# Temporal variations of rainfall in Nepal since 1971 to 2000

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**ABSTRACT:**
A preliminary study has been undertaken to find the impact of the recent global warming on the rainfall patterns in Nepal. The study has been selected at a few rainfall stations in Nepal during 1971-2000. There seemed to be no fixed trend in annual rainfall in Nepal except in the Far Western Nepal, where there seemed to be rather slightly decreasing trend in the annual rainfall. During the monsoon months, the rainy days seemed to be decreasing and the intensity of rainfall appeared to be increasing.

## 1. INTRODUCTION

Generally there are four seasons in Nepal. These are Winter (November-February); Pre-monsoon (March-May); Summer monsoon (June to September) and Post monsoon (October). Among these seasons, 70 to 90 % of rainfall occurs under the influence of summer monsoon (Nayava, 1980). At the same time, most important agriculture activities have been taking place during the summer monsoon. Therefore, the onset of the monsoon rainfall and its amount, frequency and distribution in time and space are all important factors. Therefore, the preliminary studies for a few rainfall stations have been attempted to see the annual variations of rainfall and their trends during 1971-2000. Similarly, the rainy days and the amount of rainfall during the monsoon months have also been studied to find out whether these trends of annual and monsoon rainfall have been affected by the present climate change.

## 2. DATA

At present, there are more than 150 rainfall stations, which have the thirty years (1971-2000) of rainfall records in Nepal (DHM, 1999, 2000, 2001). Among those stations, 17 rainfall stations have been selected representing the Mountains, Hills and Terai Regions. These physiographic regions fall in the Cool Temperate, Warm

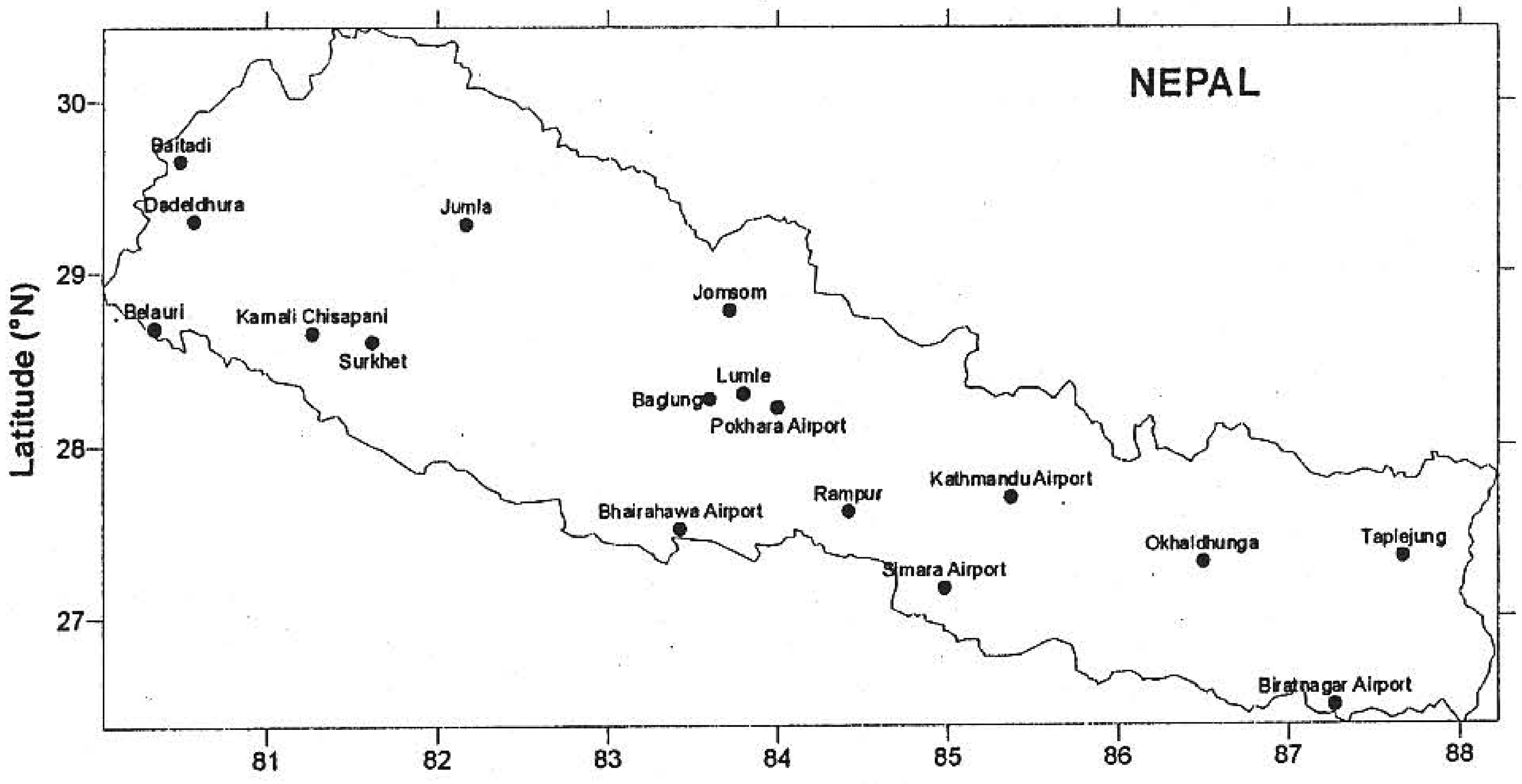


Figure 1. Selected rainfall stations in Nepal

**Table 1: Mean monthly rainfall (mm) at the selected rainfall stations in Nepal during 1971-2000**

| Index | Station Name | Elev. (m) | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 102 | Baitadi | 1635 | 45 | 7 | 59 | 52 | 140 | 209 | 326 | 2877 | 166 | 47 | 9 | 32 | 1429 |
| 104 | Dadeldhura | 1848 | 43 | 61 | 61 | 54 | 86 | 193 | 332 | 307 | 173 | 40 | 8 | 27 | 1384 |
| 106 | Belauri Shantipur | 159 | 21 | 315 | 20 | 20 | 51 | 227 | 496 | 454 | 271 | 49 | 5 | 20 | 1664 |
| 303 | Jumla | 2300 | 31 | 41 | 59 | 44 | 58 | 77 | 178 | 181 | 103 | 37 | 10 | 16 | 835 |
| 405 | Chisapani Karnali | 225 | 36 | 38 | 24 | 27 | 76 | 285 | 664 | 637 | 376 | 57 | 9 | 22 | 2251 |
| 406 | Surkhet | 720 | 34 | 35 | 29 | 31 | 79 | 256 | 448 | 418 | 198 | 49 | 10 | 21 | 1609 |
| 601 | Jomsom | 2744 | 8 | 11 | 23 | 19 | 7 | 24 | 40 | 34 | 37 | 31 | 9 | 6 | 258 |
| 605 | Banglung | 984 | 20 | 22 | 30 | 50 | 146 | 319 | 530 | 451 | 268 | 60 | 10 | 16 | 1922 |
| 705 | Bhairhawa | 109 | 16 | 15 | 18 | 22 | 66 | 261 | 549 | 377 | 258 | 8 | 7 | 15 | 1673 |
| 804 | Pokhara | 827 | 23 | 32 | 60 | 121 | 369 | 699 | 941 | 850 | 637 | 175 | 21 | 24 | 3952 |
| 814 | Lumle | 1740 | 32 | 46 | 62 | 103 | 317 | 877 | 1441 | 1369 | 854 | 207 | 30 | 23 | 5361 |
| 902 | Rampur | 256 | 17 | 14 | 21 | 19 | 151 | 348 | 555 | 431 | 300 | 84 | 8 | 18 | 1996 |
| 909 | Simra | 130 | 14 | 15 | 17 | 55 | 125 | 263 | 547 | 402 | 272 | 76 | 5 | 13 | 1804 |
| 1030 | Kathmandu | 1336 | 14 | 18 | 30 | 57 | 116 | 263 | 357 | 320 | 187 | 57 | 8 | 15 | 1440 |
| 1206 | Okhaldhunga | 1720 | 12 | 13 | 25 | 52 | 153 | 316 | 458 | 391 | 234 | 63 | 13 | 15 | 1744 |
| 1319 | Biratnagar | 72 | 11 | 13 | 16 | 48 | 164 | 321 | 534 | 368 | 305 | 89 | 11 | 8 | 1887 |
| 1405 | Taplejung | 1732 | 18 | 26 | 52 | 141 | 249 | 305 | 427 | 383 | 283 | 86 | 18 | 12 | 1991 |

*Source: DHM (1999a-c: 2000)*

Temperate and Tropical Climates categories respectively (Nayava, 1982). The time series rainfall data for the 17 selected rainfall stations were tabulated for the period 1971-2000. Data were checked and verified. The long term mean rainfall for those thirty years were calculated. These selected rainfall stations and the mean monthly rainfall data were shown in Table1. Similarly, the observed rainy days for the each and every month from 1971 to 2000 were computed for a few places.

## 3. METHOD

[redacted]

also analyzed. To do this statistical analysis of rainfall, 'EXCEL' from the Microsoft software has been used. The detailed analyses are follows:

a) Starting from the Far Western and Mid-Western Regions of Nepal, Jumla was selected as representing the Mountain Region. Dadeldhura, Baitadi and Surkhet were representing the ridges and valley in the Hilly Region. Similarly, Chisapani Karnali and Belauri Shantipur were representing the Inner Terai and Terai. The inter-annual variations of rainfall from station to station were quite different. The extreme highest and lowest of the annual rainfall also varied from station to station as shown in Figure 2. Generally, the annual variations seemed to be very high in [redacted]

Region of Nepal. The selected places were Jomsom as representing the Mountain as well as rain-shadow area; Lumle, Pokhara and Banglung as representing ridges, valley floor and river valley in the Hill Region and Rampur and Bhairhawa as representing the Inner Terai and Terai region respectively.

b) The inter-annual variations of rainfall from station to station were also quite different in Western Region of Nepal. However, the inter annual variations of rainfall seemed to be higher at Pokhara compared to the other stations. Among the six selected stations in Western Region of Nepal as shown in Figure 3, the extreme highest annual rainfall seemed different from one place to other places and however the extreme lowest annual rainfall seemed to be in 1972 except two places at Jomsom and Lumle. Among those places, Jomsom and Rampur showed either increasing or decreasing trend of annual rainfall and rest of the places such as Lumle, Pokhara, Banglung and Bhairhawa showed the increasing trend of annual rainfall as shown in Figure 3.

c) A similar study was done in the Central and Eastern Regions of Nepal. Taplejung, Okhaldhunga and Kathmandu were representing the ridges and valley floor in the Hill Region and Simra and Biratnagar as representing the Terai.

The inter-annual variations of rainfall seemed quite different in all those places. The extreme highest and lowest annual rainfall was also varied in all those places in the Central and Eastern Regions of Nepal as shown in Figure 4. The annual rainfall trends at Kathmandu, Okhaldhung, Simra and Biratnagar showed a slightly increasing trend where as the annual trend of rainfall at Taplejung showed slightly decreasing as shown in Figure 4.

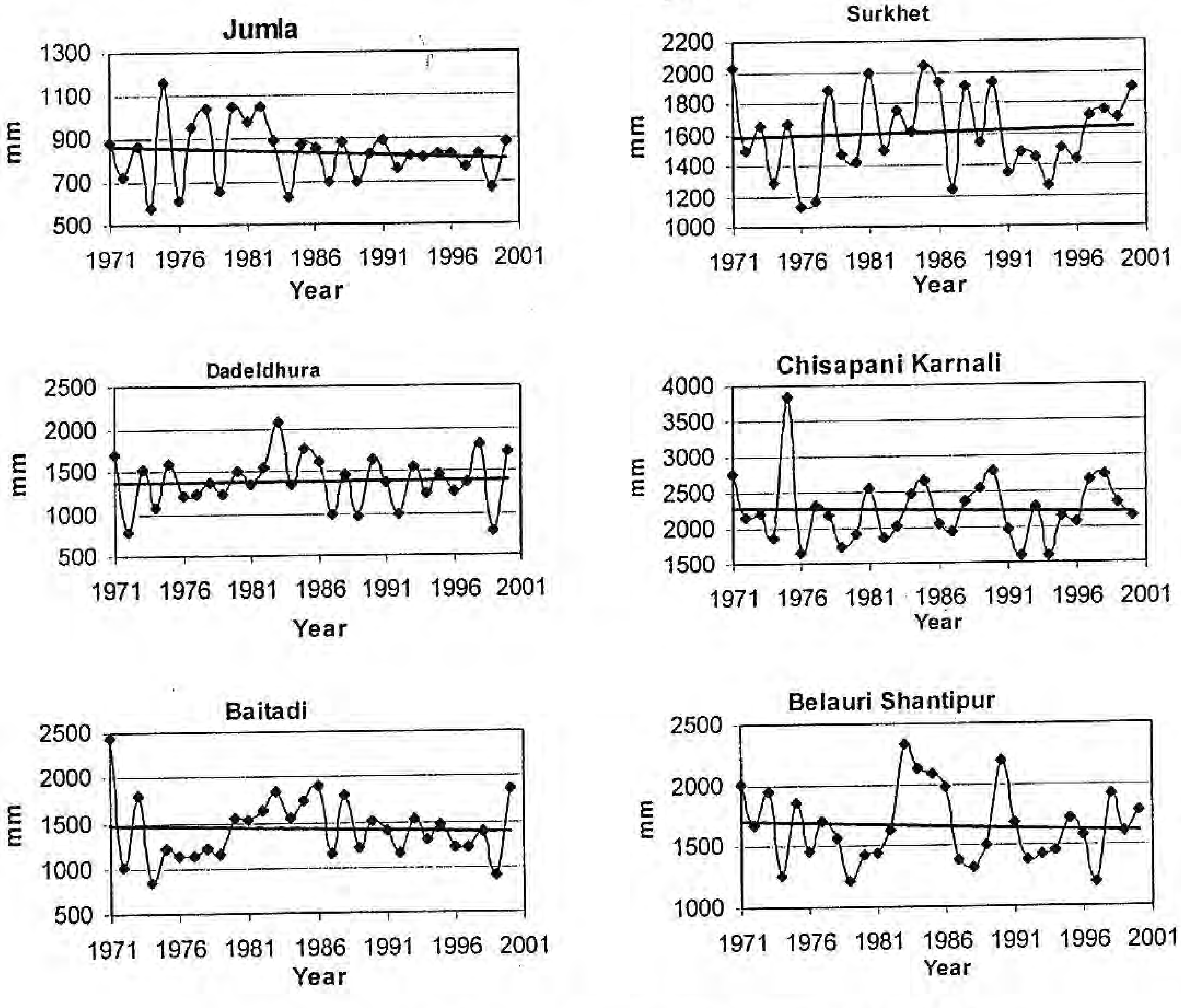


**Figure 2. The temporal variations and trends of annual rainfall at the Far western and Mid Western Regions of Nepal**

### 3.2 Analysis of monthly rainfall, June-September

It seemed that the most of the researchers have analyzed the annual trend of rainfall in terms of either regional or national scale. Of course, it depends upon the application in mind. This analysis of rainfall is made particularly for its application in agriculture activities in local scale. Therefore, the number of days of rainfall and distributions are equally important. Since, Nepal's agricultural activities depends upon the monsoon rainfall which accounts for about 70 to 90% of annual rainfall, the monsoon months of June to September were selected for the trend analysis of rainfall for Jumla, Surkhet and Bhairhawa in Nepal. At the same time, the uses of rainfall and their implications in agriculture will be highlighted.

The monthly information of rainfall and agronomic data are not adequate for proper analysis to find their relationship, say as monthly rainfall may be quite enough, in the contrary the rainfall occurred only either in the beginning or the end of the month and the prolonged dry spell may had occurred between those spells, the serious damage or loss of yields in crop may have happened and therefore, while studying the interaction between the weather and agriculture.

Food and Agriculture Organizations of the United Nations (1986) has considered the ten days of weather data and ten days report of agronomic data. This period is most reasonable period for collecting the required information on weather

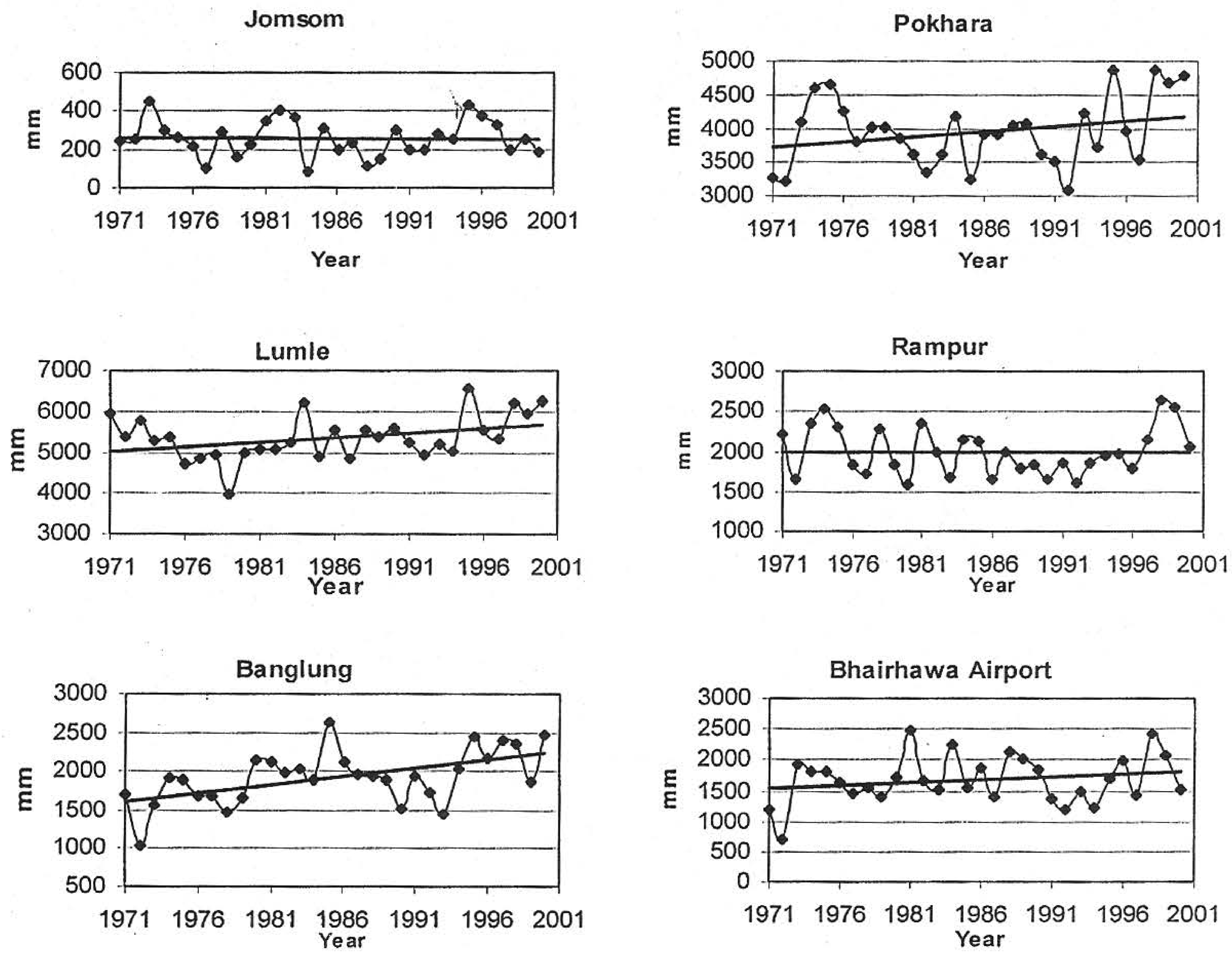


**Figure 3. The temporal variations and annual trends of rainfall at the Western region of Nepal**

and agronomic in national and international scale. Those data will be used in Water balance model developed by FAO (1986), which compared available water and water requirements of a given crop for each decade of the growing season. A shortfall or large excess of later in any decades will result in a reduction of "crop index", which the model generate as a means of monitoring crop condition and forecasting yields.

### 3.2.1 Jumla

The number of rainy days (greater than 1.0mm) and the mean monthly rainfall for Jumla at each month from June to September during 1971 to 2000 have been analyzed as shown in Figure 5. The trend of number of rainy days and the mean monthly rainfall in the month of June seemed no change, but the trend of rainy days in the month of July was very much decreased and to the contrary mean monthly rainfall at the same month seemed to be a little increase. It showed that the intensity of rainfall has increased during that month of July. The trend of rainy days as well as the mean monthly rainfall in August slightly decreased. At the end, the trend of rainy days in the month of September rather increased and the mean monthly rainfall in September also observed slightly increase.

### 3.2.2 Surkhet

The number of rainy days (greater than 1.0mm) and the mean monthly rainfall for Surkhet at each month from June to September during 1971 to 2000 were analyzed as shown in Figure 6. The trend of number of rainy days and the mean monthly rainfall in the month of June seemed to be a little increase as shown in Figure 6. On the contrary, the trend of number of rainy days in July increased and the mean monthly rainfall in the month of July seemed no change. Similar to Jumla, the

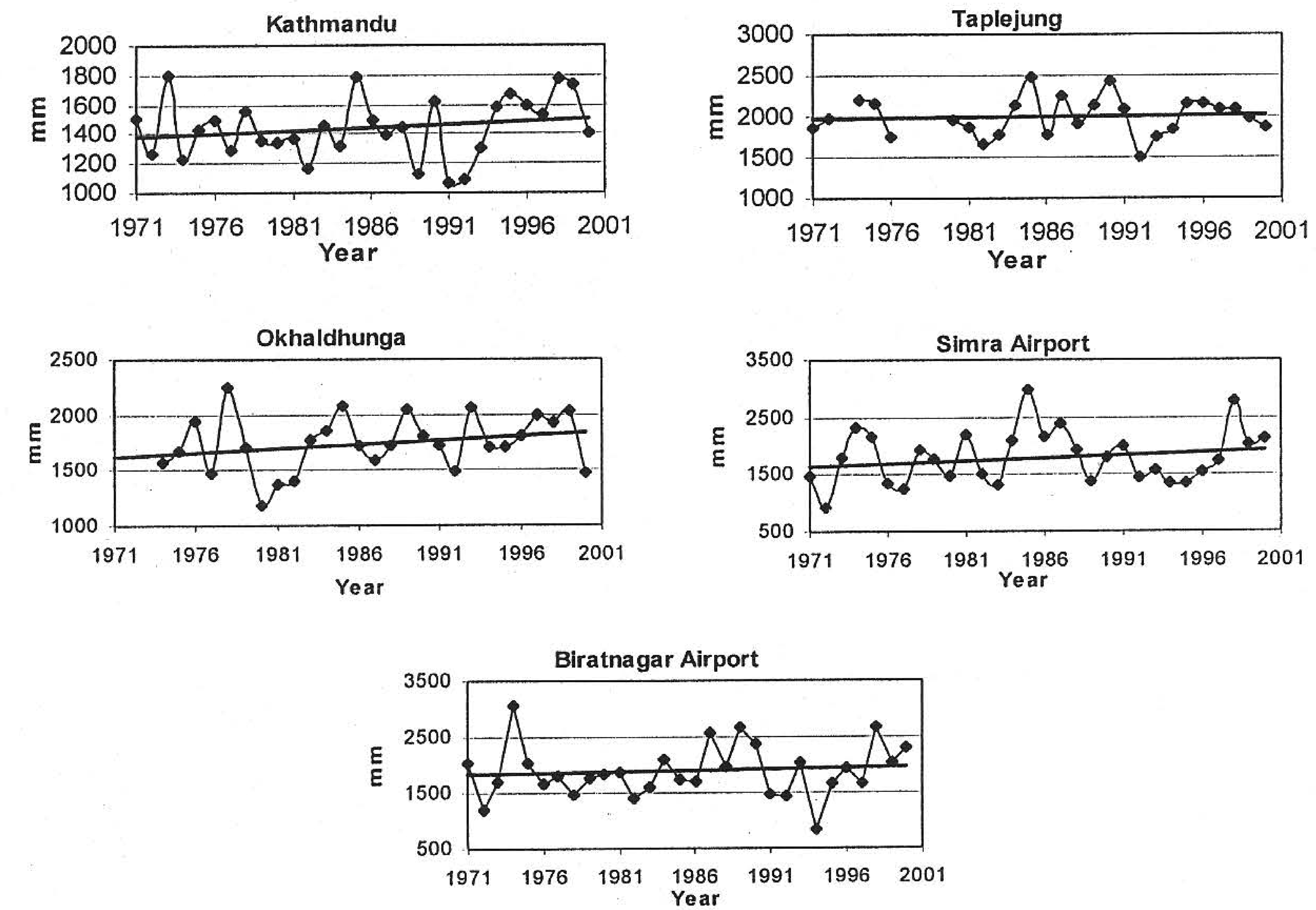


Figure 4. The temporal variations and trends of annual rainfall at the Central and Eastern Regions of Nepal

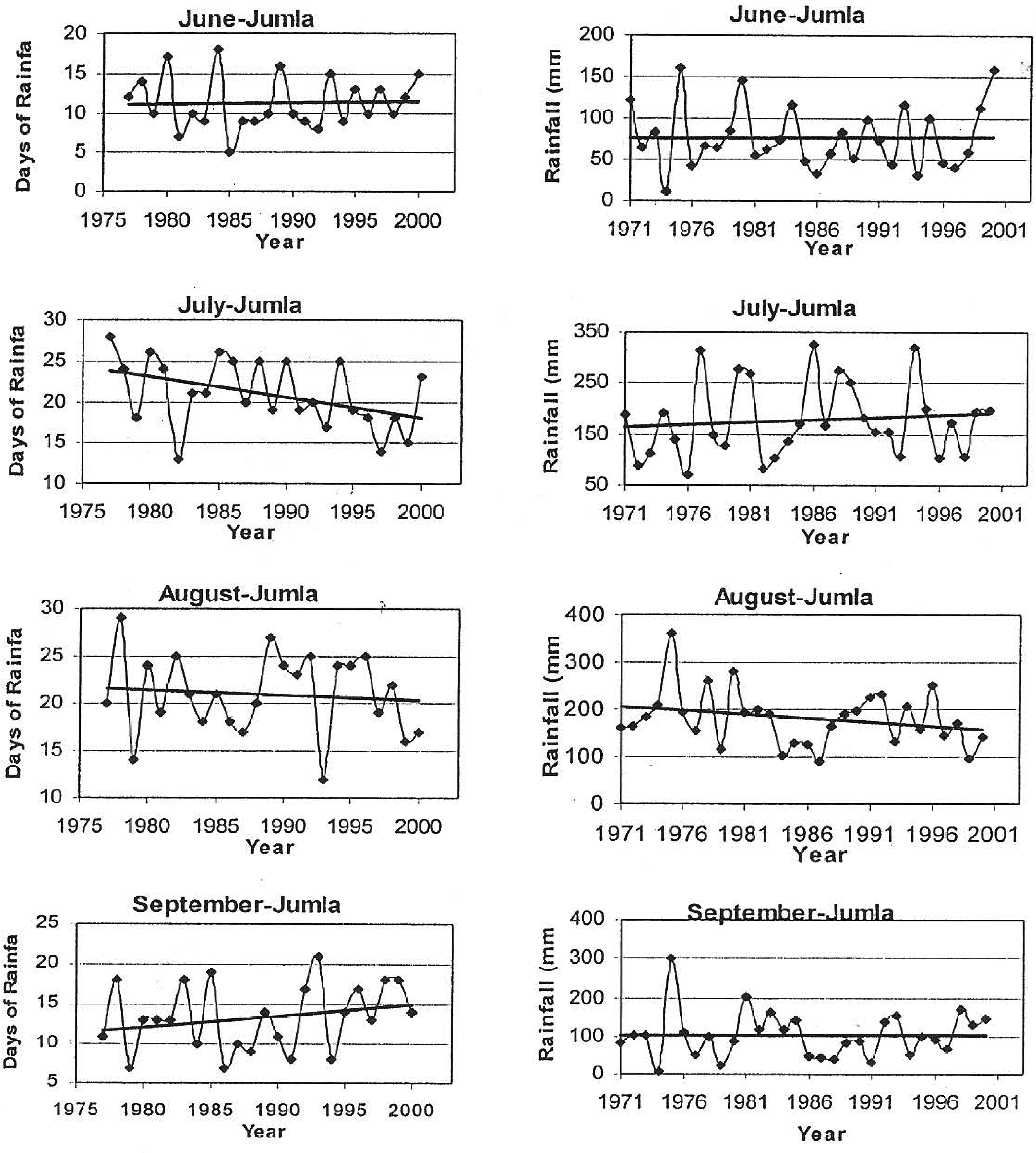


**Figure 5. The temporal variations of rainy days and mean monthly rainfall during the monsoon months and their trends at Jumla**

intensity of rainfall has increased during the month of July. During the month of August, the trend of rainy days as well as mean monthly rainfall seemed increase. Similar to Jumla, the trend of rainy days and the mean monthly rainfall in the month of September seemed a little increase.

### 3.2.3 Bhairhawa

Similar to Jumla and Surkhet, the number of rainy days (greater than 1.0mm) and the mean monthly rainfall for Bhairhawa at each month from June to September during 1971 to 2000 were analyzed as shown in Figure 7. During the month of June, the trend of rainy days as well as mean monthly rainfall seemed a little increase. The trend of number of rainy days in the month of July seemed no change and the trend of mean monthly rainfall seemed a little decrease. At the same time, the trend of rainy days in the month of August seemed to decrease, where as the trend of mean monthly rainfall seemed increase. At the end, the trend of rainy days in the month of September seemed to be quite decrease and it seemed that the last ten years the pattern of rainy days have shifted in a very much lower side. On the contrary, the trend of mean monthly rainfall also seemed to be a little decrease.

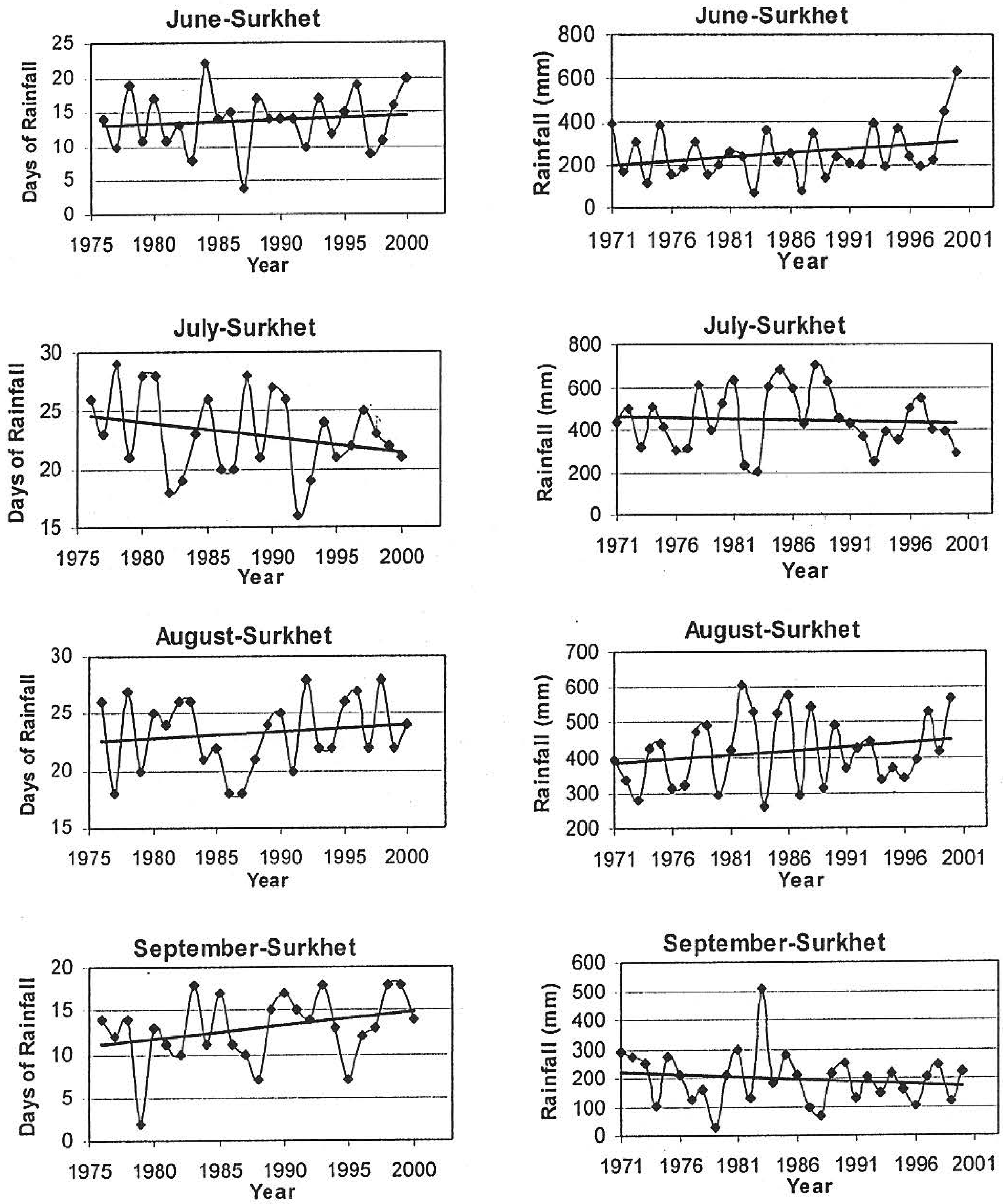


**Figure 6. The temporal variations of rainy days and mean monthly rainfall during the monsoon months and their trends at Surkhet**

## 4. RESULTS

There were no fixed trends of annual rainfall in the Mountain, Hill and Terai Regions of Nepal. However, it is quite interesting to note that the particular cross-section in the Far and Mid- Western Regions of Nepal, the annual rainfall in all the places such as Jumla, Dadeldhura, Baitadi, Surkhet, Chisapani Karnali and Belauri Shantipur showed decreasing trend.

The trend of number of rainy days decreased in the month of July at Jumla and the contrary mean monthly rainfall have increased during that month and this showed that the intensity of rainfall may have increased. The trend of rainy days as well as

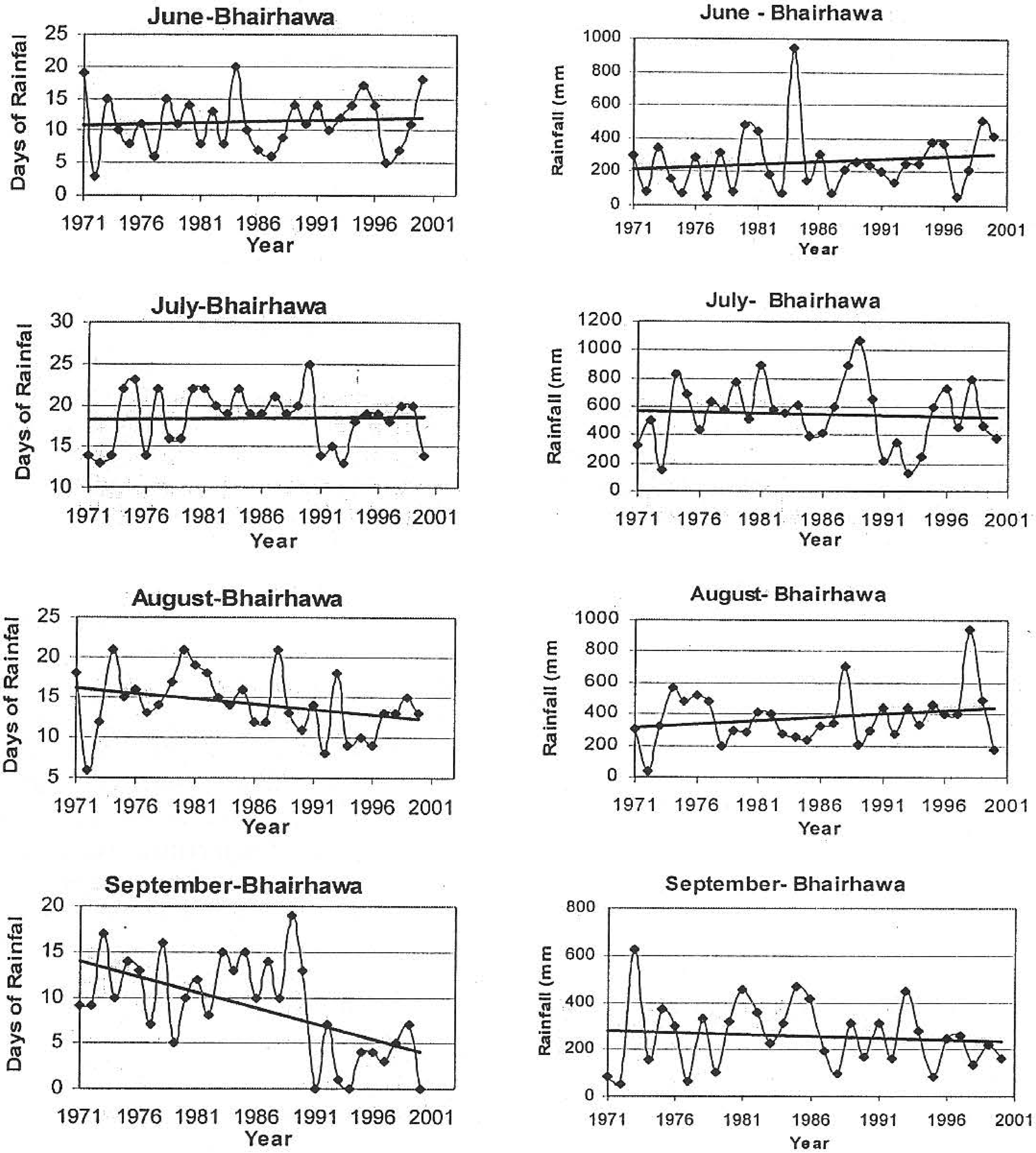


Figure 7. The temporal variations of rainy days and mean monthly rainfall during monsoon months & their trends at Bhairhawa.

mean monthly rainfall have decreased during the month of August at Jumla.

Similarly, the number of rainy days seemed decreasing in the month of July in Surkhet and the number of rainy days seemed decreasing in the month of August in Bhairhawa.

During the month of September, the trend of rainy days have very much decreased and it showed that the last ten years the pattern of rainy days have shifted in a very much lower side.

During 1971-2000, the year 1973, 1975 and 1984 seemed to be generally much more rainfall than normal throughout the country and on the contrary, at the same period, 1972, 1982 and 1992 seemed to be much lower rainfall than the normal throughout the country. Due to the longitudinal difference of $8^0$ from the east to west and $3^0$ from the south to north in Nepal, the country had experienced not equal distribution of rainfall in the west or east in the same year. For example, the western parts of Nepal had observed much lower rainfall than the normal in 1979 and agricultural activities were badly affected in those areas. It has been noted that 1992 had also dry year throughout the country and the government of India had declared a drought in Bihar state of India and monsoon rainfall was very much delayed in the western part of Nepal. The western parts of Nepal had suffered a drought in 1992. It has been strange coincidence that along with the other years every ten years after 1972, Nepal seemed to have observed significantly below normal rainfall either in the Eastern or in the Western regions.

## 5. DISCUSSION

Shrestha et al., (1998) have also studied the annual rainfall data on Nepal over the past three decades and they have remarked that the annual rainfall data show large inter-annual and decadal well as regional within Nepal. They have also mentioned the lack of long term increasing trend in the rainfall records and the model by Meehl et al., (1994) suggest an increase of 5-15% in monsoonal precipitation with green house gas – induced global temperature increase.

This is a very preliminary analysis to come up with definite conclusions, but it clearly showed that the number of days of rainfall seemed to be very much decreasing on the month of September at Bhairhawa as shown in Figure 7. The normal rainy days of Bhairhawa during the monsoon months is 59 days. Altogether, there are 80 rainy days in a year. If number of rainy days is reduced in Bhairhawa during the month in September, there may be water stress in paddy crop and consequently reduced the yield of paddy at Bhairhawa. It may be necessary to mention here that the onset of summer monsoon in Eastern Region of Nepal falls on $10^{th}$ of June and slowly it advances in the Western Regions of Nepal and it takes about a week to cover the whole Nepal under the influence of summer monsoon. Similarly, the withdrawal of summer monsoon takes place on 21st of September from Nepal. Therefore, the influence of summer monsoon over Nepal is only about 101 days. The nature of these kinds of study was very essential realizing these important issues.

Gerald et al. (1998) have analyzed the connection between past El Nino events and summer rainfall and rice production in Nepal, paying particular attention to last major El Nino event in 1982 when the intensity of the event was about the same as in the current year 1998. They found strong relationship between these three parameters. They have made recommendations that the concerned authorities should address this scenario while formulating national plans and policies in agriculture. They further recommended to adopt necessary measures to monitor the state of the crops in relation to El Nino and summer rainfall variations and come up with some methods to forecast the looming problem in advance. The monitoring situation with respect to agricultural meteorology must be improved with increased coordination and collaboration between the Department of Hydrology and Meteorology and the Department of Agriculture (Gerald et al., 1998).

Similarly, this study have also suggested that the present systems of yield assessments are subjective and, therefore, the objective method should be introduced in the monitoring and evaluation of crop yield and production in Nepal and this process will lead to much better assessments of yield and any impact of weather will also be evaluated (Nayava, 2000). When the impacts of weather and agriculture studied in wider areas, Food and Agriculture Organization of United Nations (FAO, 1986) recommends that ten days (decadal) of meteorological data and ten days of crop conditions should be considered along with other relevant information. Now, it is high time that such a system should introduce to find out the weather impacts on agriculture. This will support the future climate and agriculture scenario based on the past and current knowledge of weather, climate and agriculture inter-relationship. If we have these systems, we are in a better position to evaluate the past, present and future crop yields data in a very systematic and scientific manner.

Thus, to do any future forecast, one should have the present and past status of concerned data and should test those data and understand the trend and behavior of those patterns.

## 6. ACKNOWLEDGEMENT

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## 7. REFERENCES

DHM, 1999a. Daily precipitation records of Gandaki and Narayani Zones through 1996, Department of Hydrology and Meteorology, Kathmandu, Nepal.

DHM, 1999b. Daily precipitation records of Lumbini Zone through 1996, Department of Hydrology and Meteorology, Kathmandu, Nepal.

DHM, 1999c. Daily precipitation records of Bagmati Zone through 1996, Department of Hydrology and Meteorology, Kathmandu, Nepal.

DHM, 2000. Daily precipitation records of Janakpur and Sagarmatha Zones through 1996, Department of Hydrology and Meteorology, Kathmandu, Nepal.

DHM, 2000. Daily precipitation records of Kosi and Mechi Zones through 1996, Department of Hydrology and Meteorology, Kathmandu, Nepal.

DHM, 2000. Daily precipitation records of Mahakali, Seti and Karnali Zones through 1996, Department of Hydrology and Meteorology, Kathmandu, Nepal.

DHM, 2000., Daily precipitation records of Bheri, Rapti and Dhaulagiri Zones through 1996, Department of Hydrology and Meteorology, Kathmandu, Nepal.

DHM, 2001. Daily precipitation records of Nepal,1997-1998, Department of Hydrology and Meteorology, Kathmandu, Nepal.

FAO, 1986. Early Agro meteorological crop yield assessment, FAO Plant production and protection paper, 73.

Gerald, J.G, Hobbs, P.R. and Shrestha, M.L, 1998. Possible impact of the current El Nino event on Nepal's 1998 paddy crop, HMG Ministry of agriculture/Winrock International, Policy analysis in agriculture and related resource management, Series No. 1 July 1998, pp.1-15.

Meehle, G.A., and Washington, W.M. 1993. South asian summer monsoon variability in a model with doubled atmospheric carbon dioxide concentration. Science, 260,.1101-1104.

Nayava, J.l., 1980. Rainfall in Nepal, The Himalayan Review, Vol. 12, 1-18.

Nayava, J.L. 1982. Climates of Nepal and their implications to agricultural development, Ph.D. thesis submitted to The Australian National University, Canberra,.Australia.

Nayava, J.L, 1999. Monitoring and evaluation of crop yield and production in Nepal, Preceeding of the 3rd National Conference on Science and Technology, Proceedings Vol.1, Royal Nepal Academy of Science and Technology, Kathmandu, . 720-727.

Shrestha, A.B., Cameron, P.W, Jack, E.D and ayewski P.A, 2000. Precipitation fluctuations in the Nepal Himalaya and its vicinity and relationship with some large scale climatological parameters, International Journal of Climatology, 20, 217-327.s