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Analysis of Agricultural Drought and its Effects on Productivity at Different District of Nepal

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ABSTRACT

This paper examines the variation of productivity brought by the change in rainfall and temperature and the possible cause and effect of 1992 agricultural drought in Nepal. Agriculture seems to be very sensitive to short term changes in weather and that leads effects to the production of different crops. Productivity of different crops was analyzed in 1992 at regional level and different ecological zones. In 1992, insuficient rainfall (monsoon) might have caused the drought and reduces ground water recharge. This imposed effect to the change in normal rainfall pattern and duration of monsoon season. The year 1992 was seems to be dry, which has decreased the yield of major cereals crops in 3 districts of Western Development Region, 5 districts of Mid Western Development Region and 4 districts of Far Western Development Region. A total of 12 districts were signiicantly affected by drought in 1992 based on the meteorological data and productivity of crops.

Keywords: 1992 drought, agricultural impact, yield, climate change, monsoon

INTRODUCTION

Drought is a normal and recurrent feature of climate change. The prime cause of drought is the occurrence of precipitation below normal. There are various reasons for precipitation to be reduced due to over-seeding of clouds by dust particles from the Earth's surface, and an increase in albedo, a decrease in the availability of biogenic nuclei for rain drop formation caused by reduced plant cover and similar factors (Beran & Rodier, 1985). Drought is ranked irst among all natural hazards when measured in terms of the number of people affected (Obasi, 1994; Hewitt, 1997; Wilhite, 2000b). It is a complex phenomenon, but least understood of all natural hazards, affecting more people than any other hazard (Hagman, 1984). This is occurred in all regions of the world and its consequences are higher in terms of human life and livelihood relating to economic, social, and environmental impacts (Wilhite, 2000). There are few research studies available on climatologically analysis of the past drought events (e.g. Bhandari & Kayastha, 2010; Singh & Mishra, 2010; Panu & Sharma, 2002; Sharma, 1979).

The drought is also caused by the oceanic circulations, which have average patterns of current and heat storage that affect the weather and climate. For example, on the West Coast of South America, there is a Northward cold current along the shore and a warm current going South towards the Peruvian coast. The two currents are generally delected Westward around the Equator, but at uneven intervals over many years they happen to delect Southward and inshore. Such a delection was observed in 1952, which brought unusual rain to the Peruvian coast and caused widespread drought in Brazil. Important climatic variations are known to occur when a warm pool, which is normally present in the Western Paciic Ocean, moves eastward towards the coast of Peru. This sea surface temperature anomaly has been referred to in the literature as El Nino. An El Nino event in the tropical Paciic Ocean is followed by below-normal rainfall and stream low in the Western United States (Kahya & Dracup, 1993). These anomalies emerge mainly due to changes in large-scale atmospheric circulation patterns.

An agricultural drought is considered to have set in, when the soil moisture availability to plants has dropped to such a level that it adversely affects the crop yield and hence agricultural production. In brief, the deinitions of agricultural drought loat around the soil moisture deiciency in relation to meteorological droughts and climatic factors and their impacts on agricultural production. Agricultural drought links characteristics of hydrological drought to agricultural impacts, focusing on precipitation shortages, differences between actual and potential evapotranspiration, soil water deicits, and reduced ground water or reservoir levels. A good deinition of agricultural drought accounts for the variable susceptibility of crops during different stages of crop development, from emergence to maturity. Several drought indices, based on a combination of precipitation, temperature and soil moisture, have been derived to study agricultural droughts (Mishra & Singh, 2010). Such droughts could be best studied through a complex regional analysis involving a battery of variables (soil moisture, crop yield, leaf area index, vegetative growth etc.) rather than a simple point analysis. This study is signiicant to assess the cause and effects of climatic parameters and agricultural productivity and identify the anticipatory adaptation measures.

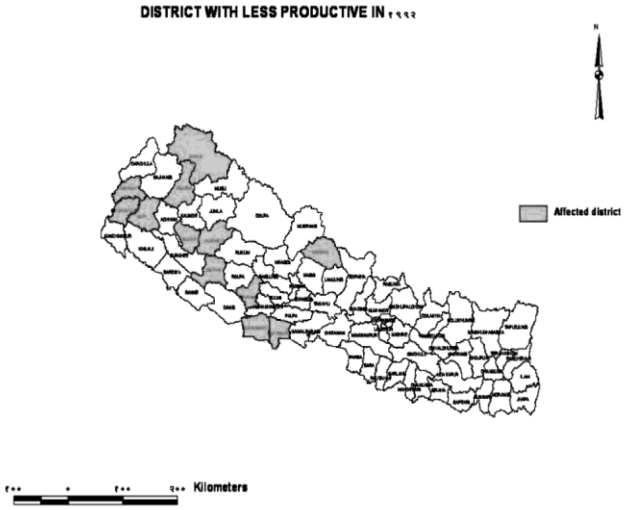
MATERIALS AND METHODS

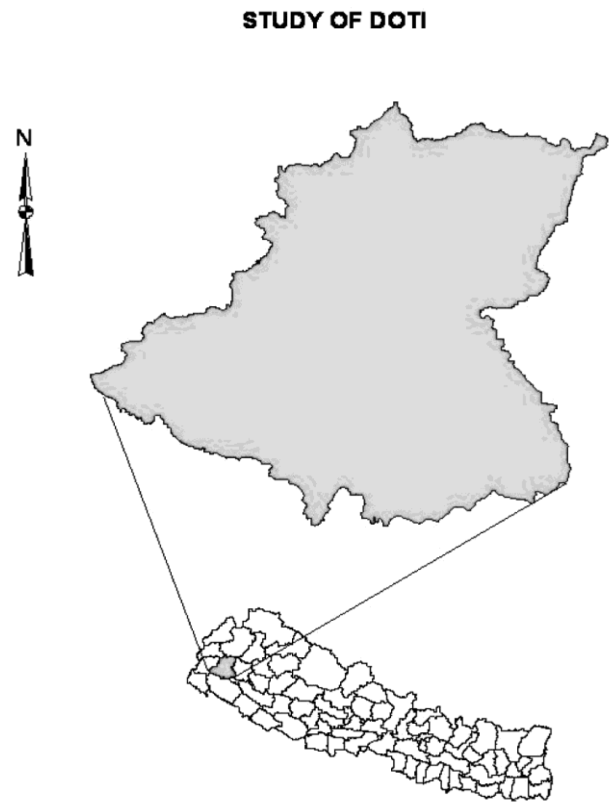
This study is focused mainly on agricultural drought that could be deined as a situation where the soil moisture of a region is consistently below the climatically appropriate moisture supply required for crop production (Palmer, 1965; Quiring & Papakryiakou, 2003) for one or more months. The main objective of this study is to study the causes of 1992 agricultural drought and quantify the total number of affected districts in Nepal. For this, the secondary data of yield of Paddy/rice (Oryza sativa L.), Barley (Hordeum vulgare L.), Maize (Zea mays L.), Finger millet (Eleusine coracana Gaertn.) and Wheat (Triticum aestivum L.) was obtained from Ministry of Agriculture and Cooperatives (MoAC), Government of Nepal and calculated the average value in 5 developmental regions viz. Eastern Developmental Region (EDR), Western Developmental Region (WDR), Central Developmental Region (CDR), Mid-Western Developmental Region (MWDR) and Far-Western Developmental Region (FWDR) and 3 ecological regions viz. Mountain (M), Hill (H) and Terai (T) respectively using SPSS and MS Excel. The regions of yield above average are excluded whereas the region of yield below average are explored to quantify the total number of districts affected by 1992 agricultural drought in Nepal, and a case of Doti was studied based on meteorological data of (1980-2003) and literature review.

RESULTS AND DISCUSSION

Yield analysis of cereals production in 1992

The average yield of 5 major cereals from 1950-2006 is 1830 $Kgha^{-1}$. In 1992 the yield is 1702 $Kgha^{-1}$. EDR and CDR have yield above average i.e. 1842 $Kgha^{-1}$ and 1865 $Kgha^{-1}$ whereas WDR, MWDR and FWDR have yield below average i.e. 1541 $Kgha^{-1}$, 1498 $Kgha^{-1}$ and 1560 $Kgha^{-1}$ respectively. Western Hill (WH) has yield above average i.e. 1549 $Kgha^{-1}$ whereas Western Mountain (WM) and Western Terai (WT) have yield above average i.e. 1184 $Kgha^{-1}$ and 1530 $Kgha^{-1}$ respectively.





Manang District of WM has yield below average 1108 $Kgha^{-1}$ whereas Mustang has yield above average 1214 $Kgha^{-1}$. Rupandehi and Kapilbastu districts of WT have yield below average i.e. 1469 $Kgha^{-1}$ and 1347 $Kgha^{-1}$ whereas Nawalparasi has yield above average i.e.

1890 Kgha^{-1}. Mid Western Mountain (MWM) and Mid Western Hill (MWH) of Mid Western Region have yield below average i.e. 1252 Kgha^{-1} and 1394 Kgha^{-1} whereas Mid Western Terai (MWT) has yield above average i.e. 1681 Kgha^{-1}. Dolpa, Mugu, Jumla and Kalikot districts of Mid Western Mountain have yield above average i.e. 1279 Kgha^{-1}, 1264 Kgha^{-1}, 1271 Kgha^{-1} and 1252 Kgha^{-1} whereas Humla has yield below average i.e. 1156 Kgha^{-1}. Pyuthan, Salyan, Dailekh and Jajarkot districts of Mid Western Hill have yield below average whereas Rolpa, Surkhet and Rukum have yield above average i.e. 1460 Kgha^{-1}, 1422 Kgha^{-1} and 1571 Kgha^{-1}.

Far Western Mountain (FWM) and Far Western Hill (FWH) of Far Western Region have yield below average i.e. 1243 Kgha^{-1} and 1330 Kgha^{-1} whereas Far Western Terai has yield above average i.e. 1796 Kgha^{-1}. Bajura of Far Western Mountain has yield below average i.e. 1105 Kgha^{-1} whereas Bajhang and Darchula have yield above average i.e. 1296 Kgha^{-1} and 1287 Kgha^{-1}. Doti, Baitadi and Dadeldhura districts of Far Western Hill have yield below average i.e. 1267 Kgha^{-1}, 1330 Kgha^{-1} and 1276 Kgha^{-1} whereas Achham has yield above average i.e. 1453 Kgha^{-1}. The total of 12 districts as shown above has the yield below an average.

Climatic variability and productivity in Doti district of Nepal

Doti district is one of the less yields district in 1992, which lies in the Far Western Development Region. This is one of the 12 districts might be affected by agricultural drought. Doti have extreme and diverse climatic conditions, and the district is prone to natural disaster such as loods and landslides. The district experience low agricultural productivity and sometimes serious damages due to these disasters.

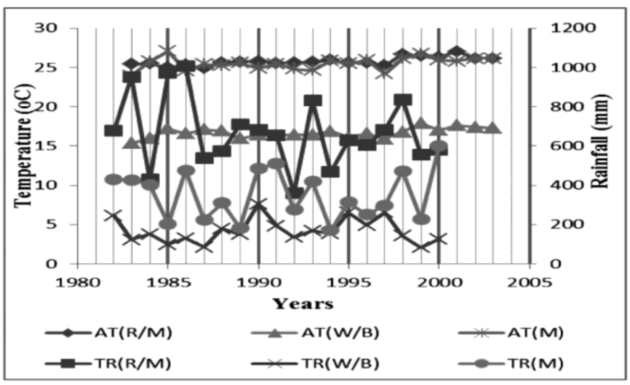


Fig. 1. Seasonal trend of rainfall and Temperature in Doti (1982-003)

AT=Mean temperature, R/M=(Rice/Millet); W/B=(Wheat/Barley); M=(Maize) TR=Total Rainfall

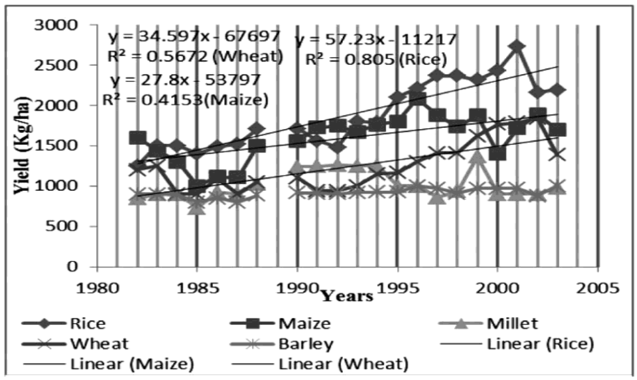


Fig. 2. Yield of cereals of Doti (1982-2003)

Fig. 1 and 2 show some of the graphic representation of climatic variability and productivity in Doti district. The type of cereals crops (rice, wheat, maize, millet and barley), and average temperature and total rainfall of growing season were analyzed below. The yield of rice, wheat and maize has been reduced in 1992 due to the reduction of precipitation in same year. The precipitation in 1992 for the yield of barley and millet did not show any effect. In 1992 drought, the variability in rainfall and temperature possesses signiicant impacts on productivity of these cereals in mountain hills and terrain region.

Monsoon and Years of Deicit Rainfall in Nepal

Rainfall variability in Nepal still remains a subject of unexplored mystery to a huge extent. A few studies have been carried out so far in case of the Monsoon rainfall in this Himalayan belt though considerable studies have been done in Indian summer monsoon. The rainfall analysis of the Indian Summer Monsoon fails to address some of the variability of monsoon especially, the spatial among the different landscapes. On the whole, as the monsoon starts from the Eastern side, and hence the eastern side receives the maximum amount of precipitation and the Western sides receive the least. However, the long term analysis of the data shows no trend of precipitation in Nepal. Their modeling results shows that the moist air from Arabian Sea causes more precipitation over Western Nepal whereas the cold dry air blowing from the Tibetan highlands decreases the precipitation over Eastern Nepal. The onset of monsoon in Nepal has been linked with the depression of monsoon in the Bay of Bengal (Barros *et al.* 2000). Efforts have been made to correlate the pattern of rainfall in Nepal with the landscape type. Nepal, with the steeply varying topographic barriers, observes varying amount of rainfall even within a short distance. Hence the sampling of the rainfall data should take into account the position and the minimum number of stations required for the place.

From the above study, in 1992, because of inadequate and untimely rainfall, drought was occurred, and most of the khet lands might have changed to fallow and decreased the productivity. Summer and winter crops were decreased in the drought affected areas. Many crops in the hills are grown under rainfed condition. So yields are extremely dependent upon timely and adequate rainfall. Quite frequently farmers in the hills have suffered from seasonal or occasional droughts. Shrestha et. al. (2000) studied the relationship between Nepalese Monsoon and ENSO. He claims an excellent agreement between the two phenomena. The drought of 1992 in Nepal has been correlated with the El Nino of 1992-1993 and the eruption of Mount Pinatubo in 1992 which cooled the Tibetan plateau signiicantly decreasing the monsoon rainfall in Nepal. The year 1992 is the driest period of Nepal and has the decreasing trend since 1990. Roughly 2-5 year oscillatory characteristics have been observed in many of the regions of Nepal (Shrestha *et al.* 1999).

Probability of future events

The probability of future occurrences of drought in Nepal is hard to predict however, there are two factors that may inluence future drought conditions: ENSO and climate change. The effect of climate change and drought on agriculture and food security will have serious implications for sustainable development in a country. Nepal's agriculture will face many challenges over the coming decades as the soils are degrading and water resources will place huge strains on achieving food security for increasing populations. These conditions may be worsened by climate change. Warming of more than 2.5^0C could reduce global food supplies and contribute to higher food prices. In Nepal most of the irrigated terraces are turned into rainfed bari land and due to this the production is decreasing.

The year and the amount of deicit rainfall as percentage of the average annual rainfall in the Marsyangdi sub catchment have been indicated in the brackets respectively, 1991 (14%) 1992 (26%), 2005 (17%) and 2006 (13%). As per the Oceanic Niño Index (ONI) value of NOAA, El Nino indices for the years are as indicated within the brackets respectively, 1991 & 1992 (2.8), 2005 (0.9) and 2006 (1.2). The guideline claims that the index values more than 0.5 are signiicant and is affecting the Indian Summer Monsoon distribution in Nepal (Neupane, 2008). Ramanathan et. al. (1999) discusses that this increment in the rising motions South of equator and the subsidence in the Northern parts may eventually shift the monsoon circulation towards the South. Consequently, Nepal would observe decrement in the amount of monsoon rainfall than the usual. Nepal is looded with rain in these monsoon months and faces the scarcity or drought in the rest 8 months of a year (Ichiyanagi *et al.* 2007).

CONCLUSION

Even though Nepal is not generally characterized as a drought prone country of Asia, drought still occurs and is one of the most important climatic extremes in terms of economic damage. Variation of temperature and erratic rainfall directly affect the agriculture and crops. In 1992, Nepal has experienced decrease in agricultural yield in WDR, MWDR and FWDR. The Agricultural drought affected districts were Rupandehi, Kapilbastu, Manang, Humla, Pyuthan, Salyan, Dailekh, Jajarkot, Bajura, Doti, Baitadi and Dadeldhura. The production was varied due to rainfall brought by monsoon. The main reason for the agricultural drought was observed due to the cause of untimed rainfall, which decreases soil moisture and consequent crop failure in 1992. The drought was hard to predict in Nepal, however, Indian monsoon and ENSO that inluenced drought in Nepal.

Government and other related agencies has to paid more attention on soil and water management through better practices such as tillage and weed control, proper fertilizer use, eficient use of ground water irrigation, moisture conservation and rain water harvesting and reuse. A better understanding of these factors in a dry year will help to stabilize and increase agricultural production in dry farming area (Katuwal & Gurung, 1998). If we look at regional as well as national efforts it shows that research on the alleviation of the effect of drought in the ield crops is limited. More attention has to be given by the agricultural researchers to the drought prone areas of Nepal. As noted because of uncertain and erratic rain and reduced irrigation facilities farmers were unable to sow their crops at the usual time. Although there were an appreciable number of rainy days, these were drizzling rain for short periods (1 to 5 min) and were insuficient for land preparation, sowing and the other intercultural operations. Farmers believe such rains make plants more sensitive to wilting in the ields which if true would exacerbate the drought condition. The range of biophysical characteristics associated with the dry land farming areas and limitations on crop production should further be documented. Similarly traditional methods and practices being followed by the farmers in the drought situations should also studied further. The main solution to drought in Nepal can be suggested by adopting the following measures

- Afforestation of the plain as a wind break and of the hilly areas as water retaining forests.
- Shifting the population in the plains.
- Intensive agriculture farming in the plains.
- Development of groundwater irrigation schemes to be used alongside surface water irrigation.
- Better forest management.

- Power (wind, solar and hydro-development).
- Continued research on soil moisture and crop science.

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REFERENCES

Barros, A.P., Joshi, M., Putkonen, J., Burbank, D.W. 2000. A study of the 1999 monsoon rainfall in a mountainous region in central Nepal using TRMM products and rain gauge observations, *Geophysical Research Letters,*: pp 3683–3686.

Beran, M.A. and Rodier, J.A. 1985. *Hydrological aspects of drought.* UNBSCO-WMO, Studies and Reports in Hvdrology no. 39, UNESCO, Paris, France.

Bhandari, G. and Kayastha, R.B. 2010. Study of agricultural drought and its impact on rice yield in Rupandehi district, west Nepal. *Ontario International Development Agency*. ISSN 1923-6654, Canada, 69-82 p.

Hagman, G. 1984. *Prevention is better than cure.* Report on Human and Natural Disasters in the Third World, Swedish Red Cross, Stockholm.

Hewitt, K. 1997. *Regions at Risk: A Geographical Introduction to Disasters.* Addison-Wesley Longman, UK.

Ichiyanagi, K., Manabu, D.Y., Yoshitaka, M., Bijaya K.V. 2007. Precipitation in Nepal between 1987 and 1996, *Int. J. Climatol.* 27: 1753–1762, Wiley Inter Science, DOI: 10.1002/joc.1492.

Kahya, E. and Dracup, J. A. 1993. US stream low pattern in relation to the El-Nino southern oscillation. *Wat. Resour. Res.* **29(8),** 2491-2503.

Katuwal, R.B. and Gurung, B.D. 1998. How farmer manage crops under drought condition: Observations on the impact of the 1994 drought on ield crops. *ARS occasional paper*: **31**, Agricultural Research Station, Pakhribas, Dhankuta, Nepal.

Mishra, A.K. and Singh, V.P. 2010. A review of drought concepts. *Journal of Hydrology:* **391** 202–216.

Neupane, N. 2008. To Study the Various Factors Affecting the Summer Monsoon Rainfall in Nepal (EID: nn3533). Department of Atmospheric Science. Jackson School of Geosciences. The University of Texas at Austin.

Obasi, G.O.P. 1994. WMO's role in the international decade for natural disaster reduction. Bull. *Am. Meteorol. Soc.* **75** (9), 1655–1661.

Palmer, W.C. (1965). *Meteorological Drought.* Ofice of Climatology Research Paper 45. U.S. Weather Bureau, Washington, 58 p.

Panu, U.S and Sharma, T.C. 2002. Challenges in drought research: some perspectives and future directions. *Hydrotogical Sciences-Journal-des Sciences Hydrologiques,* **47**(S) August 2002, 19-30.

Quiring, S.M., Papakryiakou, T.N. 2003. An evaluation of agricultural drought indices for the Canadian prairies. *Agriculture and Forest Meteorology* **118**, 49–62.

Ramanathan, V., Chung, C., Kim, D., Bettge, T., Buja, L., Kiehl, J. T., Washington, W. M., Fu, Q., Sikka, D.R., Wild, M. 1999. *Atmospheric brown clouds: Impacts on South Asian climate and hydrological cycle*, vol. 102. **15**, 5326–5333.

Sharma, C.K. 1979. Partial drought conditions in Nepal. *Hydrological Sciences Bulletin des Sciences Hydrologiques.* 24, 3, 9/1979. Blackwell Scientiic Publications. 327-333.

Shrestha, A.B., Wake, C.P., Dibb, J.E., Mayewski, P.A. 2000. Precipitation luctuations in the Nepal Himalaya and its vicinity and relationship with some large scale climatological parameters. *International Journal of Climatology* **20**: 317–327.

Shrestha, A.B., Wake, C.P., Mayewski, P.A., Dibb, J.E. 1999. Maximum temperature trends in the Himalaya and its vicinity: an analysis based on temperature records from Nepal for the period 1971–94, *Journal of Climatology*

Wilhite, D.A. 2000. Drought as a Natural Hazard: Concepts and Deinitions (Chapter 1, 3-18p.). In: *Drought: A Global Assessment* Wilhite, D.A. (ed.) (Volume 1), Routledge Publishers, London, U.K.

Wilhite, D.A. 2000b. Drought as a natural hazard: concepts and deinitions. In: *Drought: A Global Assessment* Wilhite, D.A. (Ed.), vol. 1. Routledge, New York, 1–18p.