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Computation of Flood and Drought Years over the North-West Himalayan Region Using Indian Meteorological Department Rainfall Data

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***Abstract*—**The climatic condition over Indian region is highly dependent on monsoon. India receives maximum amount of rainfall during southwest monsoon. Indian economy is highly dependent on agriculture. The presence of flood and drought years influenced the total cultivation system as well as the economy of the country as Indian agricultural systems is still highly dependent on the monsoon rainfall. The present study has been planned to investigate the flood and drought years for the north-west Himalayan region from 1951 to 2014 by using area average Indian Meteorological Department (IMD) rainfall data. For this investigation the Normalized index (NI) has been utilized to find out whether the particular year is drought or flood. The data have been extracted for the north-west Himalayan (NWH) region states namely Uttarakhand (UK), Himachal Pradesh (HP) and Jammu and Kashmir (J&K) to find out the rainy season average rainfall for each year, climatological mean and the standard deviation. After calculation it has been plotted by the diagrams (or graphs) to show the results- some of the years associated with drought years, some are flood years and rest are neutral. The flood and drought years can also relate with the large-scale phenomena El-Nino and La-Lina.

***Keywords*—**Indian Meteorological Department, Rainfall, Normalized index, Flood, Drought, NWH.

I. Introduction

As the Himalayas is huge source of water in the form of both liquid (carried by different drainage system) and solid (snowfall and ice on the mountain), it is called 'Water Tower of Asia' [1]. It also plays an important role in air circulation too which influences the climatic condition in the Indian region by defending rain-bearing south-westerly monsoon to give up maximum precipitation over Indian region in rainy season [2]. The extreme weather events like flash floods, heavy precipitation, cloud burst, and landslides have become regular in the western Himalayan region [3]. The climatic condition of the NWH region is controlled by the south-west monsoon from June to September (JJAS) and westerly disturbance from November to March. But there is a detectable change observed in monsoon precipitation only [4]. In that region severe effect on water availability has been created due to the overall changing pattern of rainfall which also leads to water stress as well as drought [5]. Recent study indicates that the rainfall becomes more intense in such a way that more precipitation takes place over a short time period. As a result, higher intensity and incidence of floods, especially flash flood happens in the river basins. On the other hand, it increases the runoff which reduces the amount of groundwater recharge. There is also a significant relationship between agricultural production and climate variabilities such as floods and droughts [6]. In that context, the present study has been planned to compute the flood and drought years using IMD rainfall data over NWH region to understand the relationship of extreme weather events like floods and droughts with the changing rainfall pattern.

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II. Study Area

The study area is North-West Himalayan region (Fig. 1). It encompasses three states namely Jammu & Kashmir, Himachal Pradesh and Uttarakhand. The geographical extension of this region varies in between 28° to 37° North latitudes and 72° to 82° East longitudes.

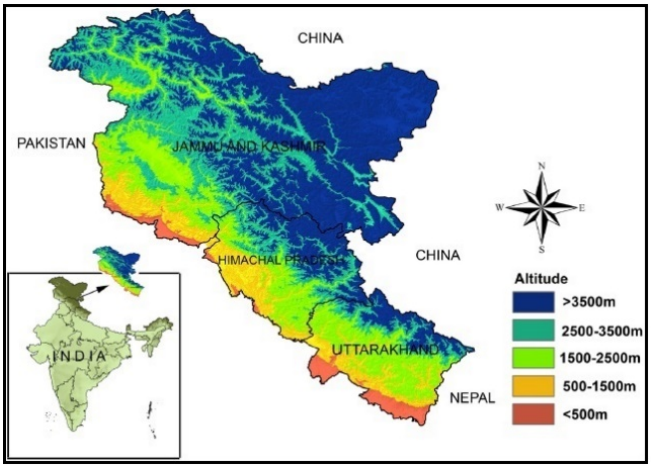

Fig. 1 Study area map of NWH region

III. Datasets and Methodology

The area average IMD rainfall data have been utilized for June, July, August, September (JJAS) during 1951 to 2014. The month wise rainfall data of JJAS have been converted into total monsoon season rainfall during 1951 to 2014.

We have used the NI method to find out the flood and drought years. The NI can be defined as follows:

NI = (Mean rainfall of JJAS – Climatological mean of JJAS rainfall)/Standard Deviation.

IV. Results and Discussions

To compute the flood and drought years we have used NI method for the present study. For that purpose the JJAS mean rainfall of each year, the climatological mean, and the standard deviation of the same have been calculated from the state Uttarakhand, Himachal Pradesh and Jammu & Kashmir respectively. We have treated those years flood years where the value of NI is greater than one. On the other hand, if the value of NI is less than minus one (-1), it has been considered as drought year.

For the state UK, in 1958: The mean rainfall of JJAS = 254.86 mm, Climatological mean of JJAS rainfall = 181.11 mm, Standard Deviation = 43.86. Therefore, NI = (254.86-181.11)/43.86 = 1.68. So, 1958 for the state UK is flood year (NI > 1). On the other hand, in 1972: The mean rainfall of JJAS = 131.85 mm, Climatological mean of JJAS rainfall = 181.11 mm, Standard Deviation = 43.86. Therefore, NI = (131.85-181.11)/43.86 = -1.12. So, the year 1958 for the state UK is flood year (NI < -1).

The calculation of NI for rest of the UK years and over the two other states namely HP and J&K has been done using the same methodology to compute the flood and drought years.

❖ *Uttarakhand*

For the state UK (Fig. 2), 1958, 1961, 1964, 1967, 1975, 1978, 1980, 1983, 1988, and 2003 can be considered as flood years. On the other hand, the drought years are 1972, 1979, 1987, 1997, 2004, 2006, 2007, 2009, 2012, and 2014. The occurrence of flood years is equal to drought years in UK which is ten but there is tendency of drought in recent years since 2000.

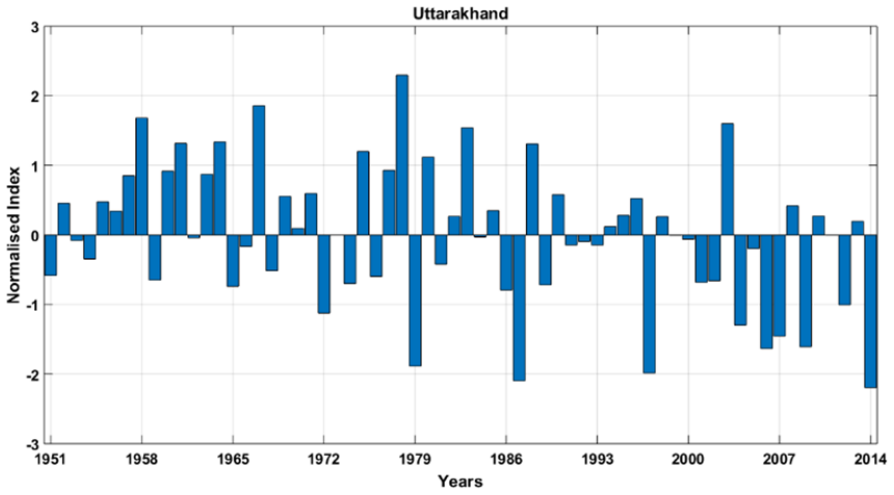

Fig. 2 Graphical representation of NI using area average IMD JJAS rainfall data for the period 1951 to 2014 over the Uttarakhand region

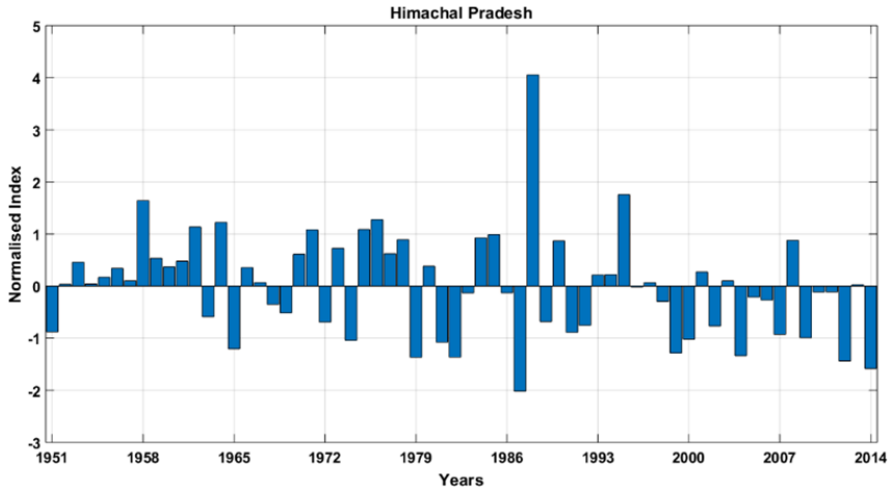

Fig. 3 Graphical representation of NI using area average IMD JJAS rainfall data for the period 1951 to 2014 over the Himachal Pradesh region

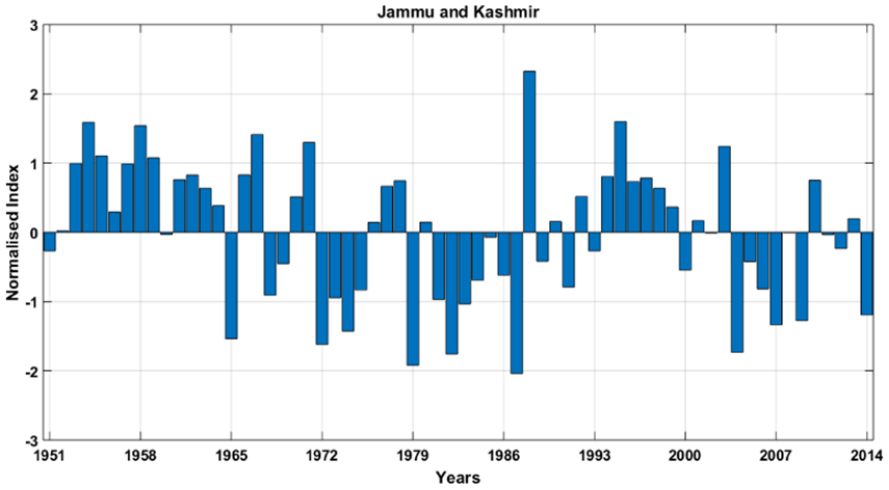

Fig. 4 Graphical representation of NI using area average IMD JJAS rainfall data for the period 1951 to 2014 over the Jammu and Kashmir region

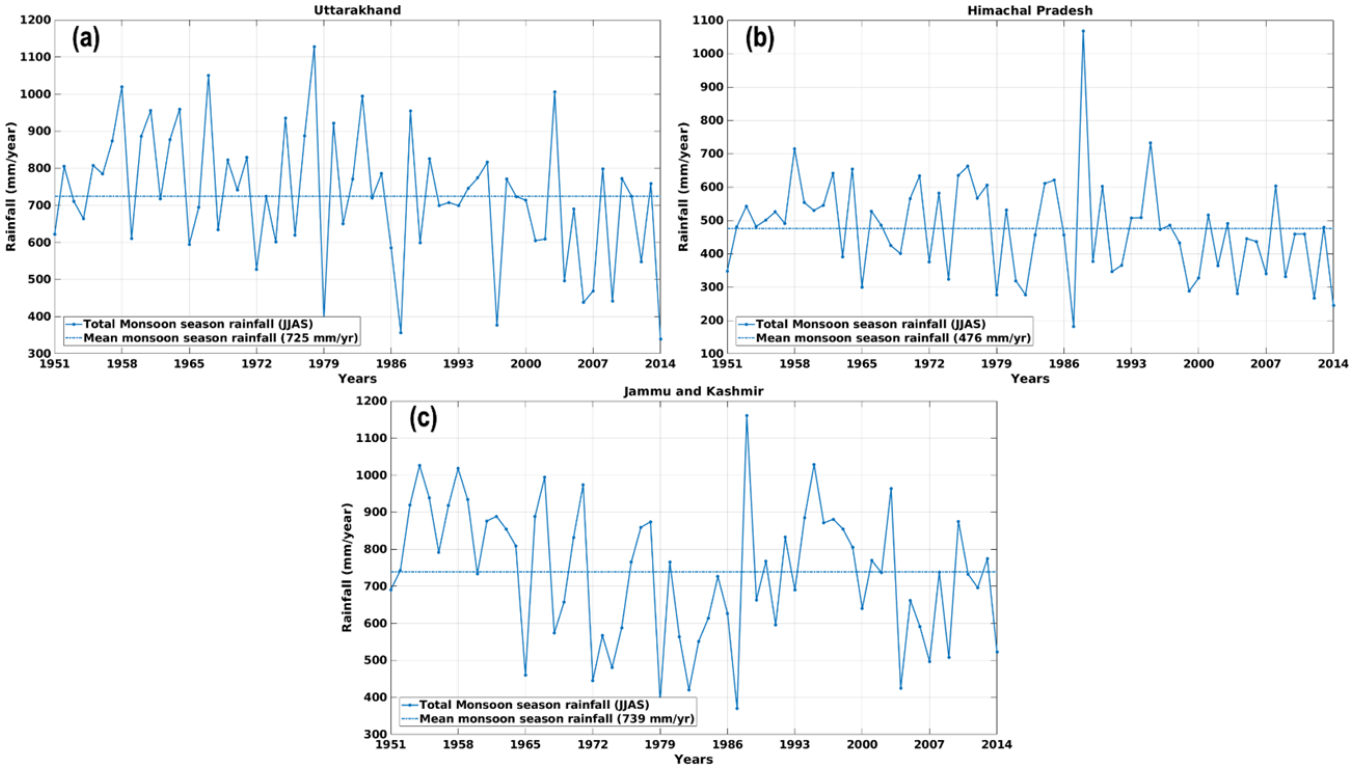

Fig. 5 Graphical representation of monsoon season rainfall (JJAS) in mm/year using area average IMD rainfall data over (a) Uttarakhand (b) Himachal Pradesh and (c) Jammu and Kashmir region during the period 1951 to 2014

❖ *Himachal Pradesh*

In case of HP (Fig. 3), the flood affected years are 1958, 1962, 1964, 1971, 1975, 1976, 1988 and 1995. The years 1965, 1974, 1979, 1981, 1983, 1987, 1999, 2000, 2004, 2012 and 2014 are the drought affected years. Here the occurrence of drought years (eleven) is more than the flood years (eight). Since 1990s there is a tendency of drought only over Himachal Pradesh.

❖ *Jammu and Kashmir*

In the state J&K (Fig. 4), the flood years are 1954, 1955, 1958, 1959, 1967, 1971, 1988, 1995, and 2003. On the other hand, the years 1965, 1972, 1974, 1979, 1982, 1983, 1987, 2004, 2007, 2009, and 2012 are the drought affected years. So the occurrence of drought years (eleven) is more than the flood years (nine). Again this NWH state has also a tendency of the incident of drought since 2000.

The time series (1951 to 2014) plots for total monsoon season rainfall along with mean monsoon season rainfall (Fig. 5) have also been introduced over all the three regions, UK, HP and J&K. For the state UK, the flood years 1958, 1961, 1964, 1967, 1975, 1978, 1980, 1983, 1988, and 2003 receive

more rainfall than the mean monsoon season rainfall 725 mm. On the other hand, the drought years 972, 1979, 1987, 1997, 2004, 2006, 2007, 2009, 2012, and 2014 receive less rainfall than the mean monsoon season rainfall over that region. Similarly, rest two states HP and J&K also follow the same trend.

The occurrence of flood is common in 1958 and 1988 for all the NWH states- UK, HP and J&K. On the other hand, 1979, 1987, 2004, and 2012 are common drought occurrence years for all of the three states.

V. Conclusions and Recommendation

The present study deals only with the computation of flood and drought years using NI. For the NWH states (except UK), the occurrence of flood years is less than the occurrence of drought years during 1951 to 2014 and there is a trend of drought in recent years in all the three states. The state UK receives one severe flood year in 1978 (NI > 2) and two severe drought years in 1987 and 2014 (NI < -2). In the similar way, HP and J&K both receive one severe flood year in 1988 and one severe drought year in 1987 respectively. So, the extreme high rainfall years indicate the severe flood and vice-versa.

The computation of flood and drought years can be computed over rest of the Indian region. The happening of flood and drought years can also be correlated with the large-scale phenomena like ENSO and IOD.

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