2012 to 2016. It is believed that the trend will follow the similar pattern for coming years (Figure 3b).

3.3. Temperature V/s Rainfall correlation

East-West central line passing through the centre of the Bihar region (say the river Ganga) is found to be the dividing line for threshold temperature. Below this line (i.e. towards the Jharkhand) the entire area witnesses a temperature greater than or equal to 35°C whereas on the other hand (i.e. towards Nepal) there is a very few areas which witnesses temperature greater than or equal to 35°C (Figure 3c).



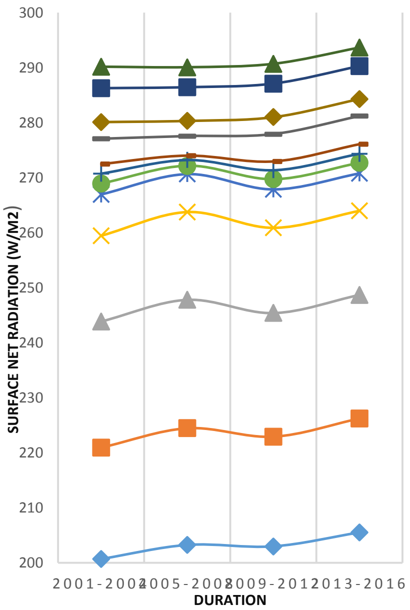
(a) (b)

(c)

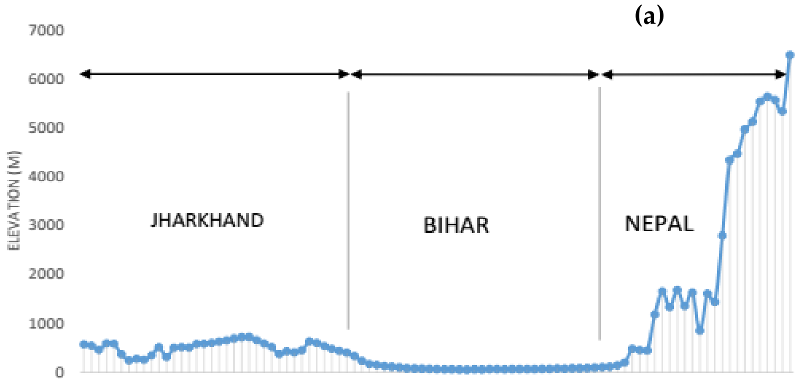
Figure 3: (a) Average annual rainfall (mm); **(b)** Average surface temperature in summer (°C); **(c)** Annual rainfall (mm) of areas having summer temperature >=35°C

3.4. Net Surface Radiation (Rn) Analysis

The results have shown that the Rn has an overall increasing trend during the period of years. The surface over the Bihar & Jharkhand are absorbing more heat than the higher latitude Nepal. It has been found that, Nepal region has the wider range of Rn which ranges from 200 W/m2 to 260 W/m2 (difference of 60 W/m2). This may basically due to the huge variation in the surface topography (i.e. entire mountain range) ranging from 500m to more than 6000m. The Bihar has the least stretch of Rn ranging from 265 W/m2 to 275 W/m2 (difference of 10 W/m2) due to the very less variation in the topography, (i.e. entire plain region) ranging from 50m to 200m. Whereas, the Jharkhand region has the moderately less stretch of Rn ranging from 275 W/m2 to 295 W/m2 (difference of 20 W/m2) which may due to the moderate surface topographic variation (i.e. some plains and Plateau) ranging from 300m to 700m (Figure 4a), (Figure 4b).



(a)

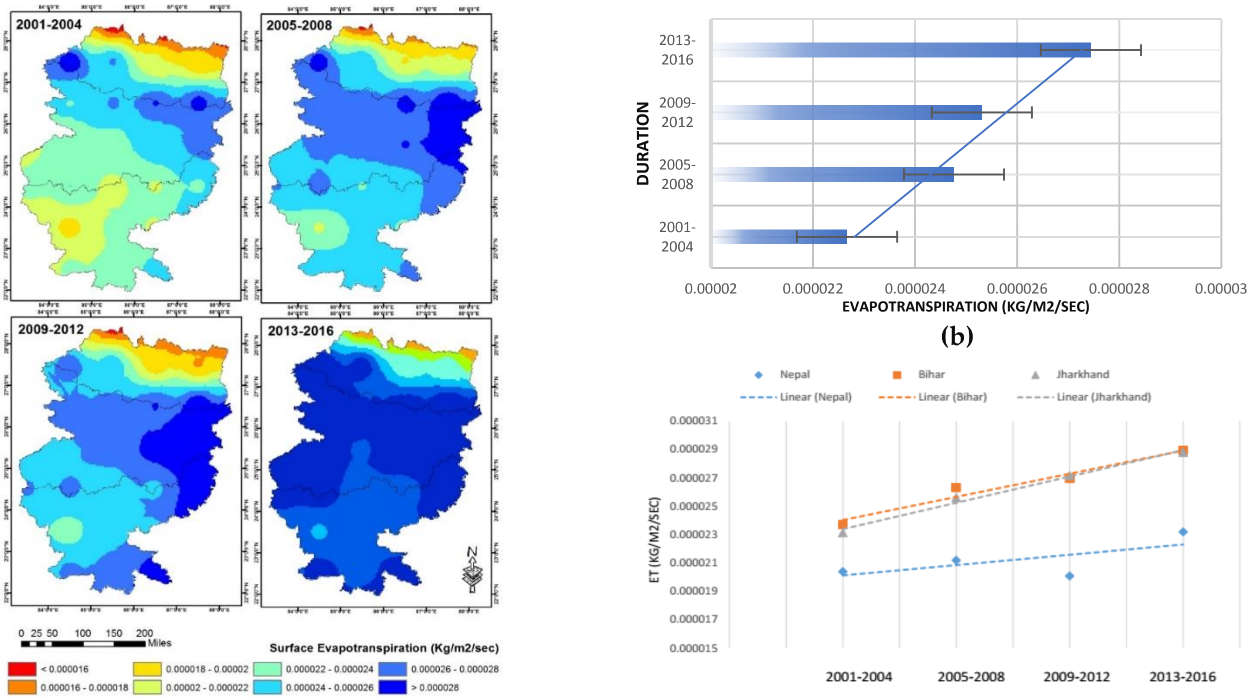


(b)

Figure 4 :**(a)** Latitudinal distribution of Net Surface Radiation (Rn), W/m2;**(b)** DEM cross-section profile of study area along N-S transect

3.5. Surface Evapotranspiration (ET) Analysis

The western Bihar- Jharkhand region has the significant increase (an increase of 8 x 10-5 Kg/m2/sec) in the rate of evapotranspiration (Figure 5a). Similar to that of Rn analysis, the ET values have also analysed and found that the trend of ET is approximately the same for the Bihar and Jharkhand whereas Nepal has the slightly different trend with lower ET values (Figure 5b). The ET values for the Bihar and Jharkhand ranges from 0.000023 to 0.000029 Kg/m2/sec whereas this is from



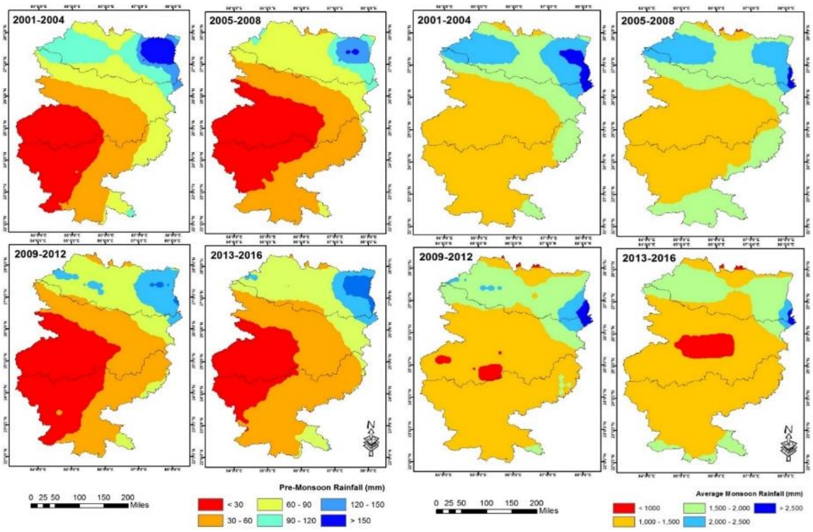
0.000019 to 0.000022 Kg/m2/sec for Nepal (Figure 5c).

(a) **(c)**

Figure 5. **(a)** Spatio-temporal variation in Evapotranspiration (ET); **(b)** Overall trend of surface evapotranspiration for the study area; **(c)** Trend of surface ET for Jharkhand, Bihar & Nepal, (2001-2016)

3.6. Pre-monsoon & Monsoon Rainfall Analysis w.r.t Net Surface Radiation (Rn) & Evapotranspiration (ET)

The average rainfall maps of pre-monsoon and monsoon season on an interval of four years (2001-2003, 2004-2008, 2009-2012 & 2013-2016) has been plotted and has been found that there is an upward latitudinal shifting in the low rainfall bands in both the pre-monsoon & monsoon condition (Figure 6a) (Figure 6b).



(a) **(b)**

Figure 6: (a) Average monsoon rainfall (mm); **(b)** Average pre-monsoon rainfall (mm)

4. Discussion

Over the period of time as the rate of surface ET is getting higher and some reasons (e.g. Central Bihar) continuously receiving less rainfall then the normal in monsoon season. This may convert the good agriculture land into fellow land in future, which will be a serious issue for both farmers and local livelihood of that region.

5. Conclusions

It can be concluded that the maximum-minimum temperature difference is increasing at the rate of 1°C per five years. The Nepal has found to be a wider stretch of Rn values due to its highly undulating topography (mountain) followed by the Jharkhand (plateau) and Bihar (plain). The surface ET has also an increasing trend over the period of time and the results are noticeable for western Bihar-Jharkhand. The four year average pre-monsoon and monsoon rainfall analysis results have shown that there is an upward latitudinal shifting of the low rainfall bands in both the pre-monsoon and monsoon conditions.

Conflicts of Interest: The authors declare no conflict of interest.

Abbreviations

The following abbreviations are used in this manuscript:
Rn: Net surface radiation
ET: Evapotranspiration
GIS: Geographical Information System

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