Characterization of hydro-meteorological drought in Nepal Himalaya: A case of Karnali River Basin

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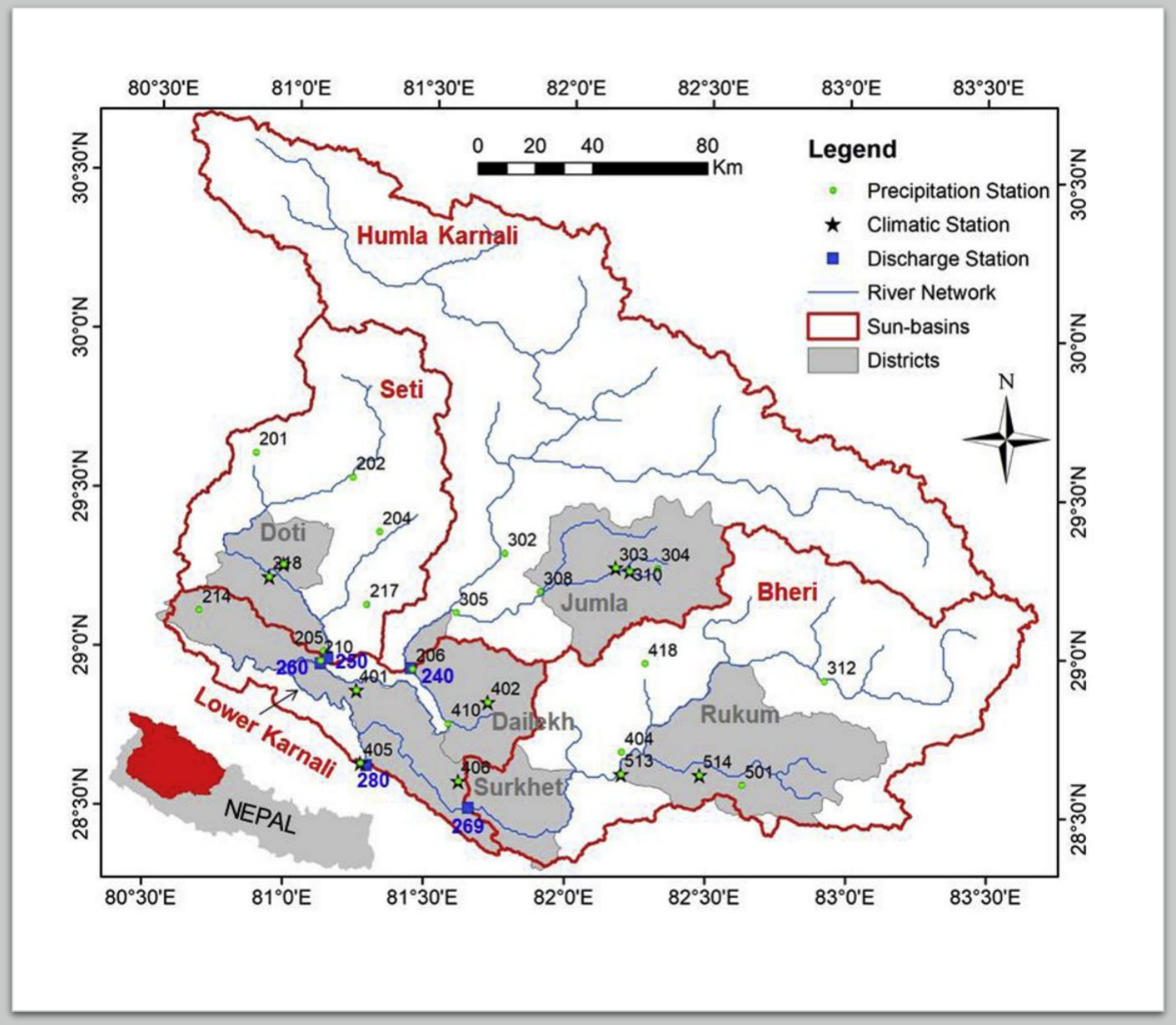
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12-14 December, 2022
International Conference on
Sudurpaschim Studies

- Karnali River Basin
  - Area of more than 46,100 km^2
  - The elevation in the basin varies from 100 to 7 721 m above sea level (masl)
  - Major three sub-basins



Location of Karnali River Basin in Nepal and hydro-meteorological stations used in this study.



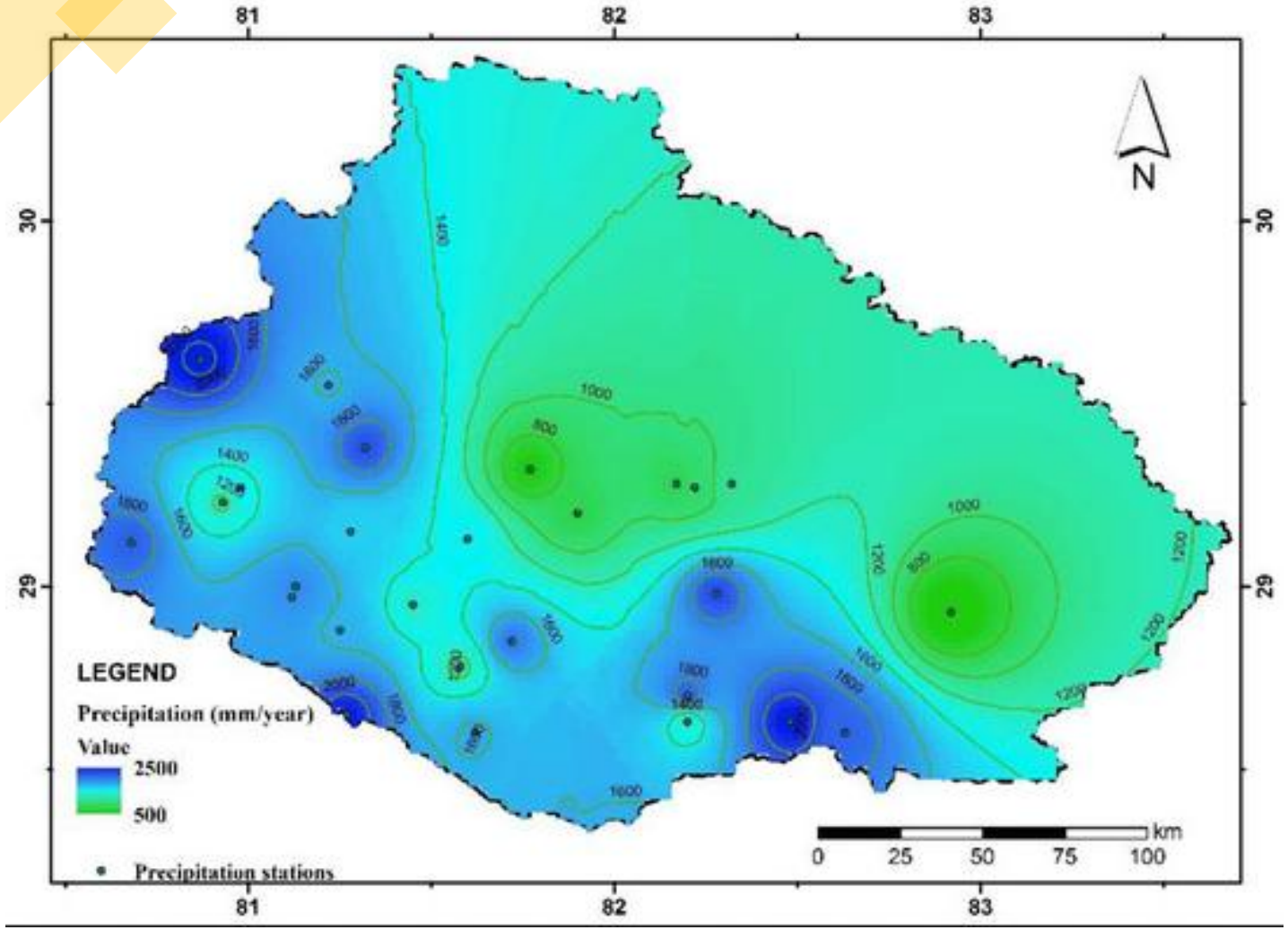
Humla, near to Simkot



Jumla, near to Chandannath municipality



Rukum, near to Taksera



(Khatiwada et al., 2016)

- The average annual precipitation in the basin is 1479 mm and
  - ❑77% of this rainfall occurs during the summer monsoon season (June to September),
  - ❑whereas only 7% occurs in winter (December to February).
  - ❑Pre-monsoon (March to May) precipitation accounts for 12% of the annual
  - ❑while post-monsoon (October to November) is only 4%

- The summer monsoon, which originates from the Indian Ocean, is the main cause of monsoon precipitation, while westerly influence mostly the winter.

The Himalayan

Nepal

Prolonged drought hits districts in Karnali, Seti

By Himalayan News Service
Published: 03:41 am Feb 17, 2018



File - Locals waiting for their turn to fill empty containers with water in Himali Rural Municipality, Bajura, on Friday, February 16, 2018. Photo: THT

Prolonged drought hits districts in Karnali, Seti

Bajura, February 16

Prolonged drought has adversely hit locals of five districts in Karnali and one district in Seti.

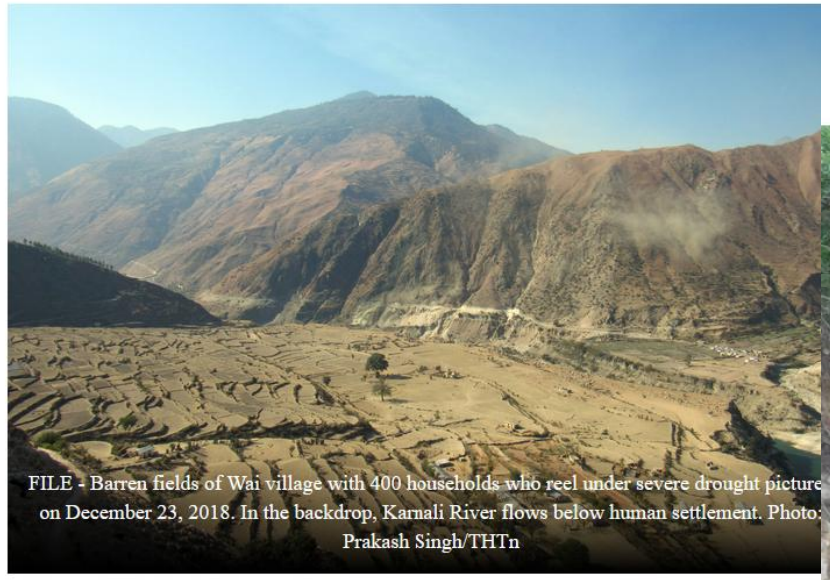
The three-year drought has badly affected eastern parts of Bajura, Humla, Mugu, Jumla, Dolpa and Kalikot districts. It is the longest drought in the last 41 years. Due to drought, farmers in the region have not cultivated anything for the last three years.

The Himalayan

Nepal

Climate change affecting food production in Karnali

By Rastriya Samachar Samiti
Published: 11:15 am Apr 28, 2019



FILE - Barren fields of Wai village with 400 households who reel under severe drought picture on December 23, 2018. In the backdrop, Karnali River flows below human settlement. Photo: Prakash Singh/THTn

Climate change affecting food production in Karnali

Jumla, April 27

Karnali is known as a fertile region for organic farm products in the country.

Eighteen thousand farmers' households in Jumla are still dependent on agricultu for livelihood. However, climate change is taking a toll on the livelihood of farmers of the region.

No matter how hard they work to increase farm production, the yield is decreasi

Scroll.in
Saturday, December 10th 2022

CLIMATE CHANGE

In west Nepal, a river basin is home to drought and poverty

Lack of data prevents a planned response to climate change in the Karnali river basin.

Slok Gyawali
Aug 23, 2016 · 08:47 pm



In a district without motorable roads, people often walk for days to Simikot to receive basic supplies | Th

In 2015-'16, a drought hit Nepal's mid-west region. Farmers of Bajhang district found themselves caught in a tragedy of continuing food insecurity

There are more than 100 drought indices discussed in literatures and applied across the globe; around 30 amongst them are used as measures of monitoring spatial and temporal variability of water shortage (Halwatura et al., 2016).

Different approaches for drought assessment include:

perception/observation-based approach,	remote-sensing data-based approach,	model-based approach, and	**in-situ (hydro-meteorological/climatic) data-based approach.**

- The two specific objectives are –

  i) to compare different drought indices and select suitable one to represent drought scenario in the region; and

  ii) to quantify major drought events in the KRB based on available data.

Observed daily time-series of precipitation, temperature and discharge from Department of Hydrology and Meteorology (DHM) for 1981–2014 were used.

Temperature data from 10 stations distributed across KRB were selected.

Likewise, precipitation at 27 stations with longer-term data availability and less than 10% missing data were selected.

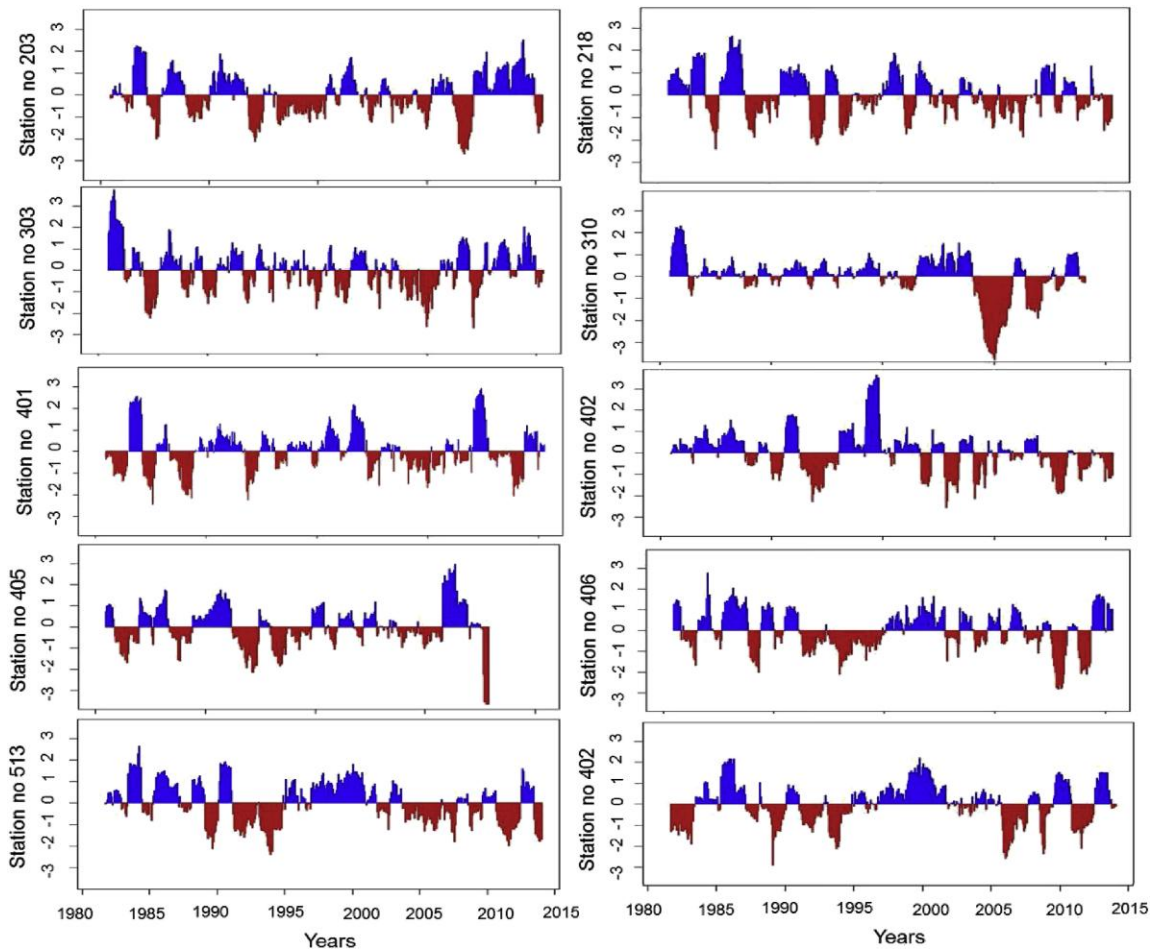


Hydrological station at Chisapani

Calculation of the drought indices:
(used in this presentation)

Standardized Precipitation Index (SPI)
Standardized Precipitation Evapotranspiration Index (SPEI)
Reconnaissance Drought Index (RDI)
Self-Calibrated Palmer Drought Severity Index (sc-PDSI)

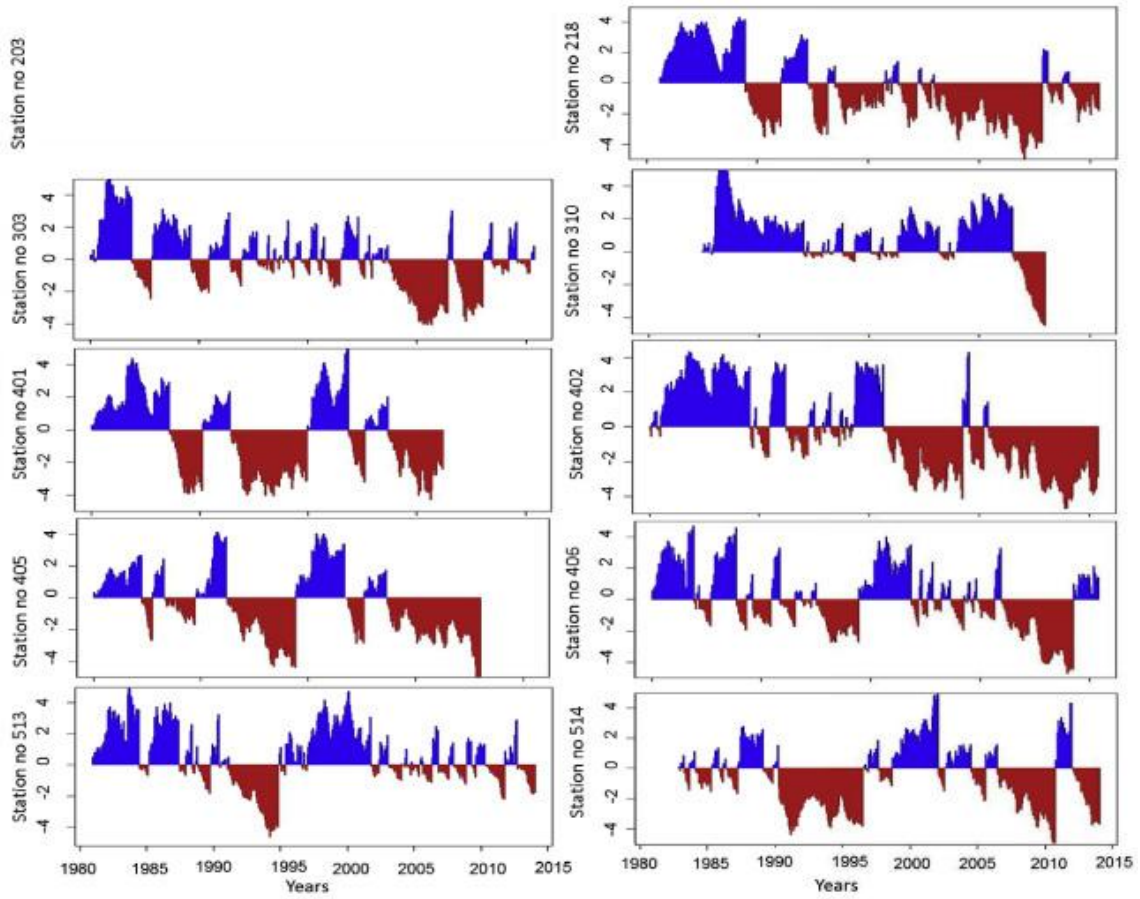




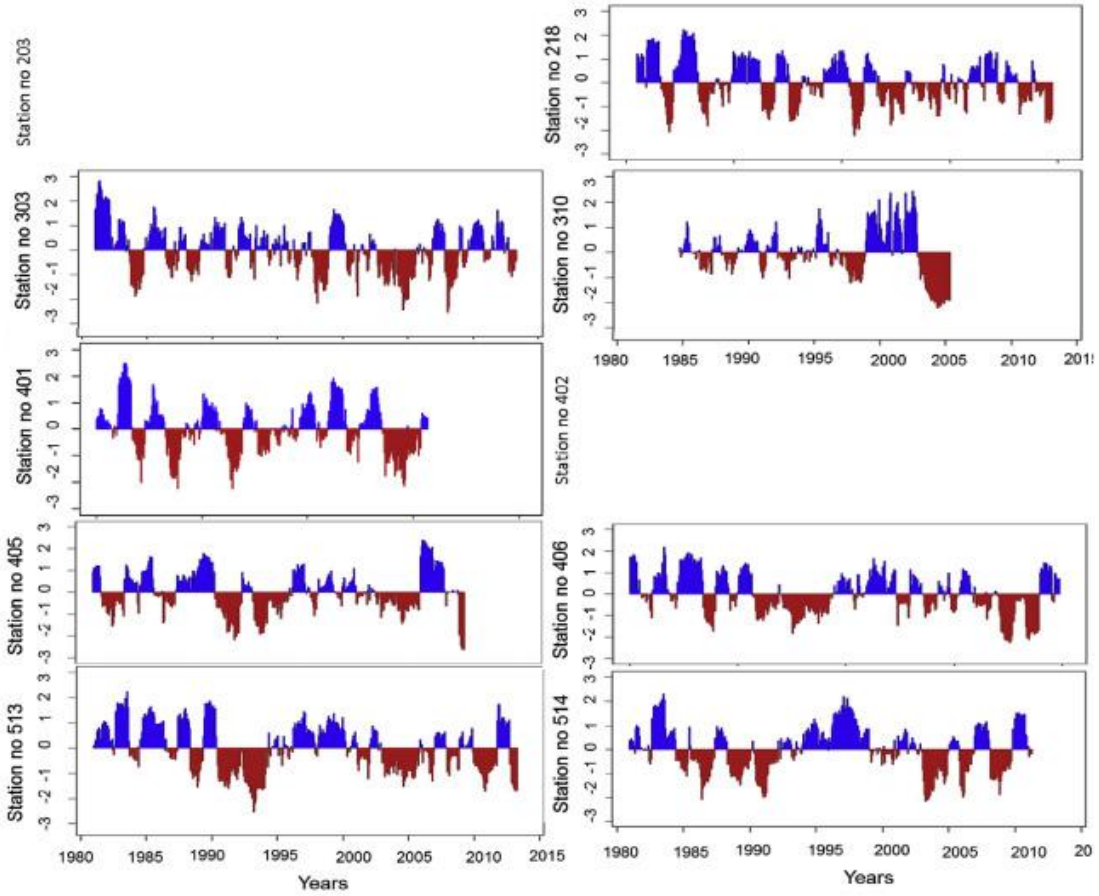
Spatio-temporal distribution of SPI in Karnali basin.

Based on the long-term time series of precipitation (McKee et al., 1993).

This study uses SPI_SL_6. exe tool available at National Drought Mitigation Centre maintained by University of Nebraska.



Spatio-temporal distribution of sc-PDSI in Karnali basin.



Spatio-temporal distribution of SPEI in Karnali basin

Palmer Drought Severity Index (PDSI) was calculated to measure the duration and intensity of long-term drought (Palmer, 1965; Guttman et al., 1992) with monthly temperature and precipitation as inputs.
For this analysis the software from greenleaf project was used

The SPEI (Vicente-Serrano et al., 2010) is the monthly difference between precipitation and potential evapotranspiration (PET) (i.e., SPEI = P–PET

Title:	SPEI Calculator
Authors:	Beguería, Santiago; Vicente Serrano, Sergio M.

Annex 3: Extreme and severe drought event months at each station

Station no	SPI (12 month)	SPEI	RDI	scPDSI
218	1985.06(E), 1992.12(E), 1993.01-1993.02(E), 1985.04-1985.05(S), 1985.07(S), 1988.01-1988.02(S), 1988.04-1988.05(S), 1992.08-1992.12(S), 1993.03-1993.05(S), 1994.10-1994.12(S), 1995.02(S), 1999.09(S), 2008.03-2008.05(S), 2014.06(S) (E-4 months S-23 months)	1984.05(E), 1998.08(E) 1984.03-1984.04(S), 1984.06-1984.07(S), 1987.04, 1992.01(S), 1993.09-1994.01(S), 1998.07(S), 1998.09-1998.12(S), 2001.06-2001.07(S), 2013.05-2013.10(S) (E-2 months S-22months)	1992.07(E), 1993.07(E), 1994.09(E), 1999.02(E), 2006.08(E), 2012.05-2012.06(E) 1985.02(S), 1987.06(S), 1989.04(S), 1992.08(S), 1996.05(S), 1999.04(S), 1999.08(S), 2001.09(S), 2004.03(S), 2005.08(S), 2006.02(S), 2008.02(S), 2010.03-2010.04(S) (E-7months S-14months)	2009.03-2009.07(E), 2010.04(E) 1989.10-1989.11(S), 1990.06-1990.07(S), 1993.10(S), 1994.02-1994.07(S), 2004.05-2004.07(S), 2006.08(S), 2007.02(S), 2007.10-2008.01(S), 2009.01-2009.02(S), 2009.08-2010.03(S), 2010.05-2010.09(S) (E-6months S-33months)
303	1984.12(E), 1985.02-1985.03(E), 2006.02-2006.03(E), 2009.08-2009.09(E) 1984.10-1985.01(S), 1985.04-1985.07(S), 1989.07(S), 1992.07(S), 1997.10(S), 2000.01(S), 2002.07(S), 2005.10-2006.01(S), 2006.04(S), 2006.07(S) (E-7months S-17months)	1998.06(E), 2005.03-2005.06(E), 2008.09-2008.10(E) 1984.01(S), 1984.03-1984.05(S), 1984.07(S), 1998.05(S), 1998.12-1999.02(S), 2001.08(S), 2005.02(S), 2005.05(S), 2005.08(S), 2008.11-2008.12(S) (E-6months S-15months)	1991.09(E), 1995.05(E), 1999.04(E), 2002.07(E), 2005.06(E), 2009.06(E), 2009.08(E) 1982.07(S), 1984.05(S), 1987.08-1987.09(S), 1988.09(S), 1989.04(S), 1990.01(S), 1991.02(S), 1999.03(S), 2001.09(S), 2004.02-2004.03(S), 2005.08(S), 2006.01(S), 2006.02(S) (E-7months S-15months)	2006.06(E), 2006.10(E), 2007.01-2007.02(E) 2006.01-2006.05(S), 2006.07-2006.12(S), 2007.03-2007.08(S), 2008.02-2008.04(S), 2009.08-2009.09(S), 2010.01-2010.04(S), 2010.06-2010.07(S) (E-4months S-27months)

	Station 203				Station no 218			
	SPI	SPEI	RDI	PDS	SPI	SPEI	RDI	PDSI
SPI	1.00				1.00			
SPEI	NA	1.00			-0.37	1.00		
RDI	NA	NA	1.00		0.13	-0.03	1.00	
PDSI	NA	NA	NA	1.00	-0.07	0.12	0.04	1.00
	Station 402				**Station 405**			
	SPI	SPEI	RDI	PDS	SPI	SPEI	RDI	PDSI
SPI	1.00				1.00			
SPEI	NA	1.00			0.15	1.00		
RDI	0.23	NA	1.00		0.27	0.16	1.00	
PDSI	0.54	NA	0.38	1.00	0.37	0.06	0.28	1.00

	Station no 303				Station no 310				Station 401			
	SPI	SPEI	RDI	PDSI	SPI	SPEI	RDI	PDSI	SPI	SPEI	RDI	PDSI
SPI	1.00				1.00				1.00			
SPEI	-0.07	1.00			0.32	1.00			0.79	1.00		
RDI	0.25	0.21	1.00		NA	NA	1.00		0.19	0.24	1.00	
PDSI	0.61	0.08	0.30	1.00	-0.06	-0.11	NA	1.00	0.48	0.61	0.23	1.00
	Station 406				**Station 513**				**Station 514**			
	SPI	SPEI	RDI	PDSI	SPI	SPEI	RDI	PDSI	SPI	SPEI	RDI	PDSI
SPI	1.00				1.00				1.00			
SPEI	-0.04	1.00			0.03	1.00			0.06	1.00		
RDI	0.21	0.23	1.00		0.27	0.20	1.00		NA	NA	1.00	
PDSI	0.59	0.29	0.35	1.00	0.73	0.35	0.35	1.00	0.04	-0.07	NA	1.00

Correlation among the different indices. Highlighted values are statistically significance at 95% confidence.

Missing rainfall data accounts for
<1% for 8 stations,
2–5% for 14 stations, and
7–10% for 5 stations located in high-altitudes.
Missing data was filled using krigging and then monthly time-series was generated before analysing.

The missing temperature data, for up to three days, were filled from average of that week. For longer missing data, they were filled based on monthly regression equations established from the previous and preceding years.

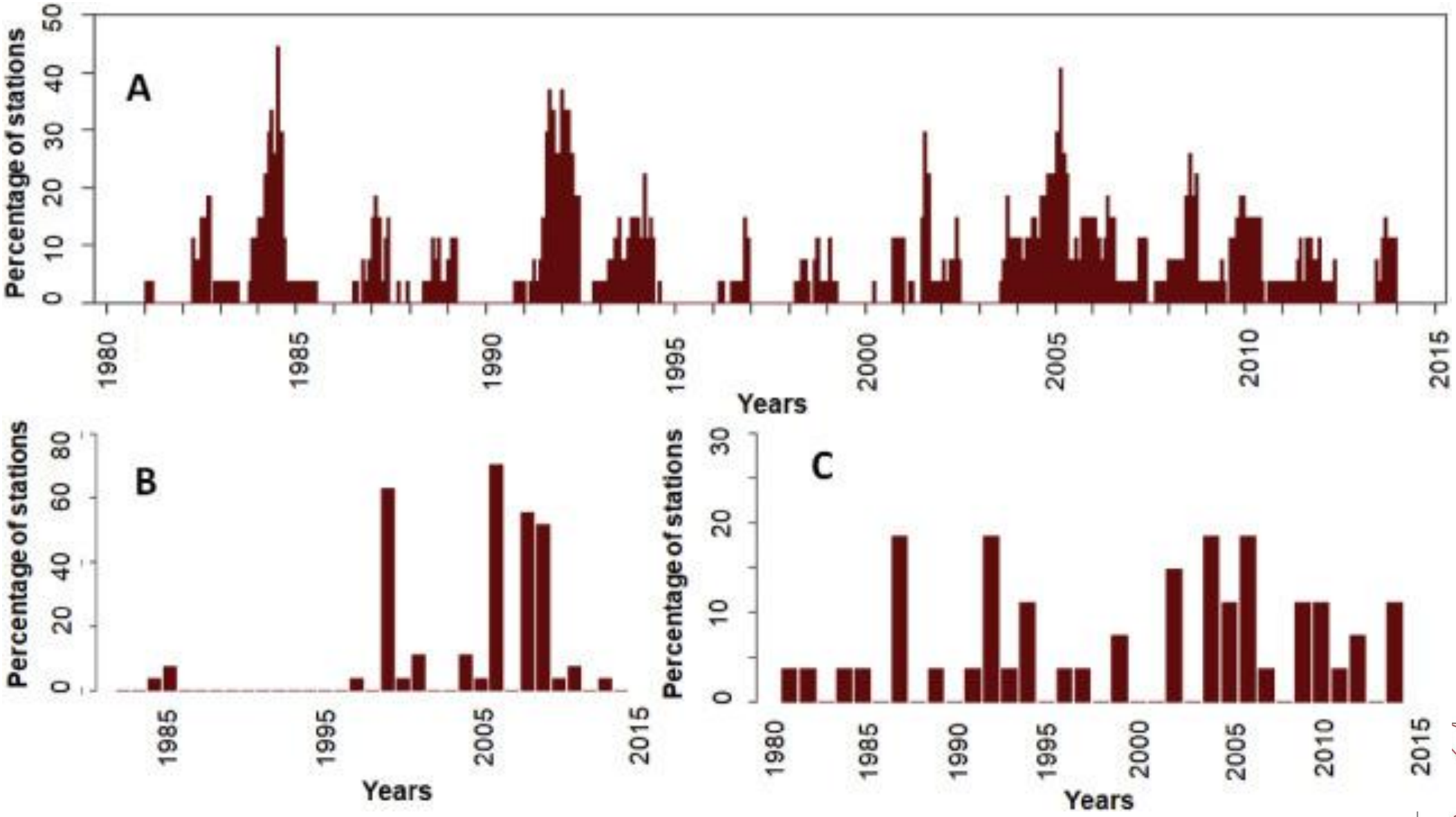
Influence of filling of data: Yes
In station 218, the year 1981 and 2011 had been filled and it seems that the PDSI is influenced by these filled values.

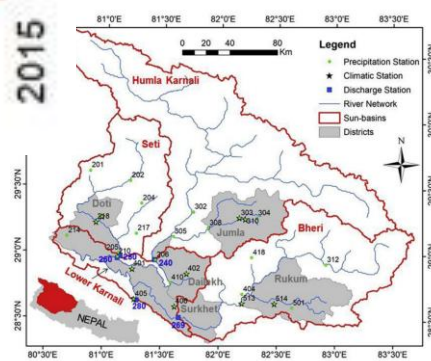
For the station no 401, the data of the years 2011 and 2012 were filled and the extreme values were reflected in the SPI indices.

Influence of filling of data: No
The temperature data of station 514 was filled mostly during the year 1981 and 1982, while the extreme dry is seen in the year 2010 in PDSI and 2004 in SPEI, therefore filling the data might have a little influence.

The station 513, the year 2010 was filled but it was not reflected as dry or wet extreme.

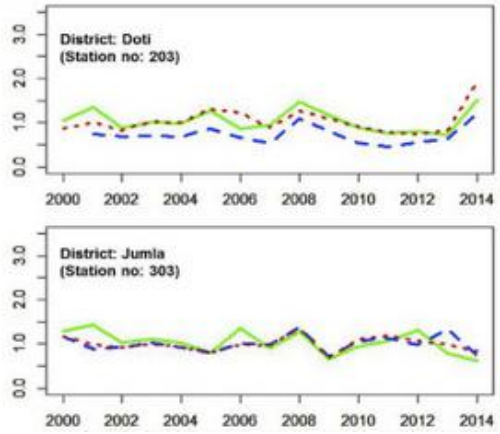
Influence of filling of data: Partial
In station 402, the temperature data was filled during the year 1996 and the precipitation was during the year 2013 and extreme from PDSI was reflected in both the years, however the extreme was not reflected in other indices.

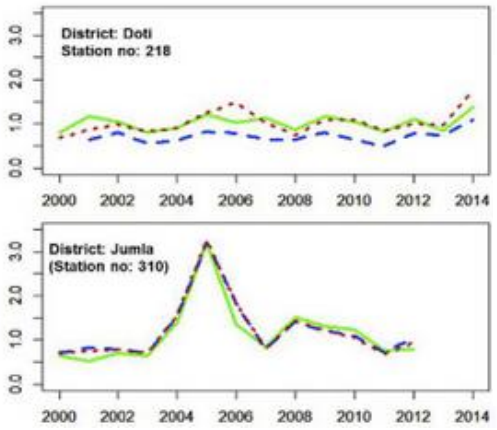


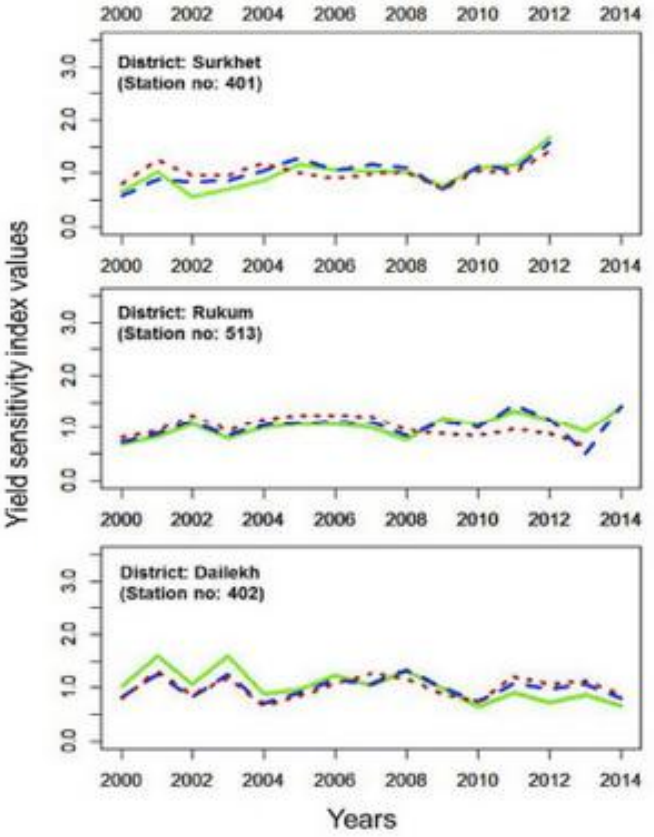


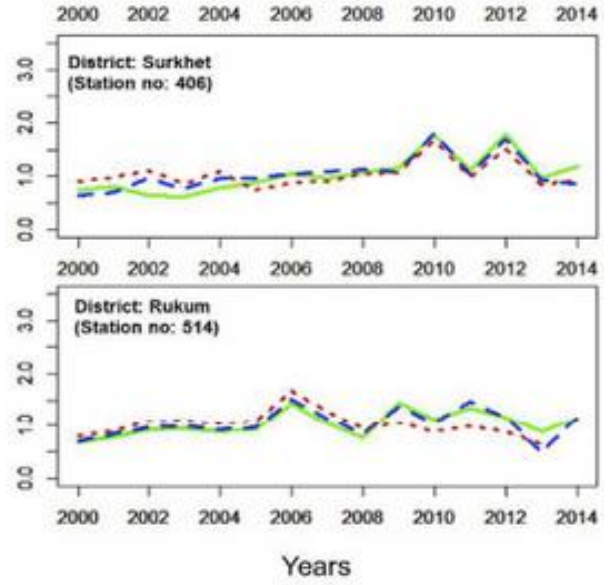
Percentage of stations showing drought events in time-series of:
a) monthly; b) winter; and c) monsoon.

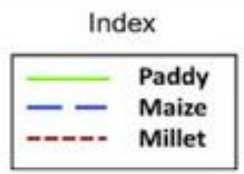
In case of crop productivity, yield of major crops (i.e., paddy, maize, and millet) are influenced by precipitation pattern and anomaly in the KRB-districts, revealing drought impacts on crop production.

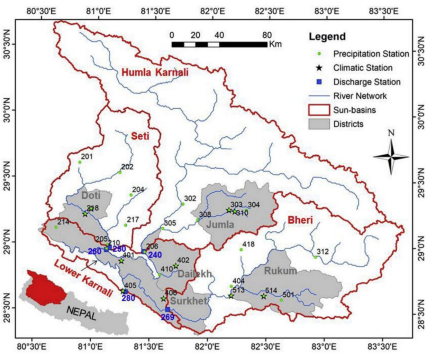












- Sensitivity of crop production to precipitation change.

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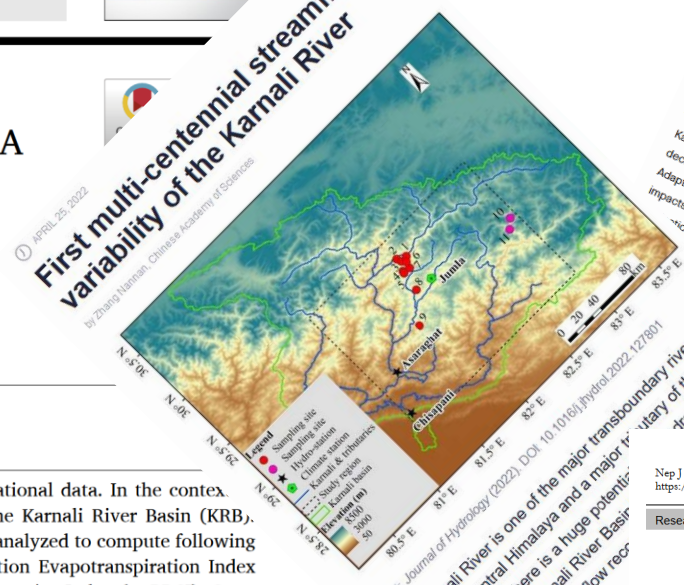
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Meteorological drought
Nepal
Precipitation anomaly
Yield sensitivity index

ABSTRACT

Himalayan river basin is marked by a complex topography with limited observational data. In the contex increasing extreme events, this study aims to characterize drought events in the Karnali River Basin (KRB). Firstly, historical data for 34-years (1981–2014) from ten different stations were analyzed to compute following drought indices: Standardized Precipitation Index (SPI), Standardized Precipitation Evapotranspiration Index (SPEI), Reconnaissance Drought Index (RDI), Self-Calibrated Palmer Drought Severity Index (sc-PDSI), Standardized Streamflow Index (SFI), and Palmer Hydrological Drought Severity Index (PHDI). Among them, SPI is able to capture the drought duration and intensity fairly well with the others. Secondly, SPI was used to analyse the drought of the entire basin. The SPI analysis showed occurrence of major drought events in the recent years: 1984–85, 1987–88, 1992–93, 1994–95, 2004–09, and 2012. The winter drought of 1999, 2006, 2008–09 were widespread and the monsoon drought is increasing its frequency. No particular pattern of drought was observed from the historical data; however, yield sensitivity index revealed that precipitation pattern and anomaly is influencing crop yield in the area. Being the first study revealing prevalence of the drought in KRB, it can provide a basis for prioritizing interventions focused on drought management in the region.




Research Article

Drought Characteristics and its Multifaceted Implications in the Karnali River Basin of Nepal

Piyush Dahal, Aashna Shakya, Jeeban Panthi, Nammy Hang Kirat, and 7 more

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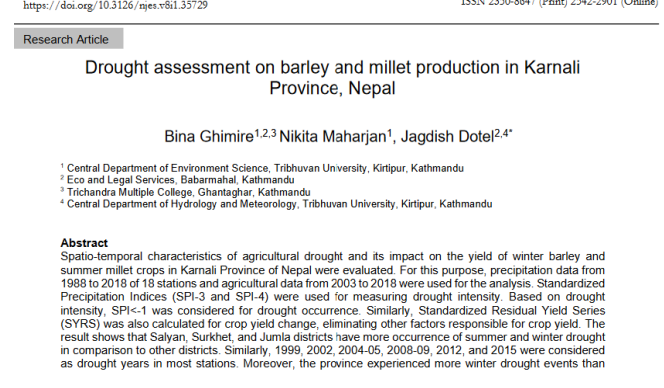
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Abstract

Karnali River Basin (KRB) located in western Nepal has been experiencing increasing temperature and decreasing precipitation trends in recent decades, making the basin highly susceptible to droughts. Adaptation to future droughts requires insight into the characteristics of past droughts and their impacts on different sectors. This study assesses the characteristics of drought occurrence and its ...ons on hydrology, agriculture, and vegetation in the KRB. The standardized Precipitation Index ...characterize drought occurrence, severity, and frequency based on the dat... ...asured between 1981 and 2021. Results indicated that ... ...valent since 2000, with the more fre... ...values for 1985, 2...


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Research Article

Drought assessment on barley and millet production in Karnali Province, Nepal

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Abstract

Spatio-temporal characteristics of agricultural drought and its impact on the yield of winter barley and summer millet crops in Karnali Province of Nepal were evaluated. For this purpose, precipitation data from 1988 to 2018 of 18 stations and agricultural data from 2003 to 2018 were used for the analysis. Standardized Precipitation Indices (SPI-3 and SPI-4) were used for measuring drought intensity. Based on drought intensity, SPI<-1 was considered for drought occurrence. Similarly, Standardized Residual Yield Series (SYRS) was also calculated for crop yield change, eliminating other factors responsible for crop yield. The result shows that Salyan, Surkhet, and Jumla districts have more occurrence of summer and winter drought in comparison to other districts. Similarly, 1999, 2002, 2004-05, 2008-09, 2012, and 2015 were considered as drought years in most stations. Moreover, the province experienced more winter drought events than

Take home message

- An evaluation of different indices revealed that SPI is well correlated with other drought indices, and therefore is capable to represent drought dynamics fairly well in data-spare regions.



Thank you ☺

Method used for sensitivity of crop production

- The precipitation anomaly was calculated by dividing long-term average rainfall in the growing season (April and September) by the amount of rainfall in the same period for a given year.

- Similarly, harvest anomaly index was calculated as a measure of deviation of the harvest production from the normal.

- Finally, the harvest anomaly index for each crop was divided by the rainfall anomaly index, returning a high number for years when only small deviations from normal rainfall levels were matched with large deviations in harvest (Fraser et al., 2008).