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TRENDS IN SEASONAL PRECIPITATION AND TEMPERATURE – A REVIEW IN DOTI AND SURKHET DISTRICTS OF NEPAL

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Abstract

Rainfall and temperature are the crucial factors for affecting the yield of cereals. The annual mean temperature in Surkhet and Doti district is 21.47^{o}C and 22.84^{o}C respectively. The annual total rainfall in Doti and Surkhet district is 1145 mm and 1609 mm respectively. The average seasonal rainfall in (July-November) in Doti and Surkhet is 670.7 mm and 1109 mm. The average seasonal rainfall in (November-March) in Doti and Surkhet is 168 mm and 135 mm. The average seasonal rainfall in (March-June) in Doti and Surkhet is 352 mm and 389 mm. The average seasonal mean temperature in (July-November) in Doti and Surkhet is 25.76^{o}C and 23.7 ^{o}C. The average seasonal mean temperature in (November-March) in Doti and Surkhet is 16.67 ^{o}C and 15.48 ^{o}C. The average seasonal mean temperature in (March-June) in Doti and Surkhet is 25.5 ^{o}C and 24.69 ^{o}C. The analysis of meteorological data indicated that the temperature of both districts is on a rising trend. It has been observed no any trend in total seasonal rainfall during wheat and barley growing season (November-March) in Surkhet. Also, the seasonal total rainfall during maize growing period (March-June) has not shown any trend in Doti. Besides, decreasing trend of annual rainfall has been observed in Doti whereas increasing trend of annual rainfall is observed in Surkhet. The temperature in 1985 in Doti and Surkhet has increased and the rainfall in the same year and same districts has decreased that has negatively affected the yield of all the major cereals except wheat.

Key words: Rainfall, Temperature, Cereals, Doti, Surkhet

Introduction

Temporal changes in discrete random extreme events are becoming important in climate change scenario studies because of their socio-economic impacts. The risk of extreme events is difficult to predict but their impacts could be severe. To outline the trend of rainfall and temperature in a certain region, it is necessary to look at the historical trends of statistical properties of seasonal rainfall extremes and temperature (Pal and Al-Tabbaa, 2009).

Temperature and rainfall are the two aspects of climatic variation in Nepal. Besides latitude the temperature in Nepal is associated with elevation. In Nepal, the average temperature increase was recorded as 0.06^{o}C per year and that in Terai and Himalayas was 0.04^{o}C and 0.08^{o}C per year respectively (Shrestha et al., 1999). Being located in the northern

limit of tropics, Nepal gets both summer and winter precipitation (Singh, 1985). The average precipitation in the country is 1768 mm (Shrestha et al., 2000), but varies greatly from place to place owing to sharp topographical variation (Nayava, 1980). The warming was higher than average in more than 12 years and the temperature has increased by 1.8^{o}C during the last 32 years (Malla, 2008).

Rainfall and temperature are the major elements of the climate that govern farming of almost all cereals. Summer monsoon is the single source of water and one of the elements of seasonal climatic variability in the country. The annual seasonal variation consists of monsoon season (June to September), a cool dry post monsoon season (October to November) followed by winter season (December to February) and a hot dry pre monsoon season (March to May) (Yogacharya, 1998). The successive folds of east-west running mountain ranges, big rivers, geographical and topographical features, create a number of windward and leeward, deep inland valleys and river basin within short distances, giving rise to spatial variations in rainfall pattern.

Agriculture is the largest sector and the backbone of the Nepalese economy. It is an important source for improving the livelihood of the rural people and improves the living conditions of the people. The rainfall and temperature regulates the agricultural yield in the country. As most of the farmers depend on good weather conditions to increase their output, seasonal precipitation and temperature has a remarkable implication in the sustainability of Nepalese agriculture. As there is no or little rain in pre monsoon and post monsoon of the year except monsoon period, cereals yield is risky, especially in hot and dry pre monsoon season. In addition, erratic rainfall and rain with thunderstorms and hailstones (especially in the pre monsoon season) cause a lot of damage to the crops and farmers are always scared of decreasing the yield of the cereals. A slight decrease in the rainfall and increase in temperature will have a negative impact in cereals yield which is a matter of great interest. On the other hand, a change in the level of temperature and rainfall induces heterogeneous impacts, which can be considered either beneficial or harmful depending on the season, altitude and type of crop. Given this severe sensitivity of cereal yields to climate factors, variety-specific adaption strategies must be adopted to mute the adverse effects of climate change (Bhandari, 2013). Adoption of new modern technology is very important in far western development region to get good agricultural production (Bhandari, 2012). However, other factors like fertility of the soil, farm management practices, variety, prevalence of diseases and insects, and the weather are responsible for the variation of agricultural production (Robertson, 1975).

Many scientists have already analyzed the trend of rainfall and temperature and studied their relationship with crop yield at different districts. However, they didn't consider the rainfall extremes and temperature with the yield of five major cereals in Doti and Surkhet districts of Nepal. There are very few literatures on extremes of rainfall and temperature and their relationship with yield of five major cereals.

This study analyzes the trend of rainfall and temperature and their effect on the yield of major cereals Paddy/rice (*Oryza sativa* L.), wheat (*Triticum aestivum* L.), maize (*Zea mays* L.), millet (*Eleusine coracana* Gaertn.) and barley (*Hordeum vulgare* L.) in Doti and Surkhet districts of Nepal.

Materials and Methods

Study area

There are 75 districts in five developmental regions of Nepal. Doti lies in FWDR whereas Surkhet lies in MWDR. The latitude and longitude of Doti is 29^{o} 15' N and 80^{o} 57' E. The elevation is 617 m above the sea level. The average annual rainfall and average monsoon rainfall is 1145 mm and 802 mm respectively.

Figure 1: Location of Doti and Surkhet districts in the map of Nepal

Similarly, the latitude and longitude of Surkhet is 28^{o} 36' N and 81^{o} 37'E. The elevation is 720 mm above the sea level. The average annual rainfall and monsoon rainfall is 1609 mm and 1313 mm respectively. The average mean monthly temperature of Doti and Surkhet districts is shown in **Table 1**.

Table 1: Average mean temperature (^{o}C)

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Surkhet	12.34	14.66	19.33	24.44	27.25	27.87	26.85	26.71	25.48	21.97	17.34	13.37
Doti	13.5	15.4	19.9	24.4	27.9	29.5	29.1	28.7	27.7	23.9	19.1	15

Data Collection

Secondary data such as rainfall, temperature and yield of major cereals (rice, wheat, maize, millet and barley) was collected from different sources like Central Bureau of Statistics (CBS), Department of Hydrology and Meteorology (DHM) and Ministry of Agriculture and Cooperatives, Government of Nepal (MoAC, GoN). Apart from meteorological data, a number of accessible libraries ICIMOD (Integrated Centre for International Mountain Development), NARC (National Agricultural Research Council), NAST (National Academy of Science and Technology) are visited time to time to collect theoretical information.

Data analysis

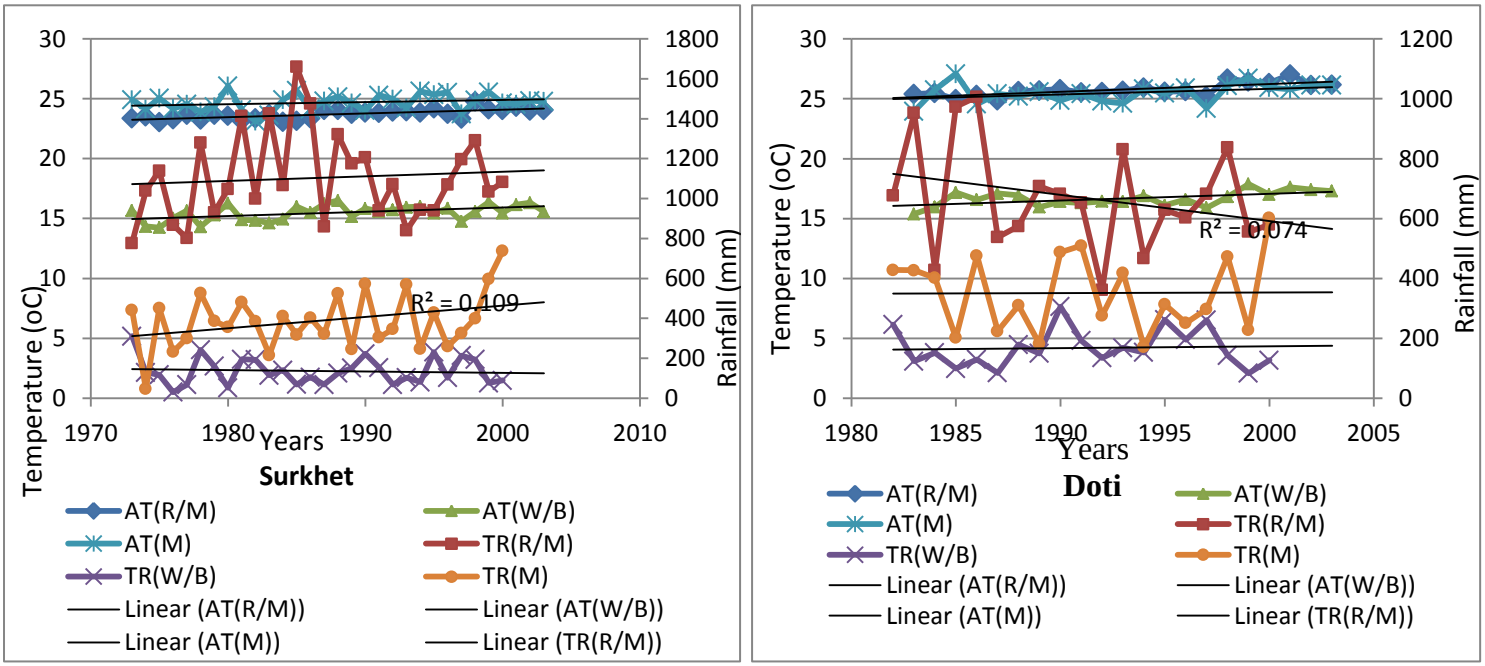
The rainfall and temperature data of Doti from 1982-2003 was plotted and studied. Similarly, the rainfall and temperature data of Surkhet from 1973-2003 is plotted and studied. Trend analysis of seasonal rainfall and temperature during the production of five major cereals was performed for Doti and Surkhet districts respectively by MS Excel. The years without data and the years with inadequate data were omitted during the study. The growing period of rice and millet is July-November, barley and wheat is December-March and Maize is March-June respectively. The rainfall and temperature trend analysis and the data analysis of yield of major cereals with the rainfall and temperature were performed. Trend analysis of rainfall and temperature were performed. The yield data of cereals were plotted with rainfall and temperature separately to identify the relationship, if any.

Results and discussion

1. Annual mean temperature (AT) and total rainfall (TR)

Being located in the northern limit of the tropics, Nepal gets both summer and winter precipitation. Westerly disturbances affect the northern and western parts of Nepal (Singh 1985). The summer monsoon is economically the most important season. The average precipitation in the country is 1,768 mm (Shrestha 2000), but it varies greatly from place to place owing to sharp topographical variation (Nayava 1980). Monsoon precipitation occupies 70 to 85 percent of total precipitation depending on the location (Singh 1985; Ives and Messerli 1989).

The annual mean temperature from 1973-2003 in Doti and Surkhet district showed a rising trend. The total rainfall from 1971-2000 in Surkhet also showed a rising trend. However, the record of total rainfall in Doti district from 1982-2000 showed a decreasing trend as shown in **Figure 2b**.



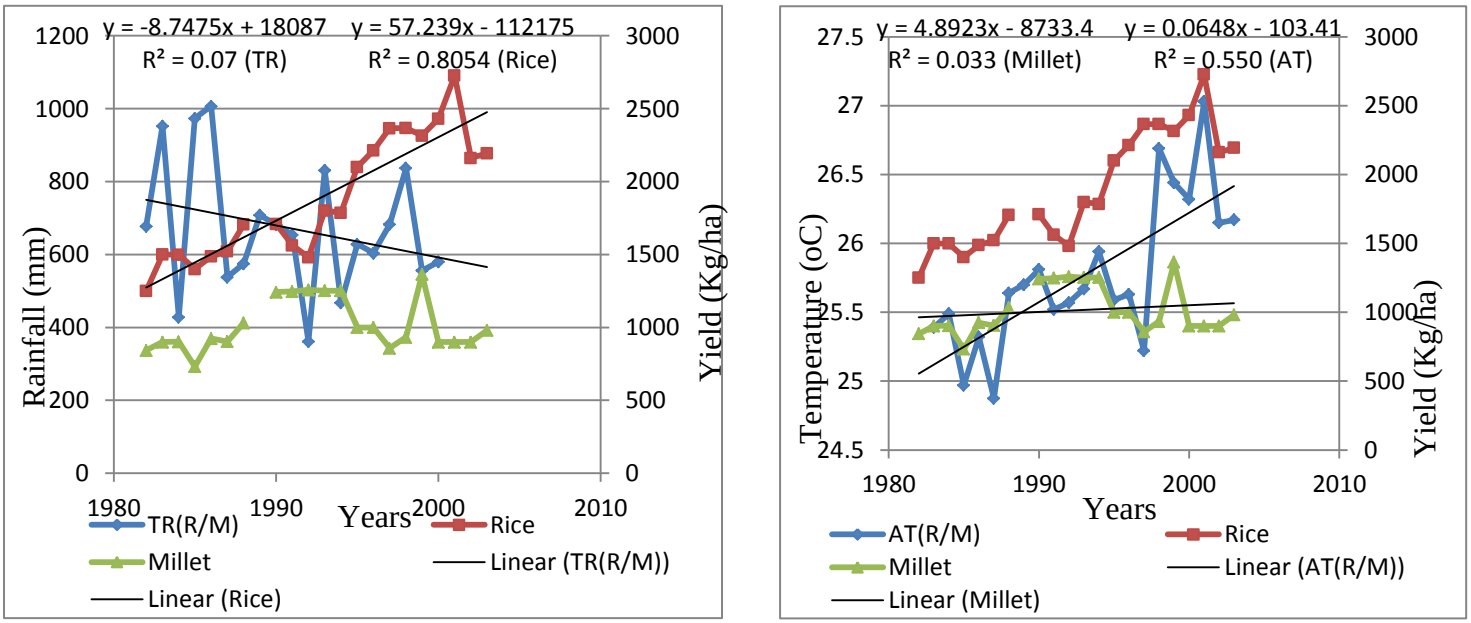
R/M=Rice/Millet W/B=Wheat/Barley M=Maize

(a) **(b)**

Figure 2: Trend analysis of seasonal mean temperature and total rainfall

2. Yield of rice and millet in Doti and Surkhet

The analysis of yield of rice and millet from 1975-2003 in Doti showed a rising trend. The yield of rice has been negatively affected in some years like 1991, 1992, 1993, 1994, 2002, and 2003. The yield of rice has decreased badly in 1992. In the same year the rainfall has also been decreased. At the beginning, when rice is planted, the crop water need is only 0.87 mm/day, but it gradually increases and reaches to 15.95 mm/day. The highest amount of water required for rice was found in the month of September i.e. 478.5 mm (Aryal, 2012). The yield of millet has decreased in the year 1985, 1997, 2000, 2001 and 2002. The yield is sharply decreased in 1985 and 1997. In the years 1984, 1987, 1988, 1992 and 1994 the rainfall is decreasing. In the years 1985, 1987, 1995 and 1997 temperature has sharply decreased whereas in the years 1994, 1998 and 2002 temperature has sharply increased. It is concluded that the decrease in yield of millet in 1985 and 1997 is due to the sharp decrease in temperature. The reduction in yield of millet in 2002 is due to the sharp increase in temperature. The reduction in yield of millet in 2000 is due to the sharp decrease in rainfall. It is concluded that the reduction of yield of rice in 1992 in Doti district is due to the decrease of rainfall in the same year as shown in **Figure 3**.



TR(R/M) = Total rainfall (Rice/Millet) AT(R/M) = Mean temperature (Rice/Millet)

Figure 3: Trend analysis of rice and millet yield with rainfall and temperature in Doti

The analysis of yield of rice and millet from 1975-2003 in Surkhet showed a rising trend. The yield of rice has been negatively affected in some years like 1978, 1979, 1980, 1981, 1982, 1983, 1986, 1987, 1988, 1990, 1991, 1992, 2002 and 2003. The yield of rice has decreased badly in 1979, 1982, 1987, 1988, 1992 and 2002. In the years 1973, 1976, 1977, 1979, 1980, 1982, 1984, 1987, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1999 and 2000 rainfall is decreasing. The rainfall in the years 1973, 1977, 1987 and 1993 has been decreased sharply. In the same years the yield of rice has also been decreased. The yield of millet has decreased in the years 1981, 1982, 1986, 1987, 1988. The yield of millet has been sharply decreased in the year 1982. It is concluded that the reduction of yield of rice and millet in 1982 and 1987 in Surkhet district is due to the decrease of rainfall in the same years.

In the years 1975, 1978, 1981, 1982, 1984, 1985, 1986, 1996, 1997, 2002, 2003 temperature is increasing. The temperature in the years 1975 and 1984 has been sharply increased. It is concluded that the reduction of yield of rice and millet in 1981 and 1986 is due to high temperature in the same years. Although the rainfall and temperature is good in 1988 the yield of rice and millet is bad. There are other factors affecting the yield of rice and millet of Surkhet in 1988 as shown in **Figure 4**.

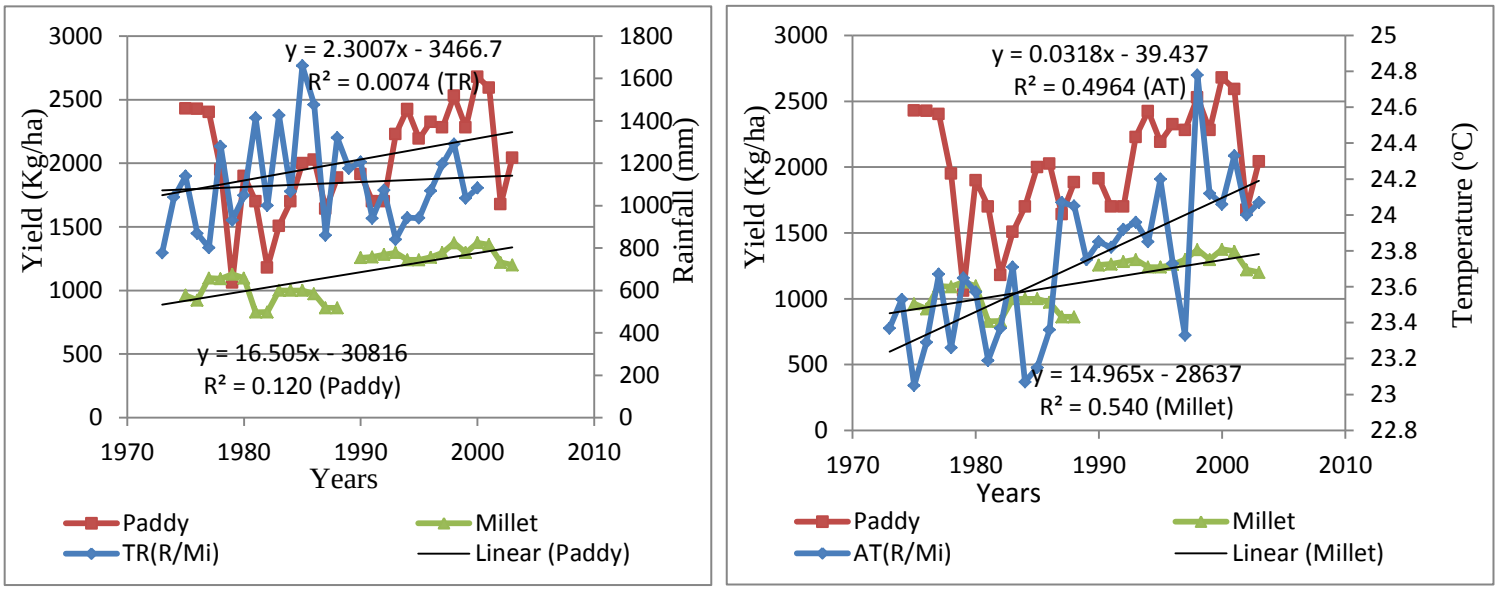
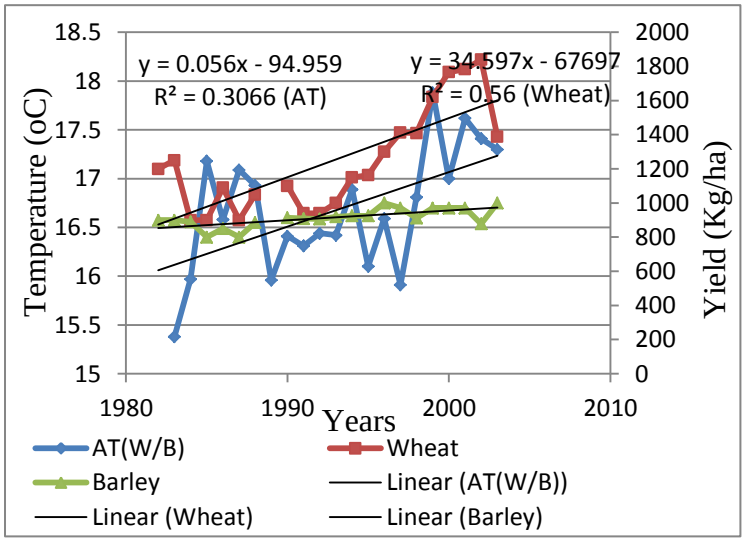


Figure 4: Trend analysis of rice and millet yield with rainfall and temperature in Surkhet

3. Yield of wheat and barley in Doti and Surkhet

The analysis of yield of wheat and barley from 1982-2003 showed a rising trend. The yield of wheat has been negatively affected in some years like 1985, 1987, 1991, 1992, 1993, 1994, 1995, 1996 and 2003. In the years 1985, 1987 and 1999 temperature is in increasing trend whereas in the years 1989, 1995 and 1997 temperature is in decreasing trend. In the years 1988, 1990 and 1995 rainfall is in increasing whereas in the years 1983, 1985, 1987, 1998, 1999 and 2000 rainfall is in decreasing trend. It has been observed that the yield of wheat in the years 1985 and 1987 is decreasing due to increase in temperature in the same years. The yield of wheat in 1995 has decreased due to decrease in temperature in the same year. The yield of barley has decreased badly in 1985. In the same year the rainfall has been decreased and temperature has been increased. It is concluded that the reduction of yield of wheat in 1985, 1987 and 1995 in Doti district is due to the decrease of rainfall in 1985 and 1987 and decrease of temperature in 1995 as shown in **Figure 5**.



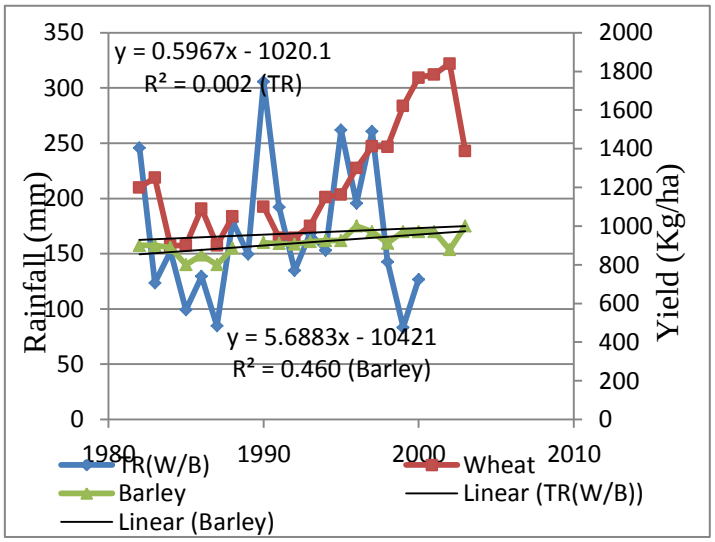
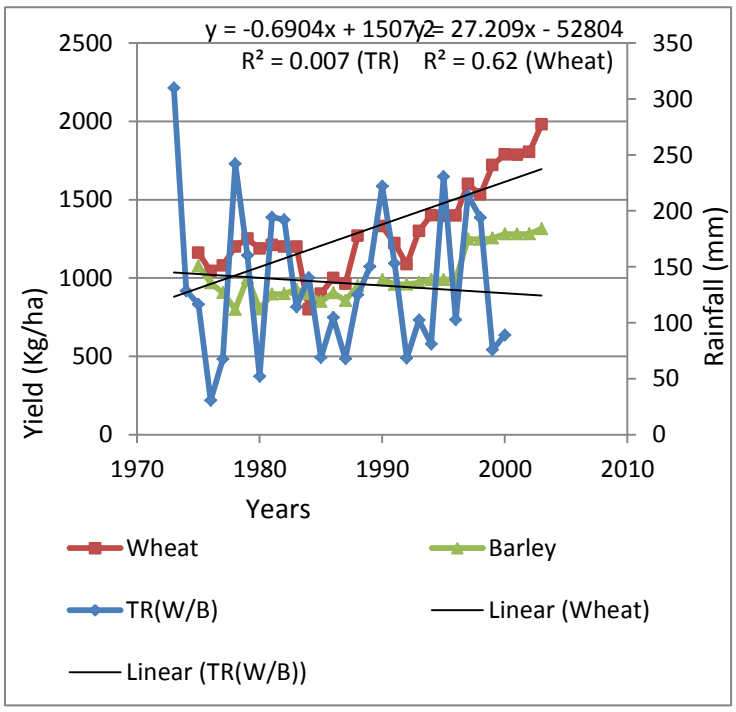


Figure 5: Trend analysis of wheat and barley yield with rainfall and temperature in Doti

The yield of wheat has been negatively affected in some years like 1984, 1985, 1986, 1987, 1991, 1992 and 1996. In the years 1977, 1980, 1985, 1987, 1988, 1990, 1993, 1994, 1999, 2001 and 2002 temperature is in increasing trend whereas in the years 1974, 1975, 1978, 1983, 1989, 1995, 1997, 2000 and 2003 temperature is in decreasing trend.



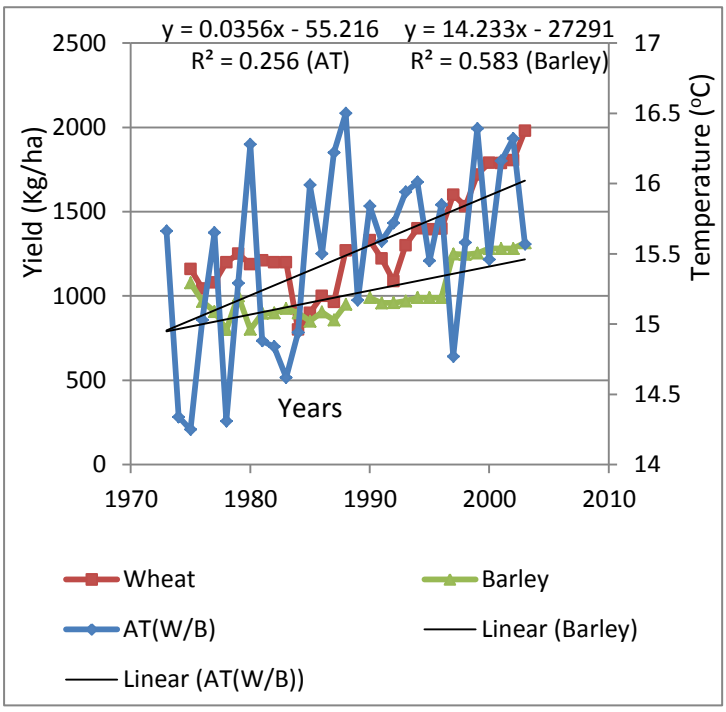


Figure 6: Trend analysis of wheat (W) and barley (B) yield with rainfall and temperature in Surkhet

In the years 1978, 1981, 1982, 1989, 1990, 1991, 1995, 1997 and 1978 rainfall is in increasing whereas in the years 1975, 1976, 1977, 1980, 1983, 1985, 1987, 1992, 1994, 1996 and 1999 rainfall is in decreasing trend. It has been observed that the yield of wheat in the year 1992 is decreasing sharply due to decrease in rainfall in the same year. In 1984 the yield of wheat has decreased due to other factors besides rainfall and temperature. Up to 60 %

variations of productivity of wheat depended on weather fluctuation. This is a matter for study in future at different temperature regimes in Nepal and extensive field works are necessary to collect the information on fertilizer application, irrigation, time of weeding and their cultural practices (Nayava et al., 2009). The latest report shows that there is positive role in percentage change in wheat yield in all the agro ecological regions. With doubling of CO_2, wheat production is likely to increase with adoption of more heat tolerant varieties (Sharma, 2007). The yield of barley in 1978, 1981, 1985, 1986 and 1987 has been decreased slightly. In the years 1978, 1981, 1982, 1989, 1990, 1991, 1995, 1997 and 1998 rainfall showed increasing trend whereas in the years 1975, 1976, 1977, 1980, 1983, 1985, 1987, 1992, 1994, 1996 and 1999 rainfall showed decreasing trend. The yield of barley has decreased slightly in the years 1978, 1981, 1985, 1986 and 1987. In the years 1978, 1981, 1985 and 1987 the yield of barley is slightly decreased due to the increase in temperature in 1985 and 1987. In the year 1987 the rainfall is low and has reduced the yield of barley in the same year in Surkhet. It is concluded that the reduction of yield of wheat in 1985, 1987 and 1996 in Surkhet district is due to the decrease of rainfall in respective years as shown in **Figure 6**.

4. Yield of maize

The yield of maize showed a decreasing trend in years 1985, 1986, 1987, 2000, 2001 and 2003 in Doti and in the years 1983, 1984, 1985, 1986 and 1987 in Surkhet. In the years 1985, 1989, 1987, 1994, 1996, 1998, 1999, 2002 and 2003 temperature showed a rising trend in Doti. In the year 1985, 1987, 1989, 1992, 1994, 1995, 1996 and 1999 rainfall showed decreasing trend. Similarly, in the years 1986, 1990, 1992, 1993, 1997 temperature showed decreasing trend. In the years 1986, 1990, 1991 and 2000 rainfall showed rising trend. The yield of maize in the years 1985 and 1987 is decreased due to increase of temperature and decrease of rainfall in the same years. The yield of maize in the year 1986 is decreased due to decrease of temperature and high intensity of rainfall in the same year. Similarly the yield of maize in 2000 and 2003 is affected by high intensity of rainfall in 2000 and high temperature in 2003 as shown in **Figure 7**.

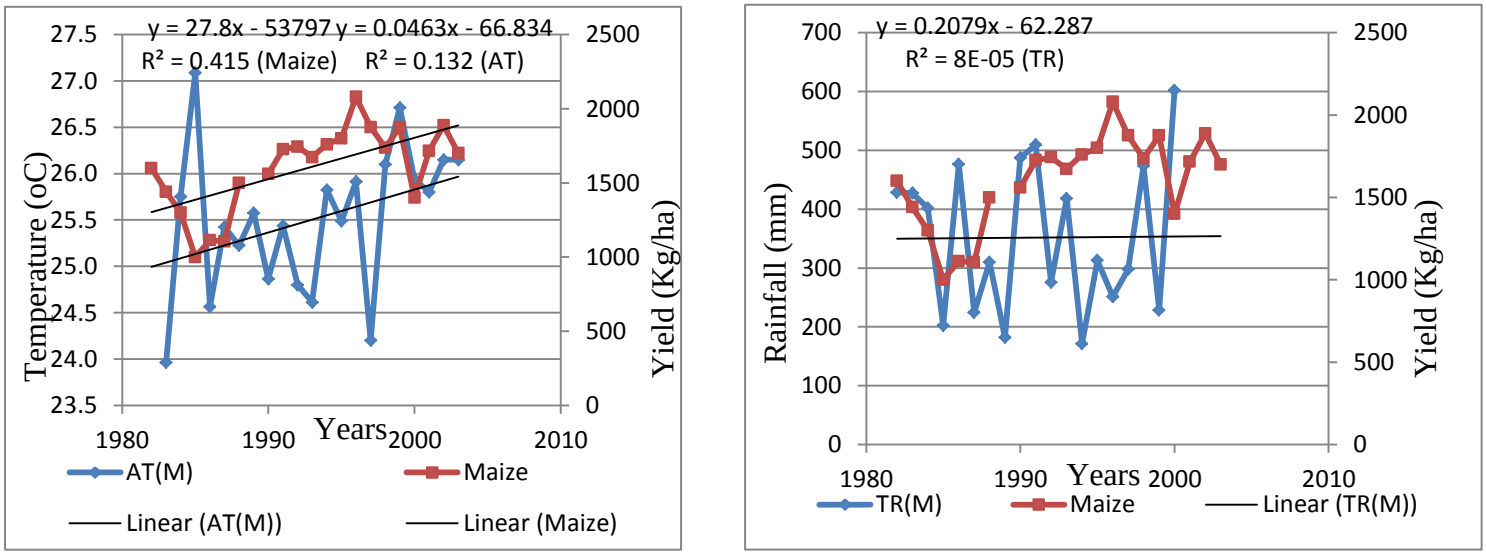


Figure 7: Trend analysis of maize (M) yield with rainfall and temperature in Doti

In the years 1975, 1980, 1985, 1988, 1991, 1994, 1996 and 1999 temperature showed a rising trend. In the year 1974, 1976, 1983, 1985, 1987, 1989, 1991, 1994 and 1996 rainfall showed decreasing trend. Similarly, in the years 1974, 1976, 1978, 1981, 1982, 1983, 1986, 1990, 1993, 1997, 2000 and 2001 temperature showed decreasing trend. In the years 1975, 1978, 1981, 1988, 1990, 1993, 1999 and 2000 rainfall showed rising trend. When the maize is given its full water requirement, 486.6 mm of water is required. The maximum amount of water i.e. 318 mm is required and utilized at the mid stage (flowering and fruiting) (Bhandari, 2012). The yield of maize in the year 1987 has decreased sharply due to decrease of rainfall in the same year in Surkhet. In the year 1984 the yield of maize has been decreased due to other factors besides rainfall and temperature as shown in **Figure 8**.

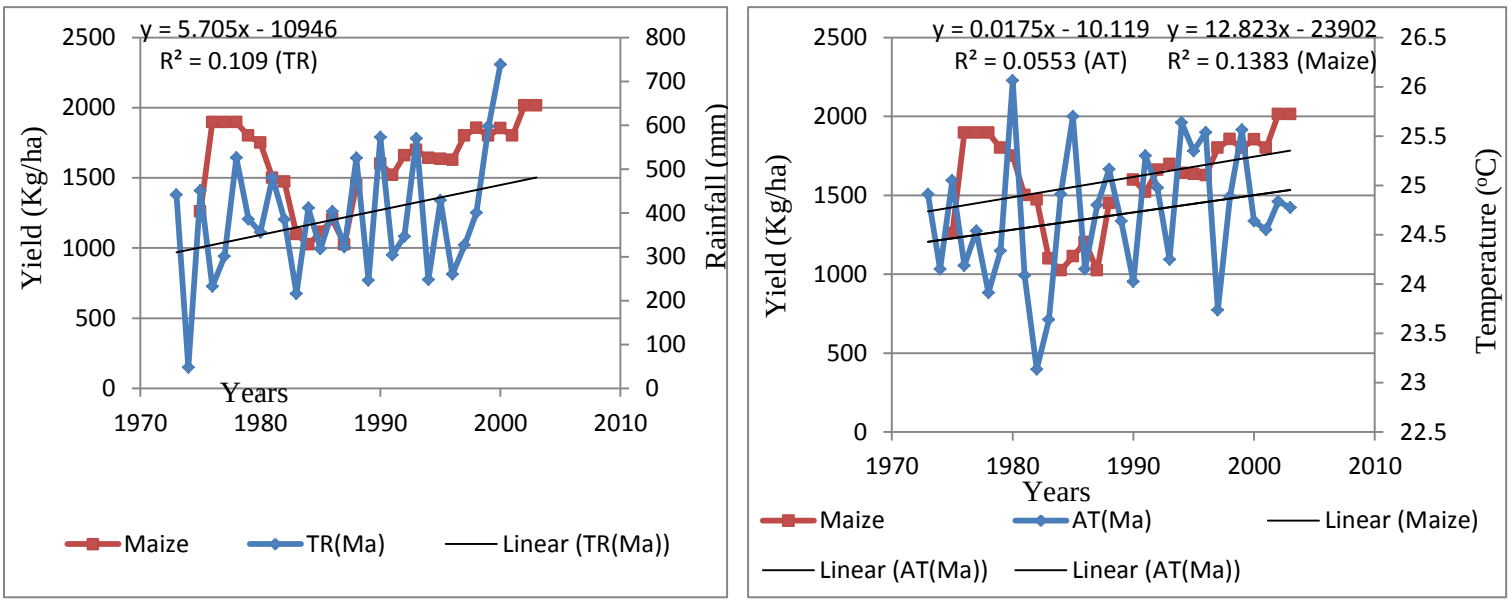


Figure 8: Trend analysis of maize yield with rainfall and temperature in Surkhet

Conclusion

The analysis of meteorological data indicated that the temperature of both districts is on a rising trend. It has been observed that there is no trend in total seasonal rainfall during wheat and barley growing season in Surkhet. Also, the seasonal total rainfall during maize growing period has not shown any trend in Doti. Besides, decreasing trend of annual rainfall has been observed in Doti whereas increasing trend of annual rainfall is observed in Surkhet.

A very good relationship of cereals yield with rainfall and temperature has been observed in 1985 in Doti and Surkhet. The temperature in 1985 in Doti and Surkhet has increased and the rainfall in the same year and same districts has decreased that has negatively affected the yield of all the major cereals except wheat. It is because wheat can grow better even if the temperature rises and in the presence of minimum irrigation. The other cereals require more water due to which the yield has reduced in 1985 in Doti and Surkhet. Therefore, 1985 agriculture drought in Doti and Surkhet has affected the agricultural yield. A very good relationship between rice yield and rainfall is found, whereas maize and wheat showed fluctuating and constant trend with the decrease or increase in rainfall.

Recommendations

On the basis of the findings and study following are the recommendations for the other researchers.

i. Technological innovations will be required to bridge the yield holes. Improved crop varieties, disease resistant varieties, proper use of fertilizers, irrigation and water management should be practiced to overcome the effect of rainfall and temperature on yield of cereals.
ii. Local farmers should be given agricultural skills on pest management and organic farming.
iii. More meteorological stations should be established in a country for the prediction of rainfall and temperature accurately. The information should thus be disseminated to the grass root level to maintain the yield.
iv. Future research should focus on analyzing trend of many meteorological factors besides rainfall and temperature data to capture regional variations of yield for obtaining a more comprehensive image on the yield of major cereals.

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