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Drought in Himachal Pradesh, India: A Historical-Geographical Perspective, 1901-2009

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Abstract

Drought, unlike other hydro-meteorological extremes, has a slow beginning but its impacts extend for long with dire consequences. Drought is a situation where there is a lack of precipitation or moisture deficiency due to departure of precipitation from the long term normal. Based on the historical-descriptive and statistical approach, this study outlines space-time dimensions of rainfall in terms of drought occurrence for the period 1901-2009 in the northwestern Himalayan State of Himachal Pradesh. The interpretation of long-term rainfall data forms the base of analysing the annual and seasonal departure of rainfall from the normal. The spatial patterns of drought occurrence were derived by interpolating point data using the spline interpolation algorithm in GIS environment.

Himachal Pradesh is the source several perennial rivers and can be perceived as water sufficient but meteorological drought is a regular feature here. The analysis reveals noticeable variations in drought occurrence in different climatic zones with higher incidence in hot humid and cold desert zones of the state. The temporal analysis suggests a changing rainfall regime; increasing rainfall in the cold desert zone and declining rainfall trends in cool and wet climatic region are evident while hot-humid region shows increasing but highly variable rainfall trends. The overall situation indicates more variable rainfall which may lead to increased extreme events which may increase the vulnerability to the livelihood system in the state.

Key words: *Drought Incidence, Rainfall variability, Himachal Pradesh*

Introduction

Drought, unlike other hydro-meteorological extremes such as floods, cloudbursts, cyclones which have speedier materialization, is different in terms of character and manifestations. It begins slowly, is insidious in character and if its duration extends for a long period large mass of people suffers dire consequences. Drought is a situation where there is a lack of precipitation in an area (Lena et al. 2004 and Shiau, 2006); the shortage of water due to deficiency of rainfall (Salas et al. 2005) and its distribution is the prime cause of drought. It is a period of moisture deficiency resulting from a specified amount of departure of precipitation from the expected or normal for a specific area. Drought may be a meteorological drought, hydrological drought and agricultural drought. Meteorological drought refers to deficient rainfall, whereas hydrological drought

refers to marked deficiency in surface and ground water levels. Agricultural drought occurs when rainfall and soil moisture is so scarce that it hampers the healthy growth of crops. These types of drought follow one after the other. As the period of water scarcity increases meteorological drought turns into hydrological drought and finally into agricultural drought.

Occurrence of drought in India has been a common feature historically. There are well documented records of drought affecting millions of people across the nation. About 68 per cent of total area in India is vulnerable to drought (Planning Commission, Government of India, 2008). The fate of entire economy is largely dependent on rains particularly on highly variable southwest monsoons. This study outlines some space-time dimensions of rainfall, particularly in terms of drought and rainfall variability for the period 1901-2009 in the northwestern Himalayan State of Himachal Pradesh.

Study Area

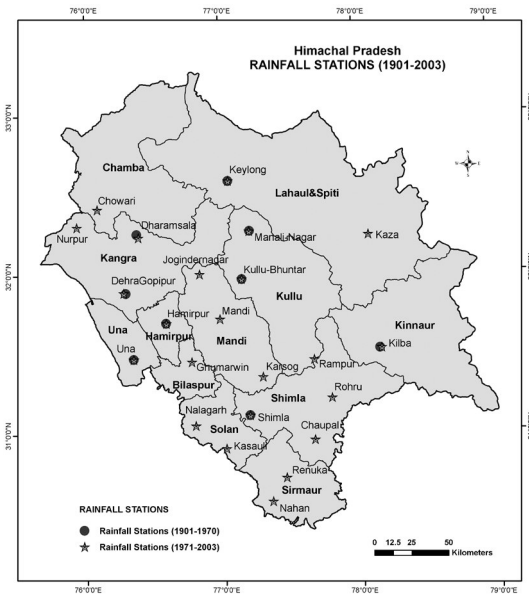
Himachal Pradesh is a mountainous state situated between 30º22' to 33º15' N latitude and 75º4' to 79º E longitude (map 1). The elevation ranges from 450-7000 meters above mean sea level. The area forms a part of Western Himalayas and can be divided into three distinct physiographical zones, namely the Siwaliks, Lesser (Middle) Himalayas and Greater Himalayas running parallel to each other in a northwest-southeast direction. The climate varies from tropical in the lower hills to temperate in the middle Himalayan region to cold desert type in Greater Himalayan region.

Himachal Pradesh is usually considered as a water rich state having large permanent snow fields feeding its perennial rivers; therefore drought occurrence in this hilly state does not hit the national news. However the incidence of such events poses serious threat to the livelihoods of those who are solely dependent on either horticulture or on subsistence farming. In the light of more recently changing horticulture dynamics and hydro-power generation activities, water has become a key element of development in the state. This paper has tried to analyse the changing face of meteorological drought occurrence in the state. The emphasis is upon appreciating the past behaviour of drought conditions and their impacts which is understood in terms of impact on crops and allied activities.

Data Source & Methodological Framework

The methodology follows the historical-descriptive and statistical approaches. The historical narratives of drought have been traced from gazetteers and a variety of published research on drought occurrence in the study area during early and mid 20th century; daily newspaper coverage of 'The Tribune' for 1971-2009. The statistical approach includes interpretations of long-term rainfall data. The data has been collected from National Data Centre (NDC), India Meteorological Department (IMD) Pune. The total monthly rainfall data of 23 stations for the period 1901-2003 (map 1) representing 12 districts and three climatic zones in the state have been considered for analysis.

The analysis has been done for two time periods: pre 1971 and 1971-2009 drought



Map 1 :

scenarios. The analysis for pre 1971 period is based on information from existing research and gazetteers and IMD rainfall data for 9 stations. The analysis includes annual and seasonal departure of rainfall from the normal and drought occurrence. The 1971-2009 period takes into consideration the daily newspaper coverage for 1971-2009 alongwith IMD rainfall data for 23 stations. The annual and seasonal patterns are discussed through tables, charts and maps. The seasonal analysis takes into account pre-monsoon (June); monsoon (July-September) and winter (December-February). The IMD defines a meteorological drought as a situation when rainfall is less than 75% of the long term normal. Rainfall deficit between 1-25% means a mild drought; 25-50% as moderate drought while more than 50% deficit means severe drought. Using this criteria, annual and seasonal drought years and probability of drought occurrence for each station has been estimated to highlight drought prone areas. The mapping of drought occurrence is done by interpolating point data using the spline interpolation algorithm in GIS environment which is best suited for surfaces that have smooth, gentle spatial variation, such as precipitation (Theobald, 2007). Since spatial interpolation requires sufficiently large number of point locations, this analysis is restricted to the period 1971-2003 because of non availability of the data for earlier period .

Analysis and Discussion

Drought in Himachal (pre 1971 scenario)

Drought situations in Himachal Pradesh occurred in 1877, 1883 and 1899 (Sinha, Ray & Shewale, 2001). Although the failure of rains leading to famine was never a recurring phenomenon in the state however occasional drought induced famine incidents occurred in the Pangi area of Chamba State in 1878-79 (Punjab Government, 1904, Gazetteer of the Chamba State, p. 260) and in Suket State (Sundernagar) in 1893-94 (Punjab Government, 1927, Gazetteer of the Suket State, p. 94). Not much is written and there is hardly any description which indicates that these were very widespread. The first decade of 20th century was a period of prolonged drought. The scanty rainfall created drought conditions in many parts of the state leading to famines. Punjab Government, 1904, states *"a rainfall variation for the last eight years (1895-1902) for four stations in the Simla district… the district has been passing through a prolonged period of drought"*. The second half of the decade marks a famine in the 'Sirmaur State' *"year 1907-08 famine conditions prevailed" (Punjab Government, 1934, pp. 90, Chapter II).*

During 1900-1970, there were 8 drought years in 1902, 1905, 1907, 1911, 1918, 1928, 1965 and 1968 (Sinha, Ray & Shewale, 2001) of which two years i.e. 1907 and 1918 were severely drought affected. The analysis of rainfall departure from the long term normal confirms many drought incidences in the state during 1901-1970 (table 1). The droughts were more persistent in the first two decades while the next two decades were comparatively less affected. The period from early 1940s to mid 60s recorded few drought years followed by a constant rainfall deficit during 1965-1970. There were significant variations in drought occurrence in different climatic zones (table 1). The temperate zone comprising of Dharamsala, Kullu-Bhuntar, Nagar-Manali and Shimla stations, as expected, reported a much lower incidence of drought than the hot humid zone in the vicinity of Punjab plains and the cold desert zone. The greatest severity of drought occurred in cold desert zone comprising Kilba and Keylong stations, where 5 years of severe drought and 20 moderate droughts were recorded. The situation in hot humid zone was somewhat similar where 2 severe and 22 moderate drought incidences occurred. Apart from the spatial variations there were seasonal variations in drought occurrence (table 2). The incidences were particularly severe in pre-monsoon and winter period in every station while the monsoon period recorded least incidences. The maximum number of droughts occurred during monsoons in Keylong, Kilba and Una stations representing Lahaul & Spiti, Kinnaur and Una districts. The first two stations represent the cold desert climate while last one adjacent to Punjab plains represents hot-humid climate. Apart from these two climate extremes, the Kullu-Bhuntar and Nagar-Manali stations have reported higher incidences of moderate drought than any other parts in temperate climates for the monsoon period.

Table 1
Annual Drought Years (1901-1970)

	Station	Climate Zone	Annual Drought Years (Moderate and Severe*)	Number of Drought Years		
				Severe	Moderate	Total
1	Una	Hot-Humid Zone	1902, 1905, 1915, 1918*, 1920, 1921, 1928, 1929, 1931, 1934, 1935, 1939, 1962, 1965, 1969	1	14	15
2	Hamirpur		1902, 1904, 1905, 1907, 1918, 1928, 1930, 1965, 1969*	1	8	9
3	Dehra Gopipur		1916, 1918, 1920, 1930, 1941, 1965, 1968	0	7	7
4	Dharamsala Obsy.	Temperate Zone	1902, 1907, 1918, 1965	0	4	4
5	Kullu-Bhuntar		1916, 1941, 1960, 1970	0	4	4
6	Nagar-Manali		1932, 1941, 1945*, 1946, 1947	1	4	5
7	Shimla Obsy.		1902, 1931, 1965	0	3	3

8	Keylong	Cold Desert Zone	1915, 1927, 1932, 1934, 1938, 1939, 1940, 1944, 1969*, 1970*	2	8	10
9	Kilba		1906, 1907, 1909, 1913, 1915, 1916, 1919, 1930*, 1931*, 1932* 1941, 1953, 1960, 1968, 1970	3	12	15
			Total	**8**	**64**	**72**

Source: National Data Center (NDC), IMD, Pune; * Severe drought year, Obsy. = Observatory

Table 2
Seasonal Occurrence of Drought (1901-1970)

	Station	Pre Monsoon		Monsoon		Winter	
		Severe	Moderate	Severe	Moderate	Severe	Moderate
1	Una	32	12	4	15	13	12
2	Hamirpur	29	11	2	11	10	17
3	Dehra Gopipur	28	9	1	10	15	14
4	Dharamsala Obsy.	20	12	3	5	11	12
5	Kullu-Bhuntar	16	15	3	12	8	12
6	Nagar-Manali*	19	11	0	16	9	8
7	Shimla Obsy.	19	13	1	6	14	18
8	Kilba	25	15	9	11	19	18
9	Keylong*	18	6	10	11	10	7
	Total	**206**	**104**	**33**	**97**	**109**	**118**

Source: National Data Center (NDC), IMD, Pune; * Data confined to 1901-1950

Drought in Himachal Pradesh (1971-2009)

The archival records show that the occurrence of drought was episodic: few drought years during 1970s; drought intensification during 1980s; lesser drought incidences in 1990s and persistent drought conditions during the first decade of 21st century. Droughts during 1970s was more persistent in the cold desert areas where maximum incidences were recorded. The lower elevation areas including Mandi, Bilaspur and Una were also badly affected. The lack of rainfall in early 1971 resulted in a drought like situation in Lahaul & Spiti district, "26 villages in Lahaul and Spiti district hit by an unprecedented drought despite the rains in other parts of HP" (The Tribune, 16 June 1971). The failure of monsoons in 1979 caused drought in every part of the state and led to heavy damage to the crops. The worst hit areas included the districts of Kullu, Bilaspur, Hamirpur, Solan and Chamba; Rampur and Kumarsain tehsils of Shimla district; and parts of Mandi district. The total loss was estimated at about 50.32 crore rupees.

The decade of 1980-89 was a period of deficit rainfall and droughts. The dip in five-year moving average curve below

the rainfall normal in almost every station (figure 1, i-xxiii) during this decade confirms the same. This created water scarcity in large parts of the state. There were 7 drought years except 1980, 1985 and 1988 (Sinha Ray & Shewale, 2001) although some drought incidents were reported in these years also, "the overflow from Renuka lake is dry for the first time in living memory… The unprecedented drought has affected 25 lakh people and 20 lakh head of cattle… the crop loss alone is estimated at Rs. 50 crore" (The Tribune, 6 June 1980). The absence of rainfall during August and September 1981 led to drought like conditions. Ten of the twelve districts except Kinnaur and Lahaul & Spiti were worst affected. Similar situation prevailed over the next year also, "Drought has been prevailing in Himachal Pradesh for the past two months" (The Tribune, 29 October 1982). This led the state into the grip of drought that continued even during the monsoons of 1983, the fifth consecutive year of rainfall deficit since 1979. The failure of monsoon continued in1984. Kangra and Shimla were the worst hit districts. In Kangra about 3100 villages were affected and crops worth 24 crore rupees were damaged. "The unprecedented drought in this region in the current rainy season has added a painful chapter to the history of Shimla district … elders of the region say that during the past 70 years they have neither heard of nor seen such a natural calamity" (The Tribune, 26 August 1984). The years 1985-87 were also drought affected in large parts of the state "The prolonged dry spell has created drought conditions in the lower hills of Himachal Pradesh … the kharif crops have been damaged in Kangra, Una, Hamirpur and parts of Mandi and Bilaspur districts" (The Tribune, 25 September 1986). The rainfall for May-July was 60 per cent less than the normal (The Tribune, 15 July 1987). The lower elevation areas mainly Bilaspur and Hamirpur were the worst affected. Crop loss was over 10 crore rupees in district Hamirpur. The central government provided drought relief package of 31 crore rupees to the state in 1987.

There were comparatively few incidents of drought during 1990s, however in terms of area affected per year by drought, Himachal Pradesh (23.7%) was the third most affected state after Saurashtra & Kutch (37.5%) and East Rajasthan (29%) and within Himachal, Chamba was the most affected district (Guhathakurta, 2003). This decade witnessed fewer drought incidences; however Sirmaur (figure 1- xvi & xxiii) was the worst hit. The failure of monsoon rains in 1991 caused drought in 6 of 12 districts. There was a drought situation in Lahaul and Pangi tehsils in late 1993; Bilaspur district in early 1994 and Chamba district in late 1998. The lack of rains in early summers of 1999 triggered drought in Hamirpur, Kangra and Solan districts, "Hamirpur district in Himachal Pradesh is facing drought-like conditions… about 75 per cent of the wheat crop has almost withered away" (The Tribune, 3 April 1999)… "The long spell of dry weather in Kangra valley has posed a serious threat to its tea industry… The tea growers have already lost over 50 per cent tea crop in the valley" (The Tribune, 1 May 1999).The prolonged dry spell since December 1998 virtually created drought in Kullu district where the apple crop was badly hit.

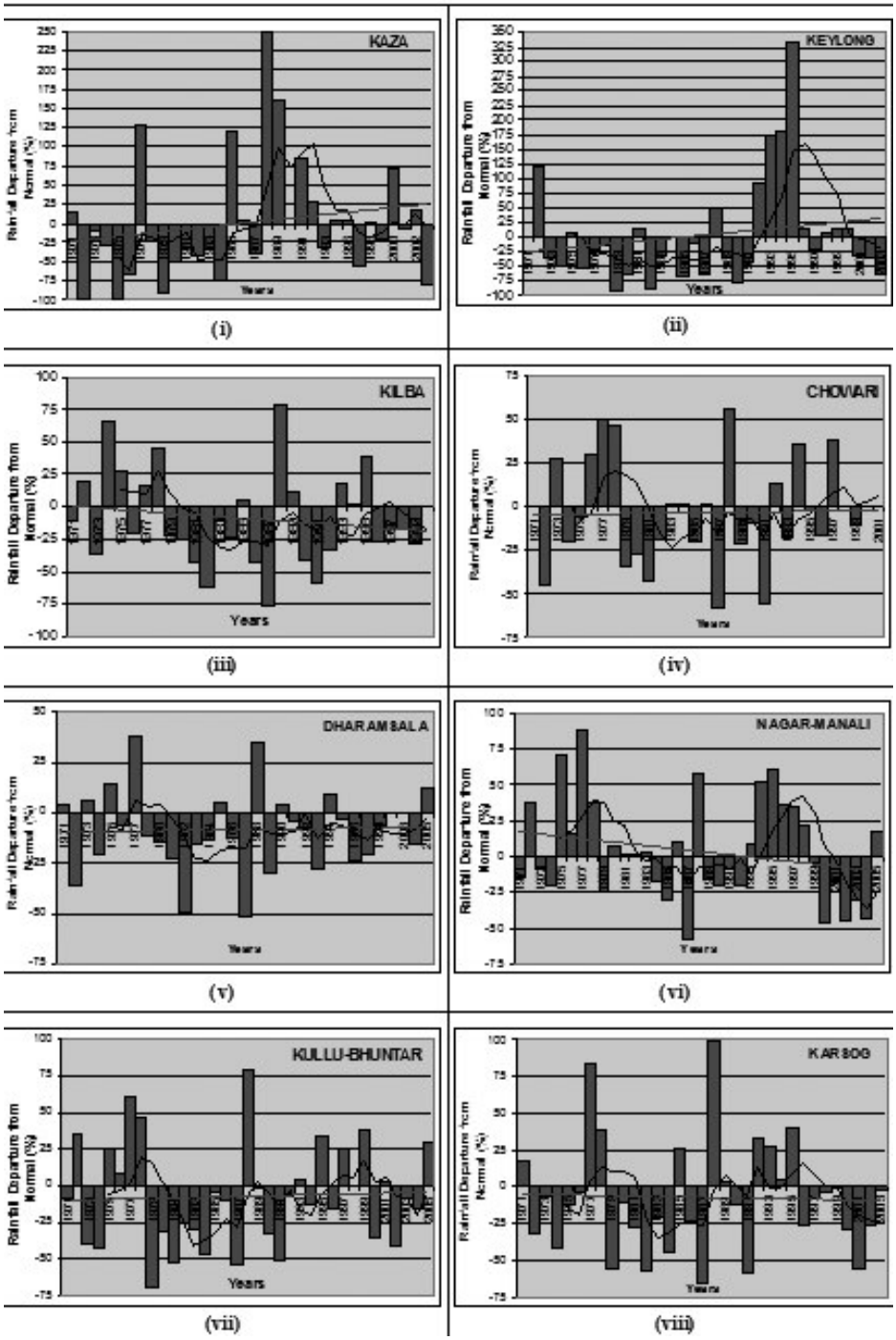
The drought conditions during 2000-2009 were reported in 2001, 2002, 2004, 2006 and 2009. The lack of winter rains during

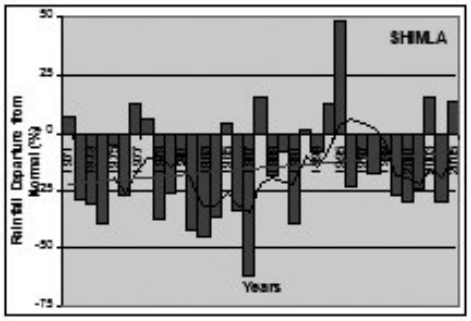
2000 and early 2001 resulted in drought situation in Solan, Kangra, Hamirpur, Bilaspur and Una districts destroying over 80 per cent of the standing crops worth 252 crore rupees. The rains eluded the state in July 2002 causing a loss of 81 crore rupees. This was the driest monsoon in last 30 years and the state government declared all 12 districts as drought-affected, "Standing crops had suffered more than 50 per cent damage... The maize, main crop of the hills, had suffered more than 90 per cent damage... damage to agricultural crops so far has been estimated at Rs 366 crore" (The Tribune, 2 August 2002). Scanty rainfall during 2004 hit Hamirpur and Bilaspur districts destroying 80 per cent of the wheat crop; damaged crops in Solan, Sirmaur, Shimla and Chamba districts. Drought damaged more than 25-30 per cent of apple fruit yield in the Kullu, Shimla and Mandi district. In 2006, the lack of rains caused widespread damage to crops in Mandi, Hamirpur, Bilaspur and parts of Kullu districts with an estimated loss of 400 crore rupees. There was severe damage to apple crop in Shimla, Kullu and Solan districts. The drought like situation in early 2007 led to heavy damage to apple crop in upper areas of Himachal while potato, wheat and oil seed crops were damaged in other parts. The rainfall deficit in early 2009 created drought-like situation that affected 60 per cent of wheat crop in Una, Bilaspur, Hamirpur and Sirmaur districts, while apple orchards were affected in Mandi, Kullu and Shimla districts. "The government today declared all 12 districts of the state as drought-affected… the state has been experiencing deficient rainfall since the month of October 2008 to July 2009" (The Tribune 31st July, 2009)… "Deficient rainfall has affected crops on over 3,63,120 hectares of land in the state and loss on account of damage to fruit crops has been estimated at Rs 248 crore… deficiency of rain ranging from 22 to 75 per cent" (The Tribune, 4th August 2009). The loss to crops was more than 50-80 per cent. The loss to agriculture crops had been estimated at 101 crore rupees, horticulture crops 19.95 crore rupees and animal husbandry 43.29 crore rupees.

Spatial Patterns of Drought: The temporal analysis of monsoonal rainfall during the period 1971-2003 indicates that drought incidents were very persistent in cold desert areas during 1970s and 1980s. The two stations, Kaza and Keylong were severely affected during this period while Kilba station suffered droughts during 1980s and early 1990s (figure 1, i-iii). The post 1990 scenario shows remarkable increase in rainfall in first two stations (Kaza & Keylong) while rainfall was below normal for Kilba. The following decade again shows decreasing rainfall and droughts in all the three stations. The overall trends indicate that this cold desert area has become wetter.

The rainfall trends in cool & wet temperate climatic regions during this period were either below normal or decreasing in almost every station with the exception of Jogindernagar and Mandi (figure 1 iv-xiv). The areas on northern parts of the region such as Manali and Rampur experienced rainfall deficiency during 1980s and post 1990. Similar trends were also observed in Rohru, Chaupal area of Shimla district (figure 1-xi & xii); Kullu-Bhuntar area of Kullu district (figure 1-vii), Kasauli area of Solan district (figure 1-xiii) and Karsog area of Mandi district (figure 1-viii). Shimla station was the most affected where

Figure 1
Himachal Pradesh (1971-2003)
Monsoon Rainfall Departure from the Normal and Drought Occurrence





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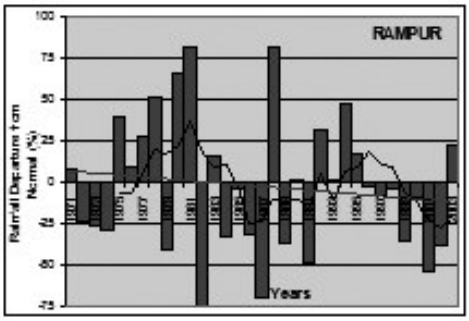

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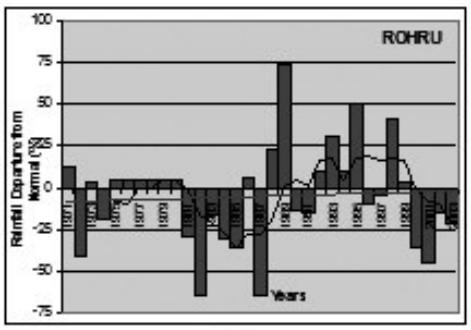

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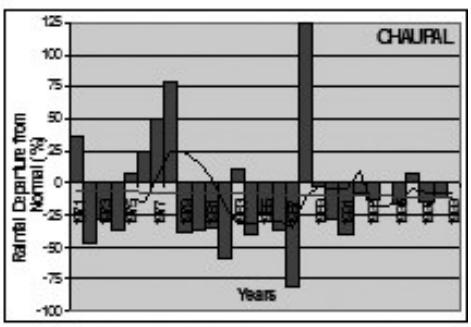

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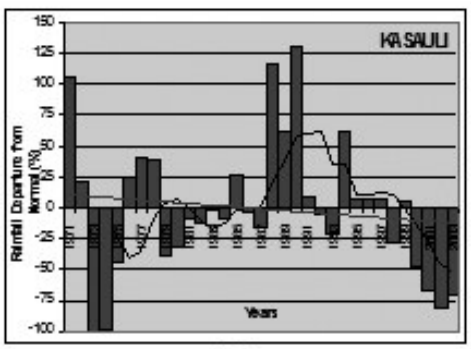

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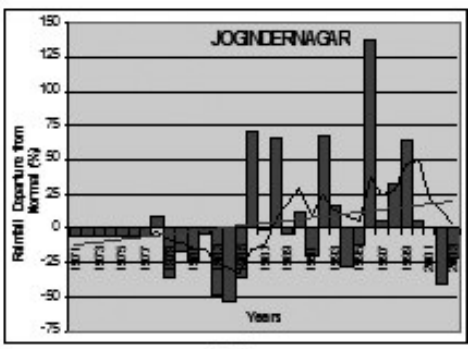

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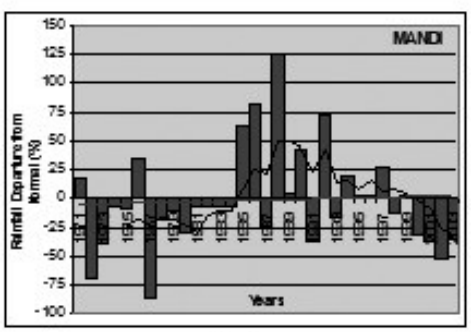

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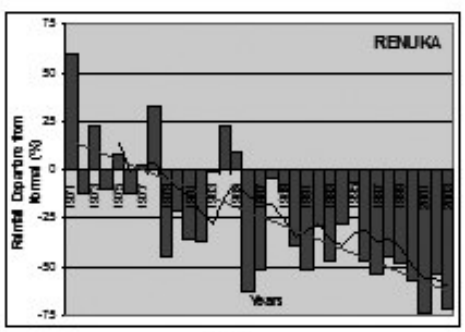

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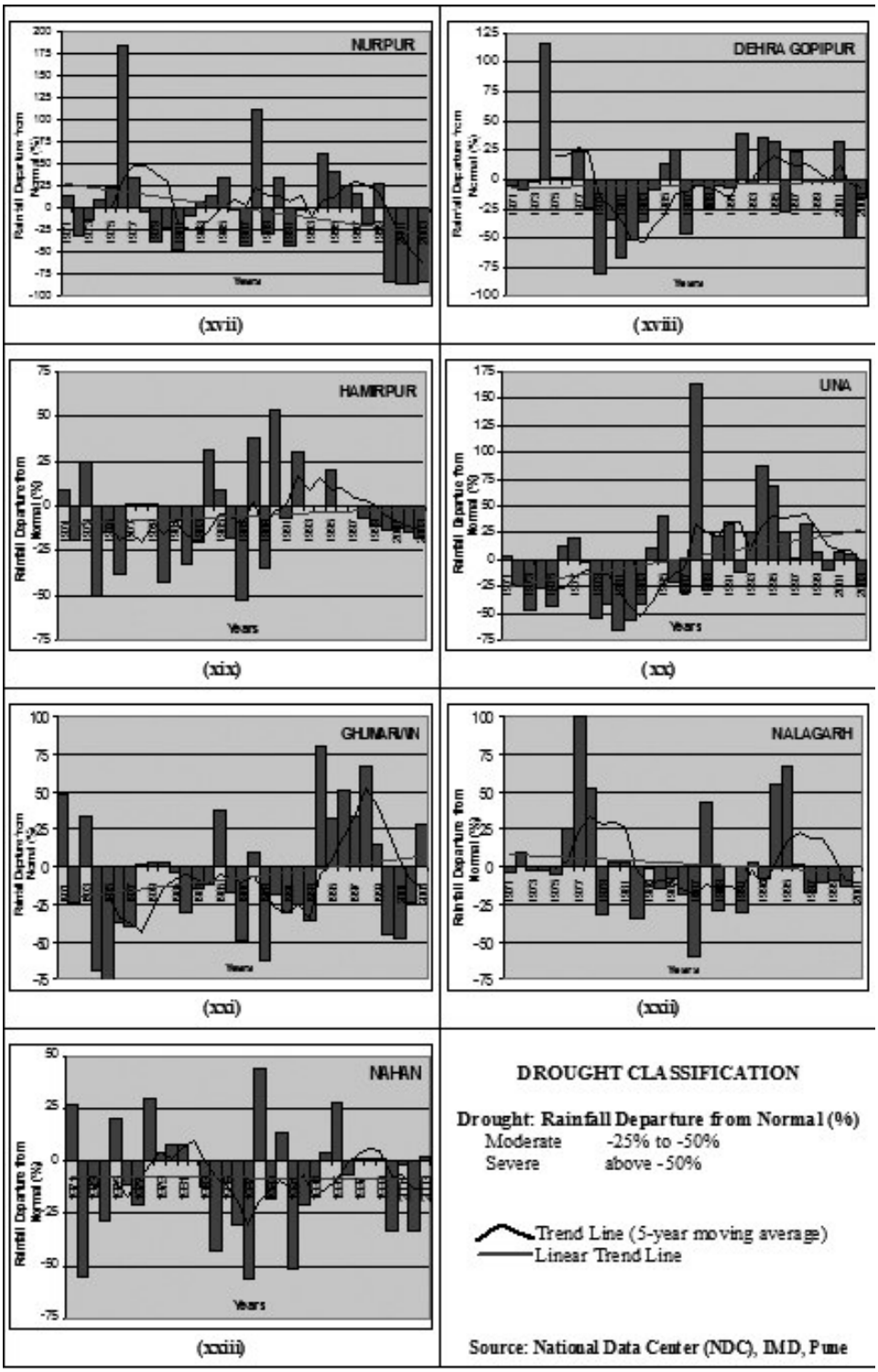

NURPUR
Rainfall Departure from Normal (%)
Years
(xvii)
DEHRA GOPIPUR
Rainfall Departure from Normal (%)
Years
(xviii)
HAMIRPUR
Rainfall Dparture from Normal (%)
Years
(xix)
UNA
Rainfall Departue from Normal (%)
Years
(xx)
GHUMARWIN
Rainfall Dparture from Normal (%)
Years
(xxi)
NALAGARH
Rainfall Departure from Normal (%)
Years
(xxii)
NAHAN
Rainfall Dparture from Normal (%)
Years
(xxiii)
DROUGHT CLASSIFICATION
Drought: Rainfall Departure from Normal (%)
Moderate -25% to -50%
Severe above -50%
Trend Line (5-year moving average)
Linear Trend Line
Source: National Data Center (NDC), IMD, Pune

rainfall declined consistently (figure 1-ix). The northern parts consisting of southern Chamba and northern Kangra have also shown continuous water deficient trends since 1980s (figure 1-iv & v).

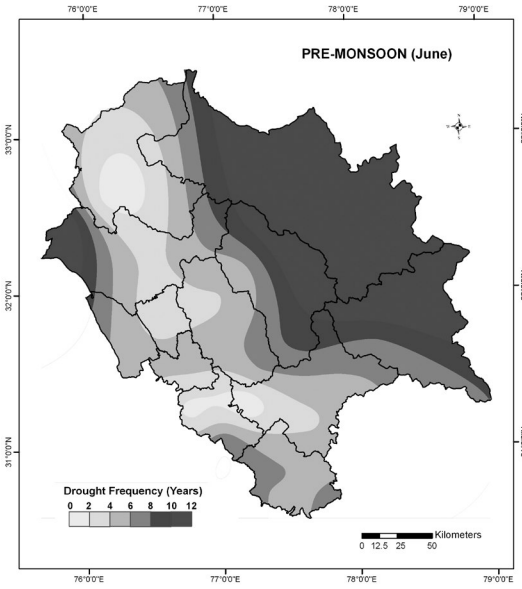
The lower parts consisting of Bilaspur, Hamirpur and Una districts show increasing rainfall trend; however large scale droughts occurred during 1970 and 1980s. The overall occurrence was comparatively less severe Dehra-Gopipur area (figure 1-xviii) of Kangra district however Nurpur station has been experiencing large scale rainfall deficit (figure 1-xvii). In this zone Sirmaur (figure 1 xvi & xxiii) was the most affected especially the area around Renuka (figure 1-xvi) where large scale drought conditions have prevailed and have been accelerating since 1990.

Seasonality of Drought Occurrence: The spatial perspective on overall seasonality of drought occurrence in the state during 1971-2003 presents an interesting picture of how drought varies in space with seasons. As far as the annual deficit of rainfall is concerned the areas of maximum annual drought occurrence include Lahaul & Spiti and northern tip of Kinnaur districts; Sirmaur district; Bilaspur and adjoining parts of Mandi districts. Lahaul & Spiti experience severe droughts while other areas are affected largely by moderate droughts (maps 2-iv & viii). Besides these, the areas of northern Chamba district; upper Beas valley and north eastern Kullu district; parts of Mandi district; western Kangra and Una districts are also affected by annual droughts.

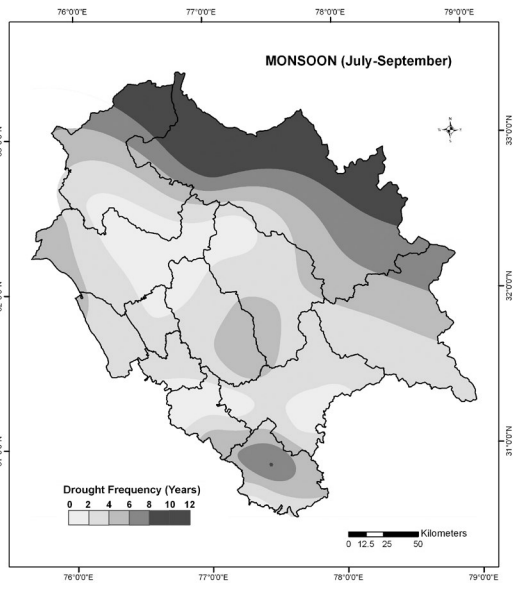
The seasonal picture presents a more detailed account of the existing & emerging variations over space. Drought conditions are most prominent during the pre-monsoons (map 2-i & v). The drought occurrence is very high in cold-dry desert zone of Lahaul & Spiti district, parts of Kullu and Kinnaur districts representing high Himalayan region and parts of western Kangra and Una districts representing hot-humid areas adjacent to the Punjab plains. The other affected areas include eastern parts of Shimla district and central Sirmaur. During the pre-monsoons the probability of severe drought occurrence is very high in cold-desert zone while moderate drought occurrence is very low. This implies that not only the drought frequency in these areas is very high during pre-monsoons but also their severity is very high.

Droughts are relatively less during the monsoon season. The cold desert areas due to interior location and obstruction of monsoons by lofty mountain ranges experience severe drought conditions. The rest of the state gets plenty of rains during this season and thus fewer droughts, mostly of moderate type, occur (maps 2-ii & vi). However within these areas the northern part of Sirmaur and bordering Shimla districts (map 2-vi) are prone to frequent droughts of moderate nature. The other areas of frequent drought include eastern and southern parts of Kullu district; Rampur & Chaupal areas of Shimla district and parts of Bilaspur and Mandi districts.

Drought in the state is a recurrent phenomenon during the winter season (December-February). The worst affected areas are the cold-desert areas of Lahaul & Spiti and Kinnaur; the lower hills of Kangra, Una, Bilaspur, Solan and Sirmaur districts. These zones are affected by occurrence of severe drought (map 2-iii). In the temperate regions of the state the concentration of



Map 2-i :



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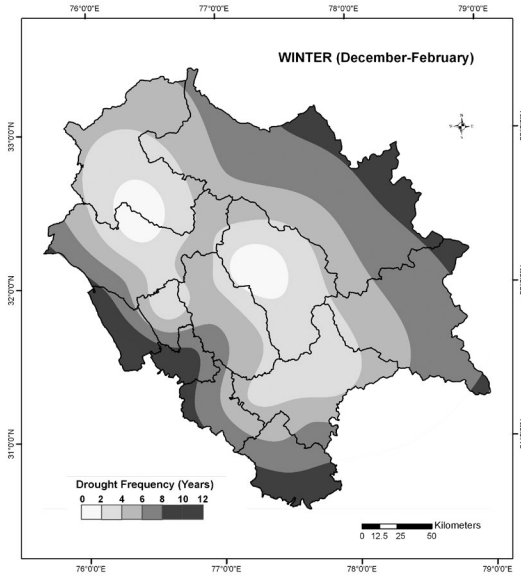
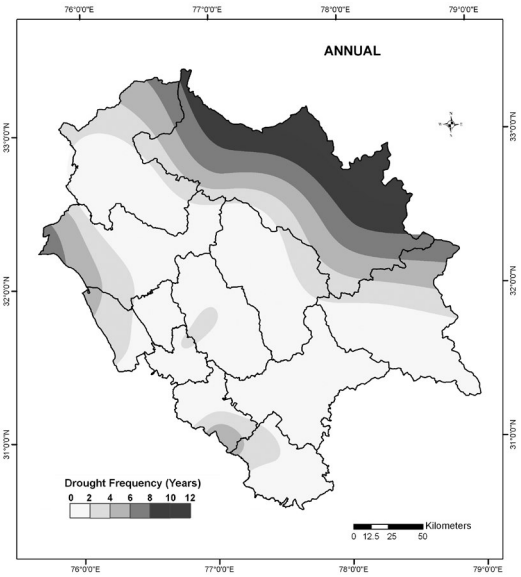
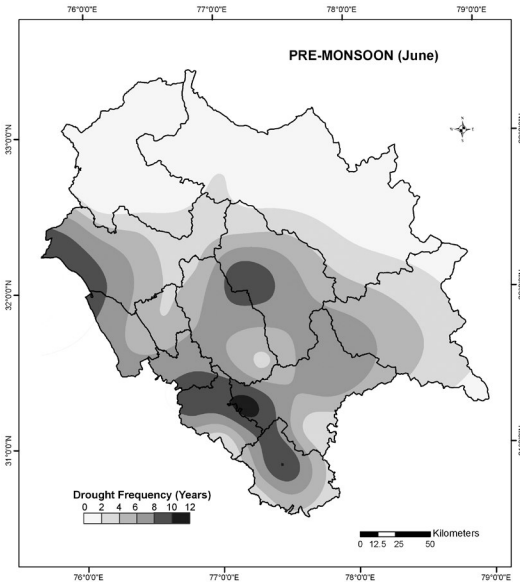


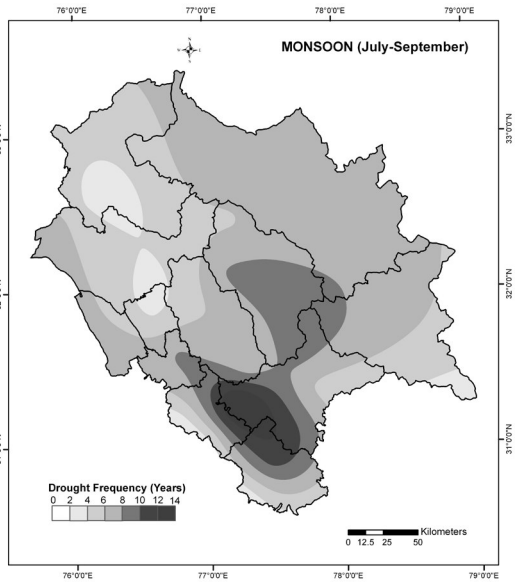
Map 2-iii :



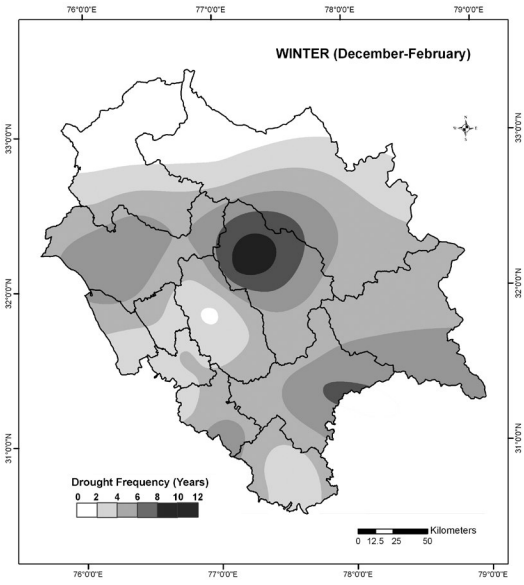
Map 2-iv :



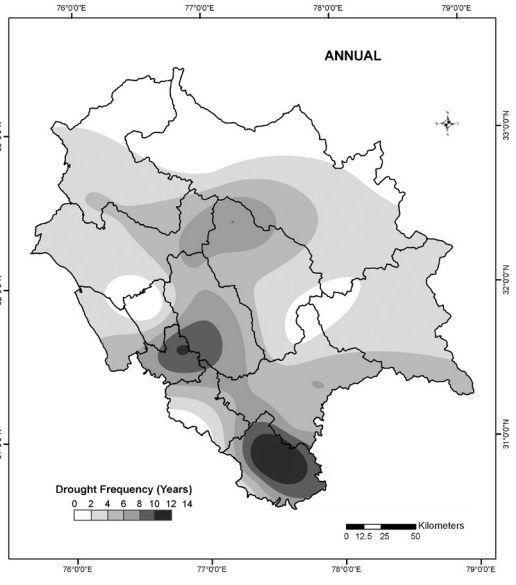
Map 2-v :



Map 2-vi :



Map 2-vii :



Map 2-viii :

moderate drought is particularly high in Kullu and Kangra valleys, eastern and southern parts of Shimla and Kinnaur districts (map 2-vii).

Conclusions

- Drought is a regular feature in Himachal Pradesh despite it being the source of several perennial rivers with an impression of it being water sufficient. There are noticeable variations in drought occurrence in different climatic zones. The incidence of drought is more conspicuous in cold desert and hot humid zones.
- The monsoon rainfall in post 1970 period suggests a changing rainfall regime. The cold desert climate shows remarkable increase whereas declining rainfall trends are noticeable in cool and wet climatic region. After the rainfall deficient period of 1980s the rainfall is displaying highly variable patterns. The hot-humid southern and western lower hills shows increasing but highly variable rainfall trend in post 1990 period.
- The seasonality of drought occurrence in the state indicates severe drought conditions in cold desert and hot-humid areas during the pre-monsoon and winter season. Winter season drought is a recurrent phenomenon in Kullu & Kangra valleys, eastern Shimla and southern Kinnaur. It is relatively low during the monsoon but the cold desert areas, Sirmaur and bordering Shimla district are greatly affected by droughts.
- The overall situation reveals that rainfall regime has become more variable thus raising the chances of more extreme events. This could lead to development ventures being hampered by extreme events thus adding to the vulnerability horticulture and hydro-power generation.

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