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EFFECT OF RAINFALL ON THE YIELD OF MAJOR CEREALS IN DARCHULA DISTRICT OF NEPAL

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Abstract

Rainfall is one of the most important factors for the growth of cereals. Inadequate water results poor growth and reduced yield. This study is aimed to explore the relationship between rainfall and yield of major cereals in Darchula district of Nepal. The yield of individual cereals is correlated with the seasonal rainfall data using MS Excel to identify the effect of rainfall on yield of cereals. The amount of rainfall in the years 1974, 1977, 1980, 1985, 1986, 1987, 1991, 1992, 1994, 1996, 1997, 1999 and 2000 was reduced which has greatly affected the yield of rice, wheat and maize in 1986 and 1987. In the years 1976, 1977, 1999 and 2000, the decrease in the amount of rainfall has reduced the yield of all major cereals in Darchula district of Nepal.

Keywords: Rainfall, yield, cereals, Darchula, Nepal

Introduction

Nepal is a small mountainous country situated on the southern slope of the Himalaya. Although it lies near the northern limit of the tropics, the climate varies from tropical in the southern plain area to polar and arctic in the high Himalaya due to intense north/south topographical variations (60 m in the south to 8848 m in the north) within a short horizontal distance of about 200 km. The main source of precipitation in Nepal is the summer monsoon (June to September), which results in response to the large thermal gradient between the warm Asian continent to the north and the cooler Indian Ocean to the south (Slingo *et al.*, 2002), and due to seasonal shifting of thermally induced planetary belts of pressure and winds under continental influences (Pant and Kumar, 1997). About 80% of the annual rainfall occurs during this period (Nayava, 1974; Shrestha, 2000). This monsoon current enters Nepal from the southeast direction. Once it enters Nepal, topography determines the spatial distribution of rainfall. The windward side of the mountain barrier receives a lot of rainfall while the leeward side receives comparatively less rainfall and is almost dry. But there are some high rainfall pockets, which are favored by the topography (windward side) and its orientation (Fig. 2). The rugged mountain topography, the fragile geology of the young Himalayan Mountains, and high intensity of monsoon rainfall makes Nepal prone to natural disasters such as floods, landslides, droughts, and other problems. With global warming and climate change in the limelight for quite some time, Nepal is no exception (Baidya, 2007).

Ecologically, Nepal is divided into three zones: Terai (plain), mid-hills (from 700 to 4000 meters above sea level and higher Himalayas. During the monsoon season, rice is the major cereal mostly grown under rainfed conditions. Wheat, sown after rice, survives on the residual soil water content and on late monsoon rains. In the Terai region, where the rice–wheat cropping system is favorable and contributes to 70% of cereal production in Nepal, there is still potential to expand the rice–wheat cropping system (Timsina and Connor, 2001). Maize is another important crop, but it is mainly cultivated in the hilly regions where it covers nearly 80% of the cultivated area. Although the Terai has a high potential for winter and spring maize, it occupies only 20% of the production area (FAO, 2001; Ojha, 2006a).

Rice (*Oryza sativa L.*), maize (*Zea mays L.*) and wheat (*Triticum aestivum L.*) are the major cereal crops in Nepal accounting for over 96% of all food grain production in the country (MOAC, 2010a). The national average yield is 2.4 t/ha for rice and 1.6 t/ha for wheat, while in farm experiments yields of respectively 3.8 and 2.7 t/ha can be obtained for the rice - wheat cropping system (Timsina and Connor, 2001). The national average maize yield is 2.0 t/ha on farm, 3.5 t/ha for improved maize practices, and 5.0 t/ha in experimental stations (Ojha, 2006b). Barley (*Hordeum vulgare L.*) occupies a very small area and is a cereals with particularly low yields of around one ton per ha. Because of its small area, the variability in production is quite high, as minor absolute changes of a few thousand hectares may result in big changes in crop production. Millet (*Eleusine coracana L.*) is the fifth most important cereals after wheat, maize, rice and barley. It is a relatively minor cereal in terms of area, occupying only 8 percent of total cereal cultivated land area (Bhandari, 2013).

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 Nepal, more than 80% of the total precipitation falls during the monsoon, from June to September (Malla, 2008). The rainfall follows an erratic trend and in general, weather conditions show higher extremes than before. There is frequent occurrence of floods and droughts in different parts of Nepal. There have been frequent incidents of unusual late and pre monsoon precipitation, decreased number of rainy days and intense rainfall events. 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 (Bhandari, 2013). Deficient rainfall in the winter of 2008 resulted in a severe drop in crop production right across the country. Wheat and barley production declined 14 and 17 percent respectively. In some districts of Mid- and Far-Western Nepal which received less than half of average rainfall from November 2008 to February 2009 report that crops yields declined by more than half. Drought results in crop failures and famine, both during the monsoon season and during the rest of the year, when winter crops are sown. In fact, Nepal's Ministry of Agriculture and Cooperatives (MoAC) has identified drought as the greatest risk to agriculture (MOAC, 2006), particularly as year-round irrigation facilities supply only 38% of arable land; the rest is rain-fed.

Floods and droughts in recent years have affected the crop productivity resulting in a high risk of acute food insecurity for local people. It has been reported that approximately 150 000 people are at risk of acute food insecurity in Nepal as of 2007 (UNWFP, 2007). To meet the domestic food requirement of the country and provide food security for people, agriculture production must increase above current levels. Drought has a devastating impact on rural livelihoods that mainly depend upon rainfed subsistence agriculture. It is the major source of uncertainty in food production in Nepal and disturbs social harmony by creating water-use conflicts (Thomas, 2008). Among recent droughts, the winter drought of 2008/2009 affected 40 out of 75 districts and had serious impacts on human health and farmers' assets. The impacts had adverse effects on half of the children, with 39% being underweight and 13% with severe malnutrition, and rural people were forced to sell their assets, migrate for outside work and even skip meals as adaptation strategies (Government of Nepal, 2009). The majority of hill farmers is poor and cannot cope with crop losses and livestock failure due to a weak asset base and lack of access to services and facilities. Therefore, it is imperative to be prepared to offset the effect of drought by building farmers' adaptive capacity (Ghimire *et al.*, 2010).

This study analyzes the yield of major cereals as paddy/rice (*Oryza sativa L.*), wheat (*Triticum aestivum L.*), maize (*Zea mays L.*), millet (*Eleusine coracana Gaertn*.) and barley (*Hordeum vulgare L.*) with rainfall in Dailekh district of Nepal.

Materials and Methods

Study area

Darchula District (as shown in figure 1), a part of Mahakali Zone, is one of the seventy-five districts of Nepal, a landlocked country of South Asia. Darchula is one of the least developed districts of the country. The district, with Darchula as its district headquarters, covers an area of 2,322 km² and has a population (2011 AD) of 133,464.

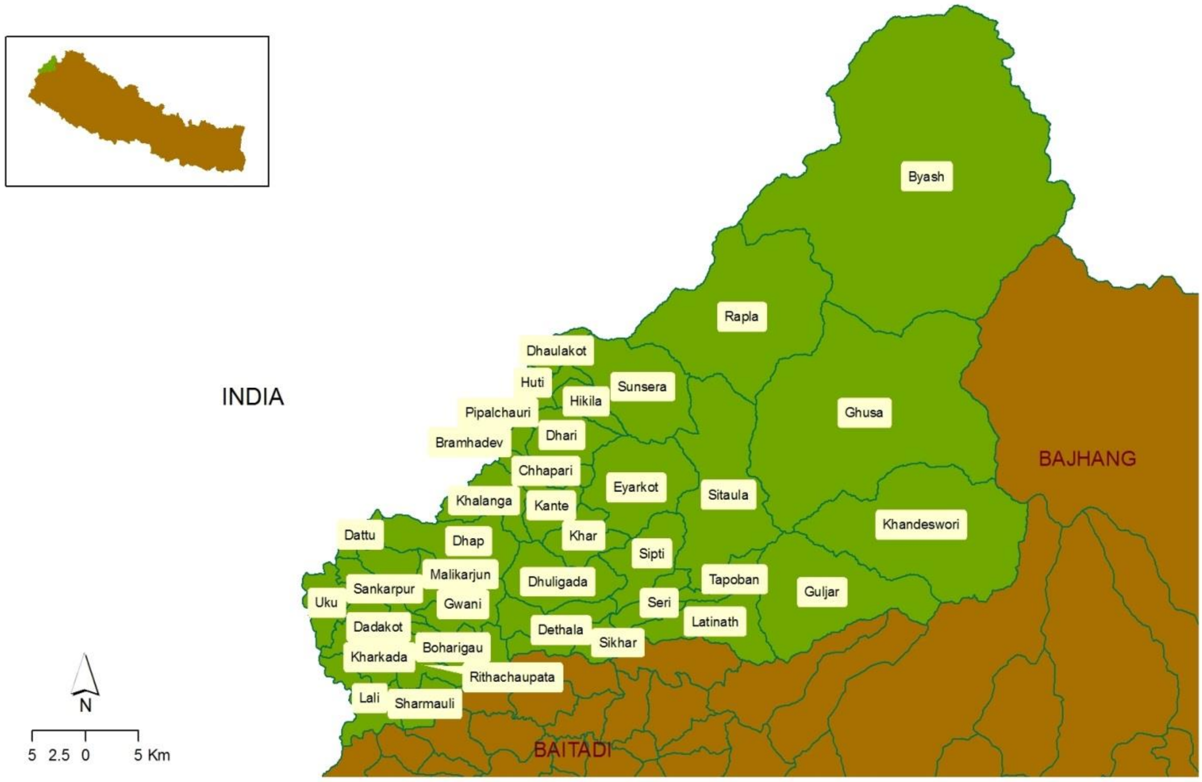

Figure 1: Map of Nepal and location of Darchula district and its VDCs

Climatology

The climate of Darchula is categorized by high rainfall and humidity. The climatic condition differs along with the elevation gradient as shown in figure 2. Climate of the Darchula District varies broadly from subtropical to alpine. In the north, most of the parts remain under snow having alpine climate. In the southern part and valleys the climate is -

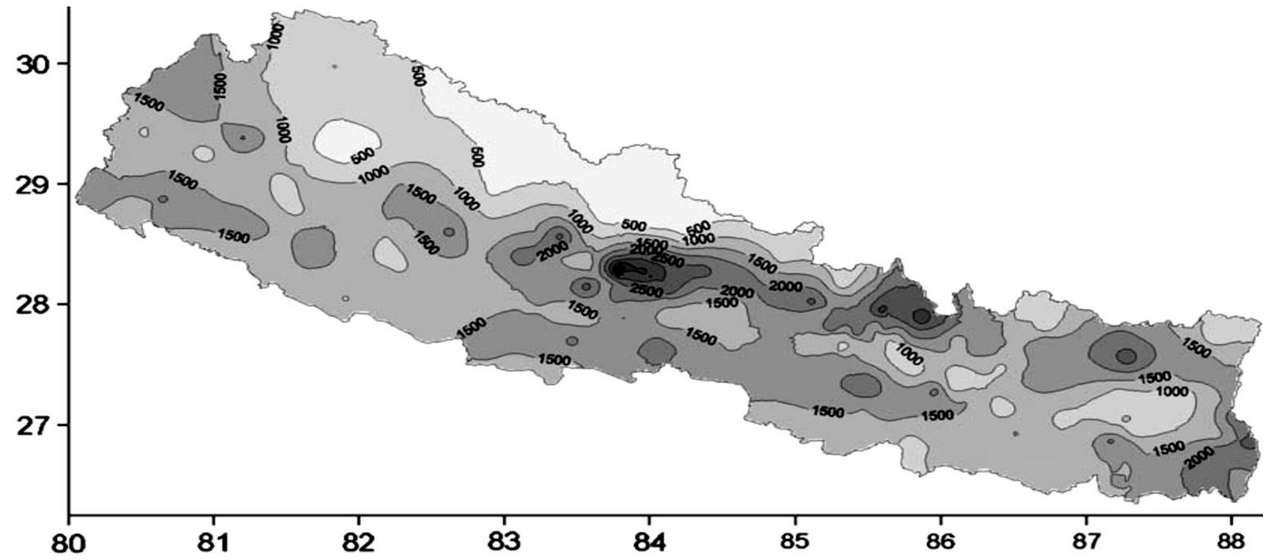

Figure 2: Spatial distribution of monsoon rainfall

subtropical. Mid- hills has temperate type. Within its elevation range of 1800 m to 6500 m, there are limited subtropical valleys in the southern margin although most of the area is ecologically temperate or highland. A cold, generally dry climate exists in the high alpine valleys just north of the southern arm of the Himalaya that cuts across the bottom of

Darchula. The average maximum temperature is 18.6°C and the minimum temperature is 7.7°C and average rainfall is 2129 mm. Most rainfall falls between May and September. All areas experience very high rainfall intensities, ranging between estimates of 125–350 mm for a 24 hour period.

Data collection and analysis

The secondary data of rainfall and yield of major cereals were collected from Department of Hydrology and Meteorology (DHM) and Ministry of Agriculture, Nepal (MOA) respectively for the period of 1974 to 2000 and analyzed to find out the relationship between yield and rainfall. The temperature data was not regular for many years, so was excluded in this study. The research papers and books relevant to the same analysis were collected from Google for literature. MS Excel and SPSS Version 19 was used for data analysis.

Results and Discussion

Agricultural yield (Kg/ha)

The average yield of paddy, maize, millet, wheat and barley is 1738, 1559, 984, 958 and 805 respectively. The yield of paddy has decreased and is below average in the years 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988, 1992, 1994 and 1998 as shown in Figure 3. The yield of maize has decreased and is below average in the years 1977, 1980, 1982, 1984, 1985, 1987, 1988, 1990, 1997, 1999, 2000, 2001, 2002 and 2003 as shown in Figure 5. The yield of millet has decreased and is below average in the years 1980, 1981, 1982, 1983, 1984, 1985, 1987, 1988, 1995, 1997, 1999, 2000, 2001, 2002 and 2003 as shown in Figure 3. The yield of wheat has decreased and is below average in the years 1976, 1977, 1978, 1979, 1980, 1981, 1984, 1985, 1986, 1987, 1988 and 1996 as shown in Figure 4. The yield of barley has decreased and is below average in the years 1976, 1977, 1978, 1979, 1981, 1982, 1983, 1984, 1985, 1986, 1996 and 1997 as shown in Figure 4. The yield of maize and millet has reduced greatly in the years 1999-2003. The yield of wheat and barley has reduced greatly in the years 1976-1979. Similarly, in the years 1984-1988 majority of the cereals had been reduced except barley in the years 1987 and 1988 and millet in the year 1986.

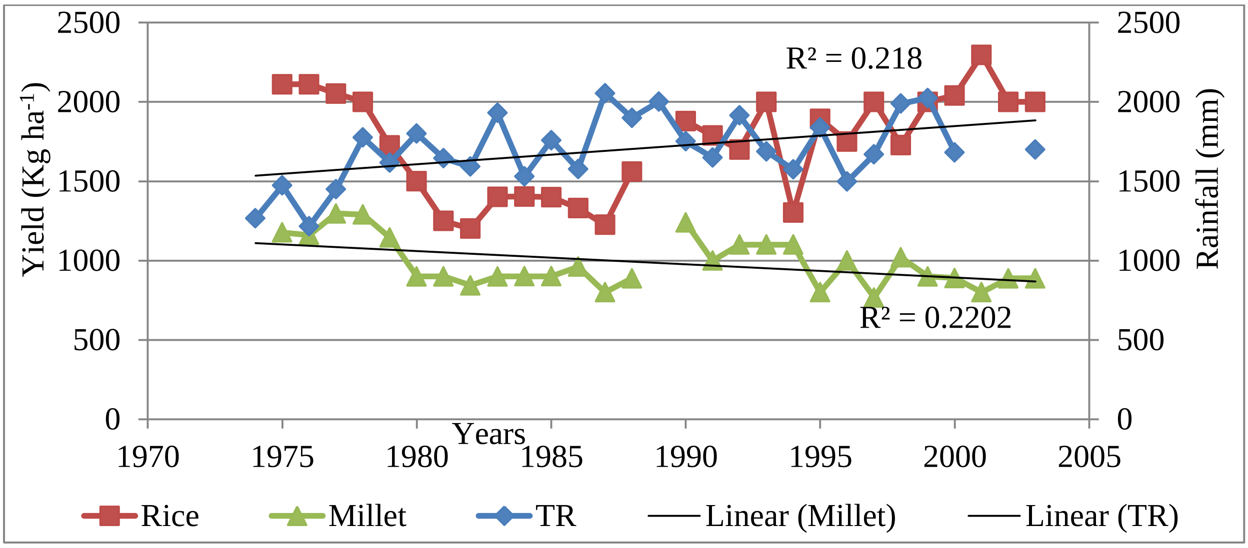

Figure 3: Variation of rice/paddy and millet yield with rainfall

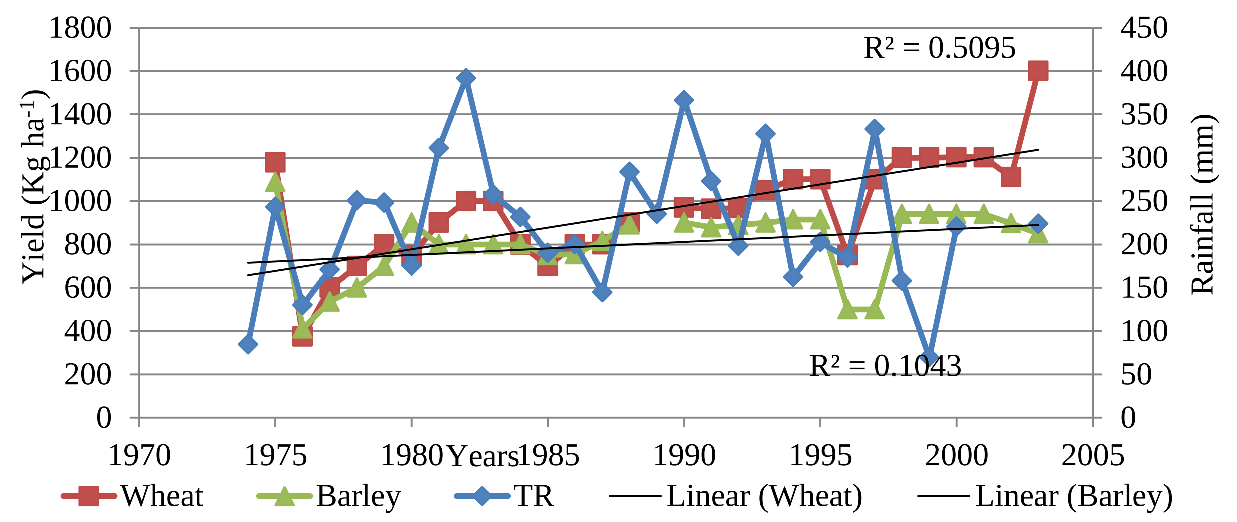

Figure 4: Variation of wheat and barley yield with rainfall

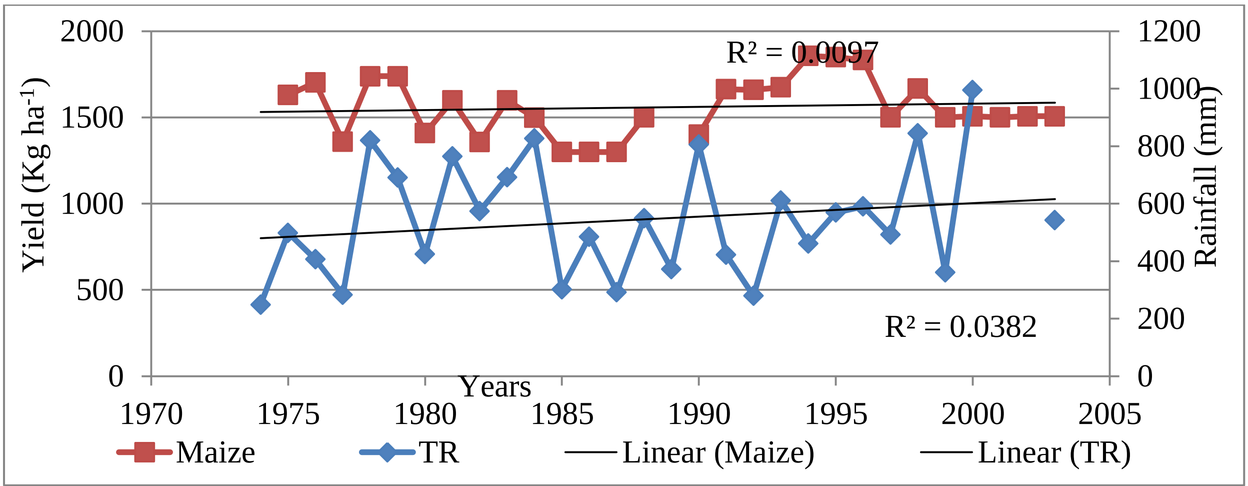

Figure 5: Variation of maize yield with rainfall

Climatology

The average rainfall during rice and millet growing season from 1974-2000 is 1699 mm. The rainfall is below average in the years 1974, 1975, 1976, 1977, 1979, 1981, 1982, 1984, 1986, 1991, 1993, 1994, 1996, 1997, 2000 and has significantly reduced the yield as shown in Table 1. The average rainfall during wheat and barley growing season from 1974-2000 is 224 mm. The rainfall is below average in the years 1974, 1977, 1980, 1985, 1986, 1987, 1992, 1995, 1996, 1999, 2000 and has significantly reduced the yield as shown in Table 2. Similarly the average rainfall during maize growing season from 1974-2000 is 543 mm. The rainfall is below average in the years 1974, 1975, 1976, 1977, 1980, 1985, 1986, 1987, 1989, 1991, 1992, 1994, 1997 and 1999. The rainfall had been greatly reduced in the years 1974, 1975, 1976, 1977, 1980, 1985, 1986, 1987, 1991, 1992, 1994, 1996, 1997, 1999, 2000 and has significantly reduced the yield of rice, millet, wheat and barley. In case of maize, the rainfall has not greatly affected the yield for the period 1974-2000 as shown in Table 3. There may be other factors besides rainfall for the decrease in the yield.

Socioeconomic factor

The major socioeconomic indicator of Darchula district is very poor. About 89.90% of the total population depends upon agriculture. Substance agriculture, lack of basic infrastructure, difficult geophysical condition, traditional agricultural practice, low literacy rate and population growth are the root causes for deep rooted poverty.

Trade is one of the most important livelihood means. Every year, people from hills come with ghee and herbs. The agriculture related commodities were sold in local bazaar (market). People of Byans and Rapla go to Tibet to fulfill their needs of clothes and other commodities. Local carpets and wool products and handmade clothes bring huge amount of money to the VDCs.

Table 1: Correlations between Total rainfall (TR), Rice and Millet

		TR	Rice	Millet
TR	Pearson Correlation	1	-.219	-.394
	Sig. (2-tailed)		.292	.052
	N	27	25	25
Rice	Pearson Correlation	-.219	1	.472*
	Sig. (2-tailed)	.292		.017
	N	25	25	25
Millet	Pearson Correlation	-.394	.472*	1
	Sig. (2-tailed)	.052	.017	
	N	25	25	25

*. Correlation is significant at the 0.05 level (2-tailed).

Table 2: Correlations between Total rainfall (TR), Wheat and Barley

		TR	Wheat	Barley
TR	Pearson Correlation	1	.194	.050
	Sig. (2-tailed)		.352	.812
	N	27	25	25
Wheat	Pearson Correlation	.194	1	.717**
	Sig. (2-tailed)	.352		.000
	N	25	25	25
Barley	Pearson Correlation	.050	.717**	1
	Sig. (2-tailed)	.812	.000	
	N	25	25	25

**. Correlation is significant at the 0.01 level (2-tailed).

Table 3: Correlations Total rainfall (TR) and Maize

		TR	Maize
TR	Pearson Correlation	1	.237
	Sig. (2-tailed)		.254
	N	27	25
Maize	Pearson Correlation	.237	1
	Sig. (2-tailed)	.254	
	N	25	25

Conclusion

The yield of millet has been reduced in the years 1999 and 2000 due to the reduced rainfall in the same years. The yield of wheat and barley has been reduced in the years 1976 and 1977 due to the reduced rainfall in the same years. Similarly, in the years 1986 and 1987 the yield of rice and wheat has been reduced due to the reduction of rainfall. The yield of maize has not been greatly affected by the rainfall. There may be some other parameters which had reduced the yield.

Besides rainfall, the geographical location of the district has resulted the minimal infrastructure available for the agricultural development. Due to this majority of the people has left the farming and moved away for other opportunities. This has also resulted the decrease in the yield of major cereals in Darchula.

Recommendations

The future research should focus the other meteorological and socioeconomic parameters besides rainfall to analyze the yield of cereals in Darchula.

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