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Drought Network News

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From the Director

Many of the readers of *Drought Network News* are familiar with the "hydro-illogical cycle" cartoon that I use frequently in presentations and publications. This illustration has been translated into many languages and serves as a constant reminder of the crisis management mentality often displayed in responding to drought emergencies and the proverbial "window of opportunity" following a drought when planning for the next event is of high priority. I hear comments routinely from government officials that recognize the need to plan, but they express hesitancy in moving forward now if water supply conditions are normal or above. The concern is that actions to plan for drought might be viewed by political opponents or the public as misdirected. Politicians certainly do not want to be viewed as placing emphasis and expending resources on what may appear to be an issue that lacks urgency when other crises exist. As drought planners, perhaps we should pray for dry conditions so that proper attention will be given to this important component of water resources planning.

After experiencing droughts in 1996 and 1998, the Southwest and southern Great Plains states are bracing for another dry year in 1999. The long-lead forecasts of NOAA's Climate Prediction Center place considerable confidence in a very dry 3-month period from March through May in this region. Much concern exists in Texas, New Mexico, and Arizona about the potential threat of another year of drought. Texas and New Mexico have made considerable progress in drought planning since 1996, and these plans are likely to be tested severely if drought recurs this year.

In the last issue of *Drought Network News*, I discussed the National Drought Policy Act and the Commission that it creates to examine current laws and programs and make recommendations to the president and Congress on the creation of an integrated, coordinated federal policy designed to prepare for and respond to drought emergencies. The Commission is nearly in place; the selection of six at-large members is all that remains to launch this new effort. The first Commission meeting will likely be held in May or June in Washington, D.C. The National Drought Mitigation Center will be working closely with the Commission over the next 18 months, providing assistance as requested. For more details on the Commission, refer to the October 1998 *Drought Network News* or check out their web site (http://www.fsa.usda.gov/

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drought/). You can also get to their site through the NDMC's web site (see the last page of this newsletter for the web site address).

In early March, I participated in a workshop in Ispra, Italy, on drought and drought mitigation in Europe. The goal of this exploratory workshop was to analyze the state of drought research, drought planning, and drought mitigation strategies in Europe. The workshop was organized by the European Commission's Space Applications Institute in Ispra and the Institute of Hydrology in Wallingford, U.K. Scientists from many fields of study representing many countries were in attendance. The proceedings of this workshop, including papers presented and the workshop summary, will be published soon. One of the outcomes of the workshop may be the formation of a European network on drought research and mitigation. The goal of this network would be to stimulate and coordinate applied research in the fields of drought alert, monitoring, assessment, and mitigation.

The NDMC is in the final stages of organizing another in the series of workshops sponsored by the U.S. Bureau of Reclamation on drought contingency planning. This workshop will be for the State of Hawaii; it comes at the request of Governor Benjamin J. Cayetano. Previous workshops in the United States have been regional in their emphasis. The goal of Hawaii is to move forward on the development of a drought plan at the completion of the workshop. Hawaii has been suffering one of their worst droughts on record since 1997.

This issue of the newsletter contains drought-related articles on Mexico, India, and Turkey. *Drought Network News* readers are requested to submit articles for the June 1999 issue to me no later than June 1. Readers are also encouraged to submit announcements and other information of interest to our network members.

Donald A. Wilhite

Contents

Severe Droughts Becoming Recurrent, More Persistent in Mexico

During recent years, severe and extreme droughts in Mexico and their consequent water deficits have become more recurrent and persistent, according to historic records and the experiences of those who have lived through these events.

In Mexico, agriculture consumes more than 85% of the available water. When the available water is insufficient to satisfy agricultural requirements, impacts can be acute. In extreme cases, lack of water has caused severe economic, social, and environmental crises, and recovery from these crises has taken much time and money.

The regions that are most affected by drought have some common characteristics: they are the most vulnerable regions, they are more productive than other regions, and they have a greater demand for water than other regions do. The north, northwest, and northeast regions, in which are located the most important irrigation zones and most of the industrial plants, constitute 70% of the country, but these regions receive less than 40% of the country's total rainfall. The southeast region, constituting 30% of the country, receives 60% or more of the total rain; in this part of the country, the rivers are larger with regular flows, and there are wide humid zones where irrigation is unnecessary. (Figure 1 shows the main hydrogeographic regions of Mexico.) The few remaining nonirrigated areas, which benefit from summer rains, have also been drastically affected by drought, because they do not have alternate sources of viable water or fast response capabilities.

The droughts of recent years have caused acute deficits even in typically humid zones, with adverse effects. During the first half of 1998, wildfires reached historic highs. This was exacerbated by rains in late 1997 that caused greater-than-normal undergrowth. In early 1998, the humidity diminished, and plants dried out and were converted into highly flammable material, increasing the risk of fire. In addition, the

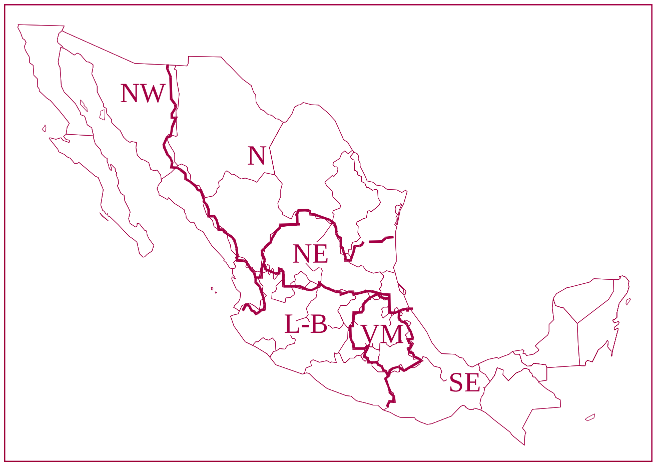

Figure 1. Main hydrogeographic areas of Mexico. NW = Northwest; N = North; NE = Northeast; L-B = Lerma-Balsas; VM = Valle de Mexico; SE = Southeast.

start of the normal rain season was delayed more than a month, further aggravating the problem and allowing environmental pollution and smoke to reach new levels.

All of these conditions were thought to be the result of El Niño, which reached an acute phase during winter 1997. During May and June 1998, the change to La Niña also favored adverse environmental conditions. It was not until late July that rainfall returned to normal, ending the problem of fires and pollution, but the rains that did occur were so intense for a short period of time that they resulted in floods and excessive water. Also, hurricanes, particularly along the coast of the Pacific Ocean, were of a magnitude that resulted in severe damages to the population, infrastructure, and social and economic stability of wide areas.

During the 1998 water year, the rains were lower than normal, and through the end of October, they had reached 96% of the historic normal on a nationwide scale, although some areas registered lower levels, mainly those areas where irrigation zones are located. The concentration of the rains in a shorter period of time (from mid-July to mid-October) was insufficient to reach normal or greater than normal values. In general, in spite of the damage they cause, hurricanes in Mexico are expected and well regarded because their presence means that rain will fill dams, guaranteeing a good agricultural season and enough water for regionwide crops. In 1998, hurricanes as well as seasonal and intense rains caused serious damages, but unfortunately they only occurred in the coastal low zones and not in the mountainous areas, where their benefit would have exceeded the damages. In the 1998 hurricane season, damages were acute and the infrastructure was severely affected in the irrigated lowland agricultural areas. Because of these damages, the water that collected in the dams as a result of the hurricanes was difficult to access.

Because of recurring severe droughts and floods, the federal and state governments of the most affected areas frequently have provided aid to the population, in order to support social and economic stability and mitigate the negative effects of these hazards. Because of the severity and areal extent of some droughts, the federal government has had to declare the affected areas disaster zones, so that emergency programs could be initiated to mitigate the effects. In these cases, the National Water Commission (CNA), the federal agency responsible for coordinating water use, works with agencies of the affected states and municipalities to diminish damages and allow conditions to return to normal as soon as possible.

At the beginning of the agricultural year, CNA sets the allocation of the water to be used in each

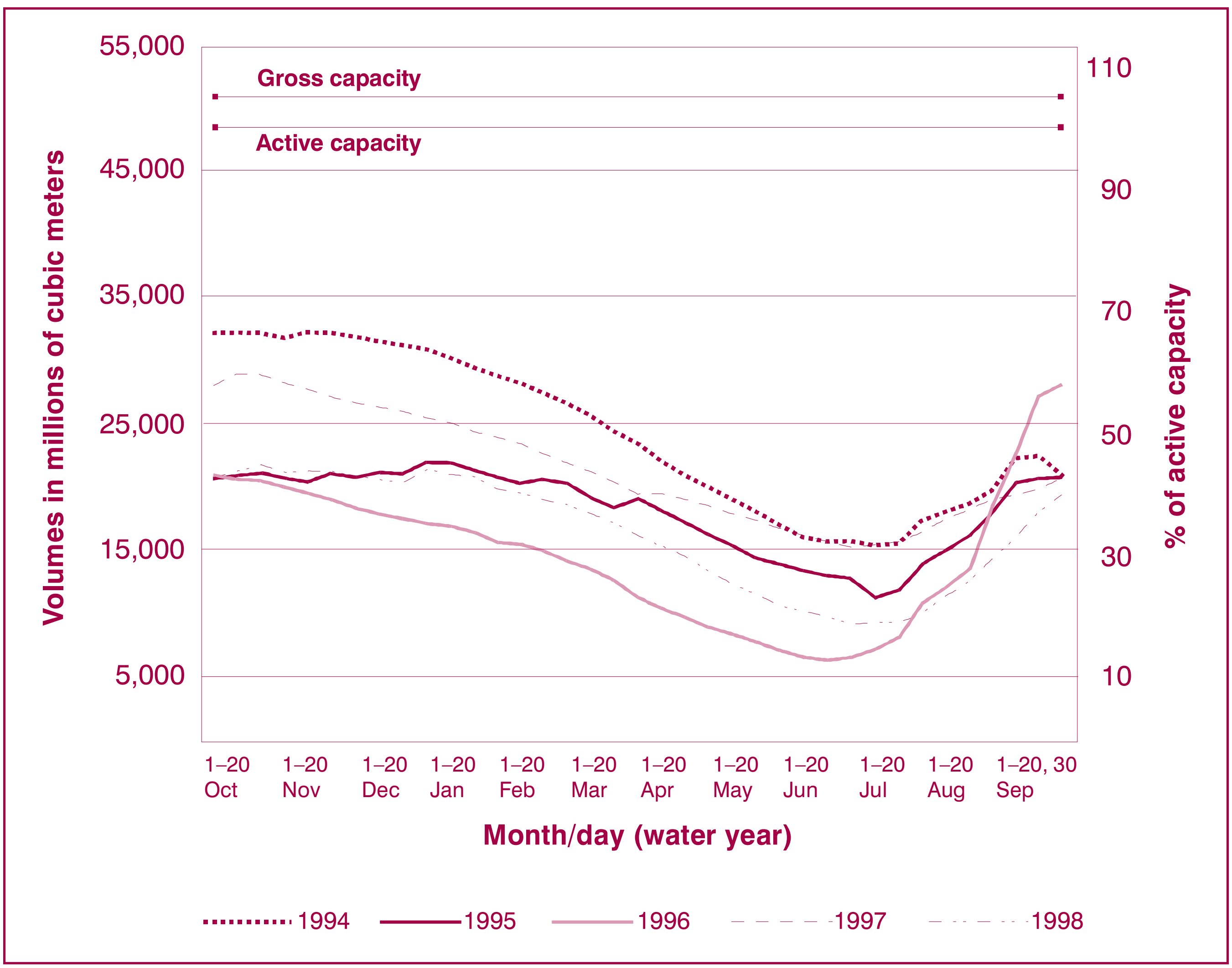

Figure 2. Storage in reservoirs for irrigation in Mexico.

Region	Capacities, $m^3 \cdot 106$		Water in reservoirs available for irrigation, beginning of water year, $m^3 \cdot 106$							
			1996		1997		1998		1999	
	Gross	Active	A. Vol.	%	A. Vol.	%	A. Vol.	%	A. Vol.	%
Northwest	23,167	22,069	10,579	48	14,838	67	10,199	46	8,554	41
North	18,163	17,588	3,846	22	7,400	42	5,976	34	3,796	21
Northeast	2,018	1,752	836	48	917	52	680	38	925	52
Lerma-Balsas	6,071	5,090	3,919	77	3,269	64	2,618	51	3,897	76
Valle de México	1,010	918	809	88	650	70	527	57	688	77
Southeast	1,046	997	100		1,029	100	717	71	1,096	100
TOTAL	51,477	48,417	20,987	43	28,105	60	20,718	42	18,958	39

Table 1. Capacity and available volumes for each geographical region, in stored water, dams, and reservoirs at the beginning of each agricultural year. Source: CNA, 1998. GDUR, 10-day record of storage in dams of the Irrigation Districts. Internal Documents, Mexico. A. Vol. = available volume.

irrigation district, especially districts supplied by dams and reservoirs. The allocations are made based on previous revisions and analyses of requirements as well as current conditions and hydrologic forecasts for the winter season. If these conditions are unfavorable, then options to restrict the surface area sown and volume of water to be used are done. By the end of March, actual and possible developments are evaluated, based on environmental conditions and spring-summer crop programs, and adjustments are made accordingly. This constitutes risk management, because those involved are trying to mitigate the negative effects of a possible lack of water.

During the course of the water year, if a deficit occurs or is greater than expected, the usual measures for mitigation are water rationing and programs to improve water use efficiency. To accomplish these measures, CNA relies on water user associations and state and municipal governments, who carry out these tasks in such a manner that the socioeconomic conditions of the local population are affected as little as possible—especially that sector of the population that has the fewest resources and whose regular income comes from activities related to agriculture: journeymen, ditchers, machinery operators, crop collectors. Certainly, the small agriculturalists also benefit from these programs, but the basic objective is that they should suffer the least adverse change and minimum damage. Unfortunately, this goal is not always achieved, and in extreme conditions, even the more ambitious programs are insufficient to mitigate the effects. Even so, not taking action would have even more disastrous consequences, and recuperation time would be longer.

Another characteristic of droughts in Mexico is their areal extension: in general, they cover large areas, and local response actions contribute little to resolving the overall problem. Some areas are only slightly affected while other areas may suffer severe impacts. In particular, in the big watersheds of the north region, where rivers are the basic source of supply and groundwater is scarce, the options for mitigating drought impacts are more complicated, because new sources of water are scarce and expensive. Nevertheless, in extreme cases, emergency programs to dig deep wells to extract groundwater have been able to satisfy the most urgent needs, mainly for human consumption. Also, in some cases during the last 5 years, the situation has been so critical that even domestic water use has been severely restricted (i.e., water available for only a few hours of the day; limiting or punishing water usage for certain activities).

Table 1 shows the water available for irrigating at the beginning of the water year; Figure 2 shows the evolution of stored water in the last few water years. From an examination of Table 1, it appears that the 1996 water year had the most critical water deficit, with the most severe damages to agriculture and livestock, because by the middle of the year, minimum historical water levels were reached. But during the rainy season, an amazing recovery occurred in storage, so that at the beginning of the 1997 water year, conditions were almost normal; nevertheless, 1997 was a difficult year, in which rain was not adequate to satisfy existing requirements and replenish storage. Therefore, 1998 did not begin as a normal year, and irrigated areas were adversely affected. Prospects for 1999 are not good, because initial storage volumes in dams are the lowest in the last 6 years, the precipitation forecast for winter 1998 was not promising, and La Niña, the cold and dry phase of ENSO, is persisting.

For the 80 irrigation districts of the country, which cover about 3.2 million hectares, there are 19 support programs for 1999; these restrict sowing to 652,454 hectares, or 55% of the total surface of those districts. Specific actions of these programs include the following: coating and piping of ditches, rehabilitation and digging of deep wells and pumping stations, rainwater collection (preparing the land for capture and retention of rainwater), substitution of autumn-winter crops for spring-summer crops where and when possible, and formation of advisory groups for watering supervision.

These actions, which would be carried out by water user associations, would help partially sustain the income of the local population. Jobs would be generated for the rural population, thus helping to diminish migration, avoid increasing impoverishment, and control social problems. For these projects, CNA has invested approximately US$37 million during the 1999 water year.

The areas where these actions will be carried out include districts in the states bordering the United States, districts in the most arid zones of the country, and basins that are shared with the neighboring states of Arizona, Texas, and New Mexico, where the hydrometeorological conditions are similar. In this way, we are advancing our ability to forecast critical situations and conduct risk management in the agricultural sector. If environmental conditions are not as severe as forecast, the plan will be adequate to mitigate the impacts; if the situation is more severe than predicted, the risks may be greater, but the early warnings of drought's occurrence will help prevent and mitigate the damages.

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Using the SPI to Analyze Spatial and Temporal Patterns of Drought in Turkey

Introduction

Drought is a natural phenomenon that has significant economic, social, and environmental impacts. Drought differs from other natural hazards in that its onset and end are difficult to determine. It develops slowly, and its impacts may remain for years after termination of the event. No single definition of drought exists that applies to all circumstances, but most definitions of drought are based on an expression of deficiency of precipitation resulting in water shortage for some activity related to use of water (Wilhite and Glantz, 1985; Dracup et al., 1980). Water resources planners usually rely on quantitative indices to decide whether or not a drought exists. Consequences of drought are usually defined by the impacts that human use systems place on water supply. Drought impacts are usually first apparent in agriculture but gradually move to other water-dependent sectors. Recovery time for water stored in surface and subsurface systems can be quite long under severe drought conditions.

Risk of drought is still a major concern in parts of Turkey where precipitation amounts are low and extremely variable. The combination of rainfall deficiency and other climatic factors, especially high temperature, creates a serious risk of drought in the central and southeastern parts of the country, where agriculture is the main economic sector (Komuscu, 1998). The impacts of drought in the low and variable rainfall regions of the country can be widespread, affecting such diverse sectors as agriculture, irrigation, and energy. In particular, the southeastern Anatolian region, which is the host of the Southeastern Anatolian Project (GAP), may face a serious threat from persisting drought conditions. Moreover,

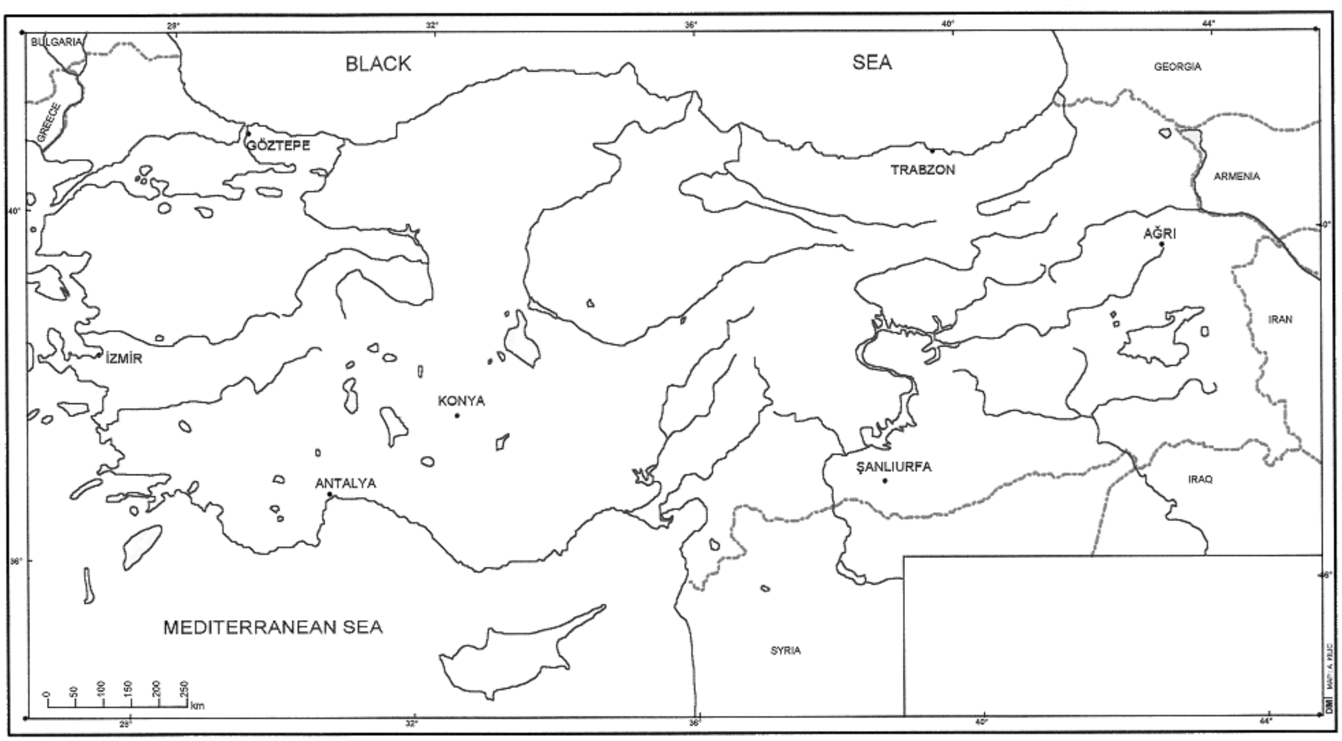

Figure 1. Geographical distribution of the stations selected for the SPI analysis.

the project includes large-scale irrigation, which stimulates higher competition among the water-dependent sectors.

Use of the SPI for drought analysis and monitoring

The impact of rainfall deficiency on water resources varies markedly on a temporal scale for different water storage components of the hydrologic system. While soil moisture responds to precipitation anomalies on a relatively short scale, groundwater, streamflow, and reservoir storage reflect longer-term precipitation anomalies. McKee et al. (1993) developed the Standardized Precipitation Index (SPI) to quantify the precipitation deficit for multiple time scales, reflecting the impact of precipitation deficiency on the availability of various water supplies. They calculated the SPI for 3-, 6-, 12-, 24-, and 48-month scales to reflect the temporal behavior of the impact. The SPI provides a quick and handy approach to drought analysis. Other advantages of this approach are its relative simplicity and minimal data requirements.

Methodology

The SPI is calculated by taking the difference of the precipitation from the mean for a particular time scale, then dividing it by the standard deviation:

$$\text{SPI} = \frac{x_i - \bar{x}_i}{\sigma}$$

The calculations become more complicated when the SPI is normalized to reflect the variable behavior of the precipitation for time scales shorter than 12 months. The normalized series of SPI values represent wetter and drier climates in the same way. McKee et al. (1994) defined the criteria for a drought event for all of the time scales and classified the SPI to define various drought intensities (Table 1).

The SPI is a relatively new index, and it has not been widely applied or tested. In this study, we tested the SPI for different climatic regions and investigated its potential use as a tool for monitoring drought in Turkey.

SPI values	Drought category
0 to -0.99	mild drought
-1.00 to -1.49	moderate drought
-1.50 to -1.99	severe drought
-2.0	extreme drought

Table 1. SPI categories.

Analysis and Results

SPI values have been computed for 40 stations, but only 7 stations representing the different climatic regions across the country will be presented here for 3-, 6-, 12-, and 24-month scales, covering 1940-97 (Figure 1). Figure 2 shows time series of the SPI values computed for Konya station for the 3-, 6-, 12-, and 24-month time scales. Konya is located in the central Anatolian region of Turkey, where the annual rainfall is around 300 mm. The most striking characteristic of the drought is the change in drought frequency as the time scale changes (shown in Figure 2). On longer time scales, drought becomes less frequent but lasts longer. At the 3-month scale, drought frequency increases but its duration decreases. In other words, on shorter time scales, drought becomes more frequent but lasts for shorter periods. Another interesting point shown by Figure 2 is that the SPI responds quickly to wet and dry periods, which means that each new month has a large influence on the period sum of precipitation. This also means more droughts of shorter duration. On the other hand, as the time scale increases, the index responds more slowly. In other words, as the time scale increases, each new month has less impact on the total, which is indicative of fewer droughts of longer duration. Both cases (more droughts but shorter duration, fewer droughts but longer duration) can be interpreted differently for different water resources. For example, soil moisture in the Konya region can be more sensitive to a 3-month drought, but it may take more time to see the effect of drought on underground water resources of the region.

Long-term series of the 3-month SPI values are presented for the 7 stations in Figure 3. It is interest-

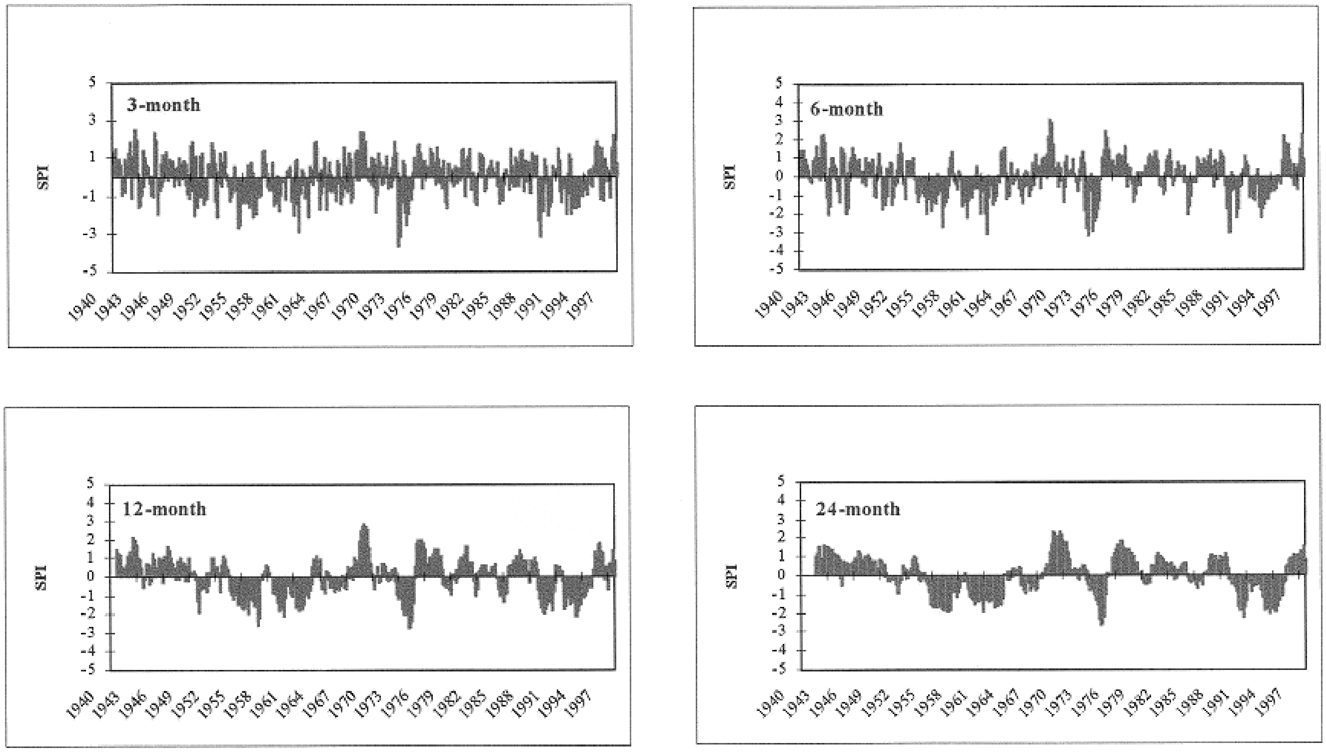

Figure 2. SPI values at varying time scales for Konya station.

ing to note that almost all regions suffer from drought to some degree, but not all the regions experience well-defined droughts during the same periods. In other words, temporal distribution and frequency of the dry periods varies markedly among the regions. Although the dry spans are more persistent and continuous in the coastal stations, the eastern Anatolian station experiences drought at a lower frequency. When we move to 6-month and 12-month SPI time series, the dry spans defined previously expand and occur at lower frequencies (Figures 4 and 5). It is interesting to note that as the time scale increases, drought occurs at higher frequencies at the coastal stations while the inner stations experience longer-duration droughts at lower frequencies, indicating that seasonal droughts are more common in the coastal areas while the interior parts of the country suffer from prolonged droughts. Sanliurfa, the southeastern Anatolian station, differs from the other locations in the sense that it suffers from short-duration but frequently occurring droughts, which may lead to serious adverse impacts for the agricultural activities in the region. Sanliurfa is in the center of the Southeastern Anatolian Project (GAP), which is a massive agricultural and water resources development program within the Turkish portions of the Euphrates and Tigris river basins. The region receives very little rainfall in the summer, creating very dry conditions coupled with high temperatures. Therefore, one of the goals of the project is the irrigation of large areas to reduce the impact of severe droughts.

Table 2 shows the time category of the drought events observed in each station for 3-, 6-, and 12-month time scales. Geographical variations in the time category of droughts present interesting patterns. On a 3-month scale, the coastal stations suffer from mild droughts more often than the interior stations, with the exception of the Sanliurfa station. Interestingly, the coastal stations suffer from severe drought more often than do the interior stations. These similar trends continue on the larger time

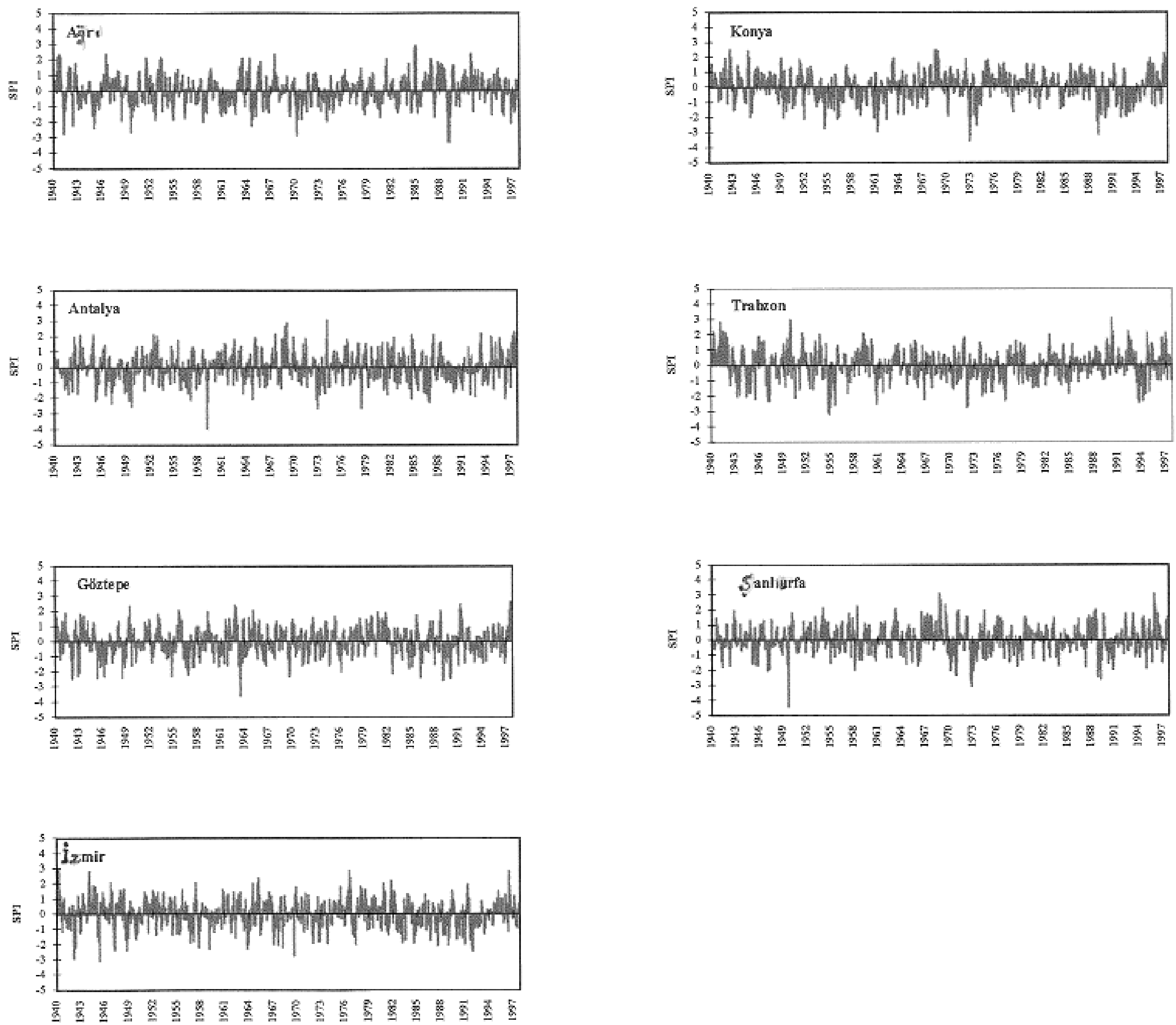

Figure 3. Three-month SPI values for selected stations.

scales. Severe droughts, however, become more common on the 6-month scale in the central parts of the country where rainfall is very low. On the other hand, two Black Sea stations, Trabzon and Göztepe, have the most frequent drought events on a 12-month scale in almost all drought categories. This indicates that coastal parts of the country are affected by both short- and long-duration droughts at different levels while the interior stations are under the influence of long-lasting mild droughts. The most interesting results are observed in the Sanliurfa station, located in the center of the GAP. This station is affected mainly by mild droughts. It is not affected by severe droughts as much as the coastal stations are, although it receives less rainfall.

In this study, we presented a brief drought analysis using the SPI and demonstrated its potential use for drought analysis with minimal data requirements. It is our view that development of a drought monitoring system, based largely on meteorological and climatic information, can be a great help for early assessment of drought impacts in Turkey. In this

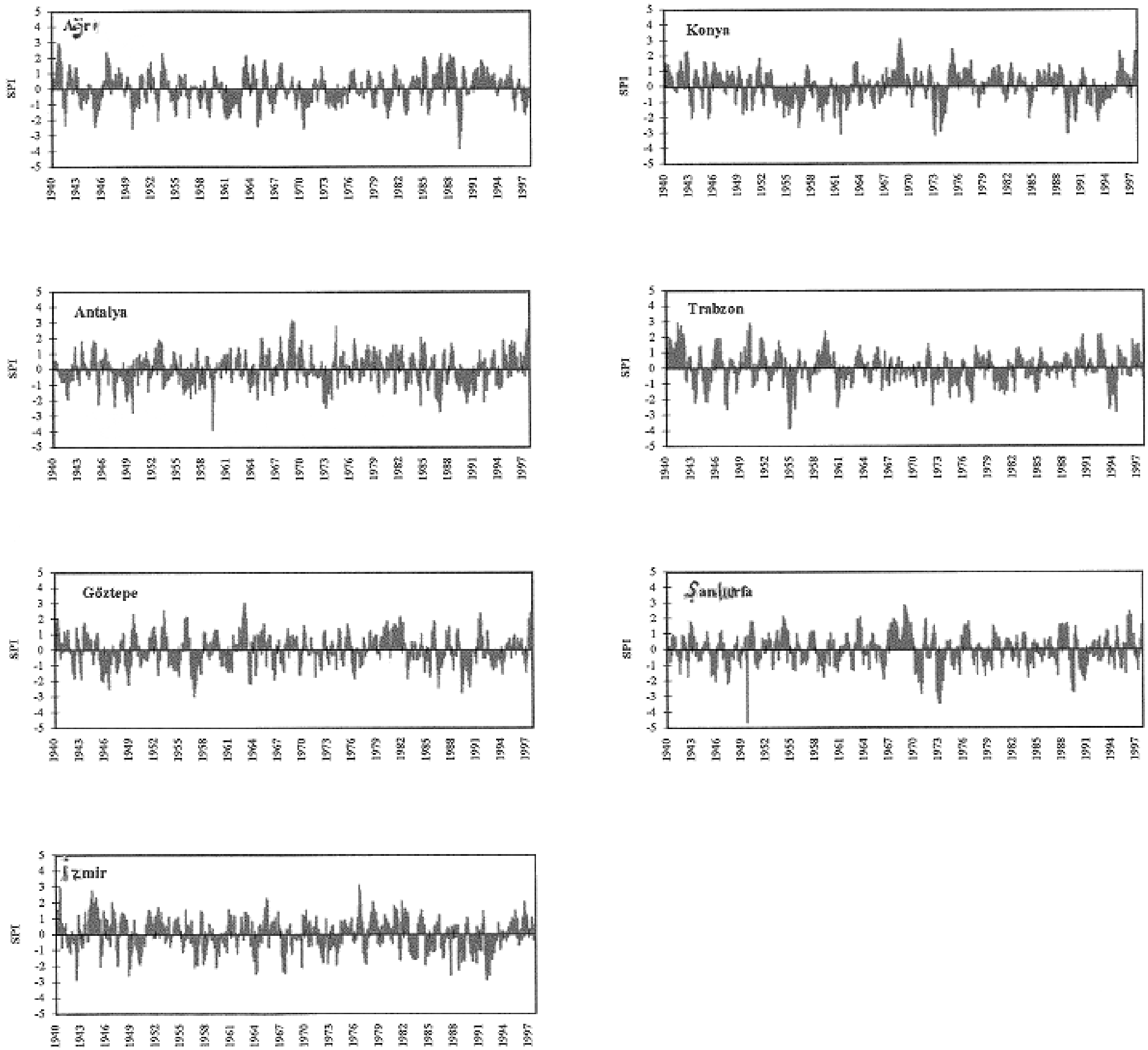

Figure 4. Six-month SPI values for selected stations.

sense, the SPI can be a valuable tool for monitoring climatic conditions, particularly in drought-prone areas of the country.

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References

Dracup, J. A.; K. S. Lee; and E. G. Paulson, Jr. 1980. "On the definition of droughts." *Water Resources Research* 16:297–302.

Komuscu, A. U.; A. Erkan; and S. Oz. 1998. "Possible impacts of climate change on soil moisture variability in the Southeast Anatolian Development Project (GAP) Region: An analysis from agricultural drought perspective." *Climatic Change* 40:519–545.

McKee, T. B.; N. J. Doesken; and J. Kleist. 1993. "The relationship of drought frequency and duration to time scales." *Preprints*, Eighth Conference on Applied Climatology, January 17–22, Anaheim, California, pp. 179–184.

McKee, T. B.; N. J. Doesken; and J. Kleist. 1994. "Drought monitoring with multiple time scales." *Proceedings of the Ninth Conference on Applied Climatology*, pp. 233–236. American Meteorological Society, Boston.

Wilhite, D. A.; and M. H. Glantz. 1985. "Understanding the drought phenomenon: The role of definitions." *Water International* 10:111–120.

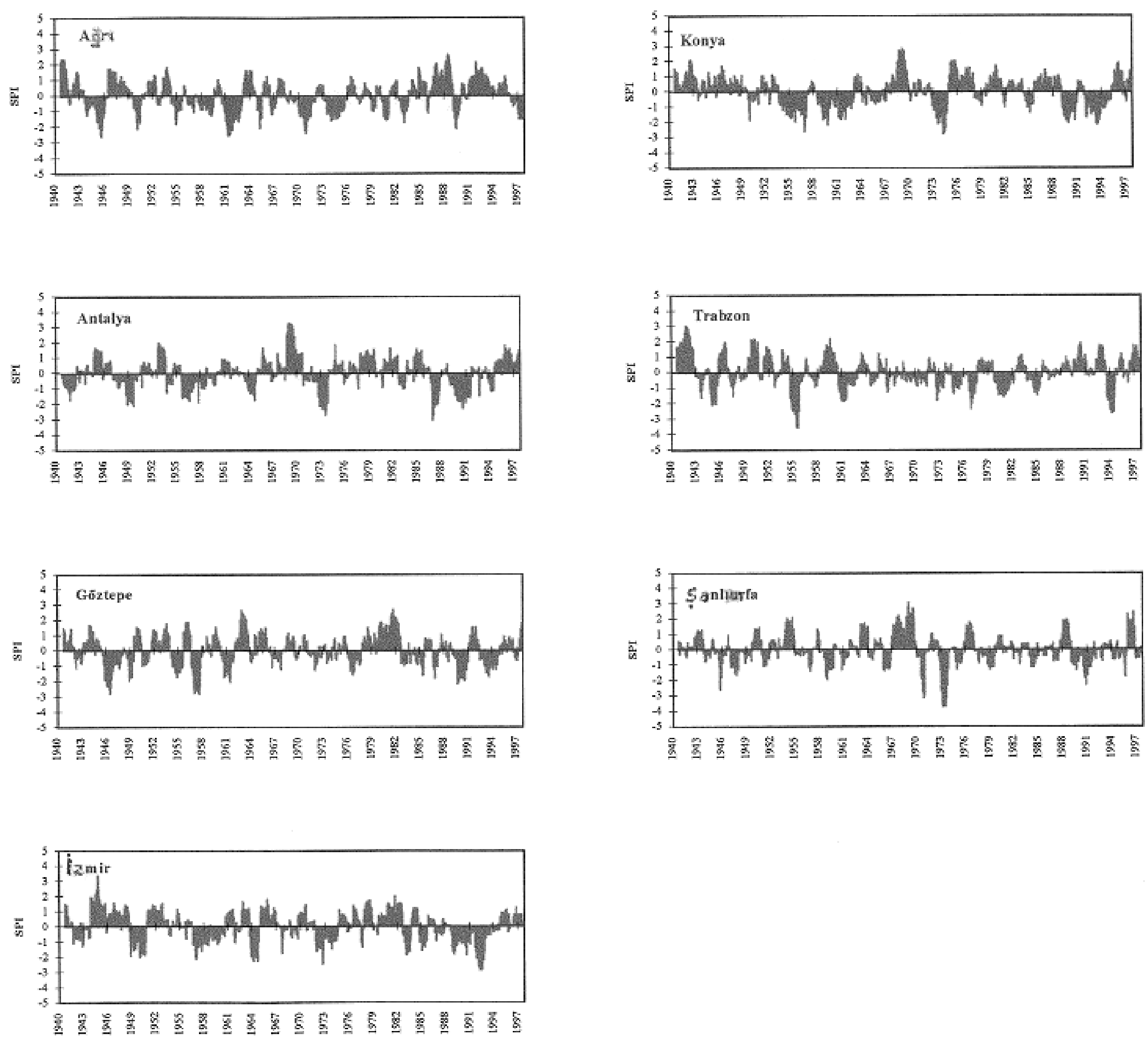

Figure 5. Twelve-month SPI values for selected stations.

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SPI	Drought category	Time (%) (3 mo.)	Time (%) (6 mo.)	Time (%) (12 mo.)
0 to -0.99	mild	32.2	31.8	31.3
-1.00 to -1.49	moderate	10.8	10.8	10.3
-1.50 to -1.99	severe	3.9	3.9	4.6
≤-2.0	very severe	1.8	2.1	2.6

KONYA

SPI	Drought category	Time (%) (3 mo.)	Time (%) (6 mo.)	Time (%) (12 mo.)
0 to -0.99	mild	31.7	30.5	28.1
-1.00 to -1.49	moderate	8.6	9.2	9.2
-1.50 to -1.99	severe	4.1	3.6	6.2
≤-2.0	very severe	3.0	3.4	2.3

ANTALYA

SPI	Drought category	Time (%) (3 mo.)	Time (%) (6 mo.)	Time (%) (12 mo.)
0 to -0.99	mild	33.8	34.7	32.4
-1.00 to -1.49	moderate	9.2	8.1	5.7
-1.50 to -1.99	severe	3.6	4.2	6.2
≤-2.0	very severe	2.6	2.7	2.7

TRABZON

SPI	Drought category	Time (%) (3 mo.)	Time (%) (6 mo.)	Time (%) (12 mo.)
0 to -0.99	mild	34.4	36.1	39.8
-1.00 to -1.49	moderate	7.6	6.9	5.6
-1.50 to -1.99	severe	3.7	3.9	4.2
≤-2.0	very severe	3.3	3.1	3.2

GÖZTEPE

SPI	Drought category	Time (%) (3 mo.)	Time (%) (6 mo.)	Time (%) (12 mo.)
0 to -0.99	mild	32.8	34.1	35.3
-1.00 to -1.49	moderate	10.3	10.1	7.1
-1.50 to -1.99	severe	3.1	4.3	4.5
≤-2.0	very severe	3.0	2.0	2.9

SANLIURFA

SPI	Drought category	Time (%) (3 mo.)	Time (%) (6 mo.)	Time (%) (12 mo.)
0 to -0.99	mild	37.7	34.0	39.1
-1.00 to -1.49	moderate	7.5	7.9	9.3
-1.50 to -1.99	severe	4.0	3.3	2.1
≤-2.0	very severe	1.7	2.9	2.0

İZMİR

SPI	Drought category	Time (%) (3 mo.)	Time (%) (6 mo.)	Time (%) (12 mo.)
0 to -0.99	mild	32.7	31.8	29.2
-1.00 to -1.49	moderate	8.7	8.8	10.0
-1.50 to -1.99	severe	3.6	5.2	5.1
≤-2.0	very severe	2.7	2.9	2.4

Table 2. Time category of the drought events for 3-, 6-, and 12-month time scales for the selected stations.

Rainfall Climatology of Jammu and Kashmir State, India

We have written a number of articles on various aspects of weather characterization and forecast verification under temperate environments of Jammu and Kashmir (India). We have also touched on some of the approaches that might help in solving climatically triggered problems (Hasan and Kanth 1997). Fortunately, we were lucky enough to make significant progress in some (if not all) of the approaches. The present article focuses on an analysis of rainfall/ precipitation in this state of the Indian Union under different agroclimatic zones, with an update on forecast verification analysis of temperate Kashmir (India) during 1997–98.

India is classified into agroclimatic zones or major agro-ecological regions (Figures 1 and 2). By definition, an agroclimatic zone is a land unit, in terms of major climate and growing period, that is climatically suitable for a certain range of crops and cultivars (FAO, 1983). An ecological region is characterized by distinct ecological responses to macroclimate as expressed in vegetation and reflected in soils, fauna, and aquatic systems. Several attempts have been made to classify our land area into climatic regions or zones, and these are well documented (Sehgal et al., 1992). The important point is the degree of recognition that has been given to these various approaches and their use in promoting the objectives of effective agriculture, macro-level land use planning, and effective transfer of agrotechnology. Two approaches seem to meet these objectives—the National Agricultural Research Project (NARP) approach (Figure 1) and the recent Agro-Ecological Region approach (Figure 2). In the NARP approach, state universities were advised to divide each zone/state into subzones; accordingly, 129 subzones were delineated for India, based pri-

Zone/ Station	Position (lat./long.)	No. of years of data	Annual precipitation
Subtropical			
Jammu	32.40°N/74.50°E	58	1,088
Udhampur	32.55°N/75.05°E	65	1,510
Intermediate			
Ramban	33.15°N/75.15°E	62	1,118
Kisthwar	33.15°N/75.45°E	53	865
Akhnoor	32.53°N/74.44°E	54	1,144
Punch	33.47°N/74.07°E	53	1,486
Reasi	33.05°N/74.50°E	65	1,668
Temperate			
Srinagar	34.05°N/74.50°E	70	635
Sonemarg	34.19°N/75.19°E	62	1,710
Avantipora	33.53°N/74.54°E	64	577
Anantnag	33.45°N/75.05°E	61	608
Kulgam	33.38°N/75.01°E	68	845
Baramulla	34.12°N/74.22°E	66	904
Badgam	33.50°N/74.35°E	59	570
Shalimar	34.08°N/74.83°E	18	835
Cold arid			
Dras	34.26°N/75.46°E	58	556

Table 1. Mean annual precipitation (mm) of important stations. Source: IMD, Pune India.

marily on rainfall, existing cropping patterns, and administrative units. The Jammu and Kashmir state was thus divided into 4 zones (Figure 1). In the agro-ecological region-based approach, recognition was given to the climatic conditions, length of growing period, land form, and soils (Sehgal et al., 1992) (Figure 2). Thus India has been divided into 20 agro-ecoregions. The Jammu and Kashmir state comprises 3 regions, as depicted in Figure 2. The crop distribution in the state is shown in Figure 3.

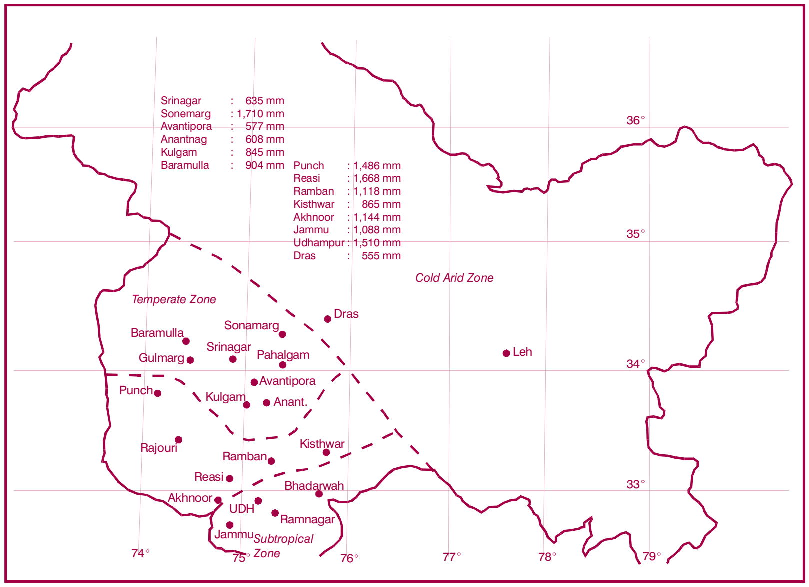

Figure 1. Agroclimatic zones of Jammu and Kashmir (NARP), with average rainfall for selected places. Not to scale.

Total rainfall analysis

Rainfall has been analyzed in various ways, including studying the mean total rainfall for the entire year from different stations (Figure 1 and Table 1). This analysis has been confined mainly to the southwestern region of the state because of lack of meteorological data. In spite of this, the data available from some of the representative sites in each zone seems to be sufficient for an objective characterization. We see that there is a lot of variation within the state and further within each zone (Figure 1). For example, minimum rainfall occurs in the cold arid zone (556 mm) and maximum rainfall occurs in the temperate zone (1,710 mm). Within the temperate zone itself, there is a lot of variation between sites that are in proximity or located at similar latitudes/longitudes. For example, Baramulla and Sonemarg are located at almost the same latitude but differ in precipitation by 800 mm. The same is true in the intermediate zone, where the difference between Kisthwar and Reasi stations is as high as 1,000 mm.

Assured weekly rainfall analysis

The India Meteorological Department (IMD) in Pune has done a commendable job of analyzing the weekly rainfall data available for the period 1901–85. The analysis was performed by fitting a theoretical distribution to the available data series and then determining the frequency of different amounts from this distribution. Of the theoretical distributions, normal distribution is the easiest to handle and, if applicable, yields quicker results. But in the case of weekly rainfall, the distribution is generally skewed. To overcome this skewness, and because of some other important limitations of the available data on weekly totals (abnormally high total rainfall for any week, occurrence of a number of zero rainfall cases, etc.), an incomplete gamma distribution model was used by the IMD for carrying out weekly rainfall probability analysis. This is expressed as

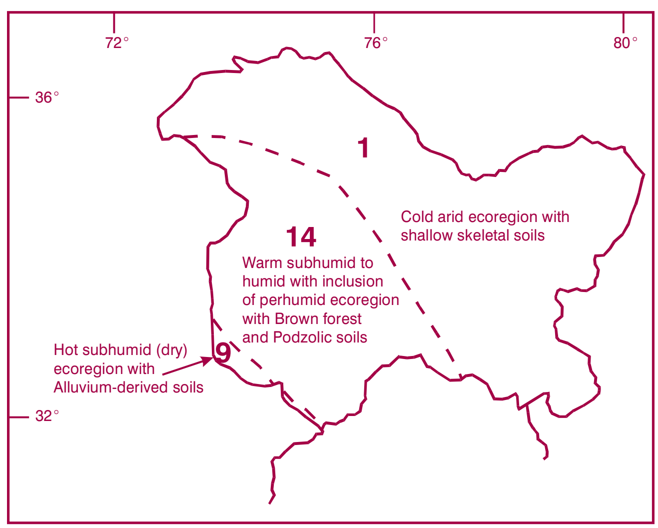

Figure 2. Agro-ecological regions of Jammu and Kashmir. Not to scale.

SMW	JAMMU (subtropical) 70%	50%	30%	PUNCH (intermediate) 70%	50%	30%	ANANTNAG (temperate) 70%	50%	30%	DRAS (cold arid) 70%	50%	30%
17	0	0	5	0	6	21	2	8	19	3	13	28
18	0	0	2	0	3	17	1	5	14	1	5	14
19	0	0	4	0	8	22	1	7	16	0	6	16
20	0	0	4	1	10	23	2	9	21	0	4	10
21	0	0	4	0	7	17	0	3	11	2	6	13
22	0	0	3	0	3	16	0	1	8	0	1	7
23	0	0	6	0	4	22	0	1	7	0	0	4
24	0	2	13	0	16	30	0	2	10	0	0	2
25	0	3	16	5	18	34	0	1	8	0	1	3
26	2	11	27	8	21	39	0	2	8	0	0	1
27	8	24	49	16	34	58	0	2	6	0	0	0
28	22	45	81	30	48	71	0	2	8	0	0	3
29	37	59	90	47	69	97	1	8	18	0	0	1
30	56	89	137	51	81	122	3	9	19	0	0	4
31	52	82	120	47	69	97	1	8	18	0	0	1
32	40	70	115	44	70	103	1	7	13	0	0	1
33	27	50	80	32	51	76	1	5	12	0	1	3
34	22	45	74	21	36	57	1	6	13	0	1	4
35	11	30	58	15	38	72	0	3	16	0	0	3
36	3	18	51	4	18	40	0	0	4	0	0	2
37	0	10	35	5	22	48	0	1	8	0	0	2
38	0	0	10	0	12	24	0	0	4	0	0	2
39	0	1	9	0	0	14	0	0	6	0	0	2
40	0	0	1	0	0	8	0	0	2	0	0	2

Table 2. Assured rainfall amounts (mm) at different percentages of probability levels (from representative stations in each zone). SMW = standard meteorological weeks. Source: IMD Pune India.

Error structure	Summer —55 reports day 1	day 2	day 3	Overall	Winter —29 reports day 1	day 2	day 3	Overall
Correct	6	11	9	26 (47.3)	5	6	6	17 (58.6)
Usable	2	0	2	4 (7.2)	0	0	0	4 (13.8)
Total usable	8 (27)	11 (36.5)	11 (36.5)	30 (54.5)	5 (23.8)	6 (28.6)	10 (47.6)	21 (72.4)
Unusable	11	7	7	25 (45.5)	4	4	0	8 (27.6)
RMSE	16.9	14.4	9.3	14.0	9.9	8.5	3.3	7.7
Ratio score	68.4	83.3	72.2	74.5	66.7	70.0	80.0	72.4
H.K. score	0.42	0.65	0.42	0.51	0.1	0.25	0.75	0.54

(figures in parentheses indicate percent)

Table 3. Forecast verification analysis of precipitation at Shalimar (temperate zone) during 1997–98 summer and winter seasons. Source: Experimental Agromet Advisories Services (NCMRWF) Annual Report 1997–98, Division of Agronomy, SKUAST, Shalimar, Kashmir, India.

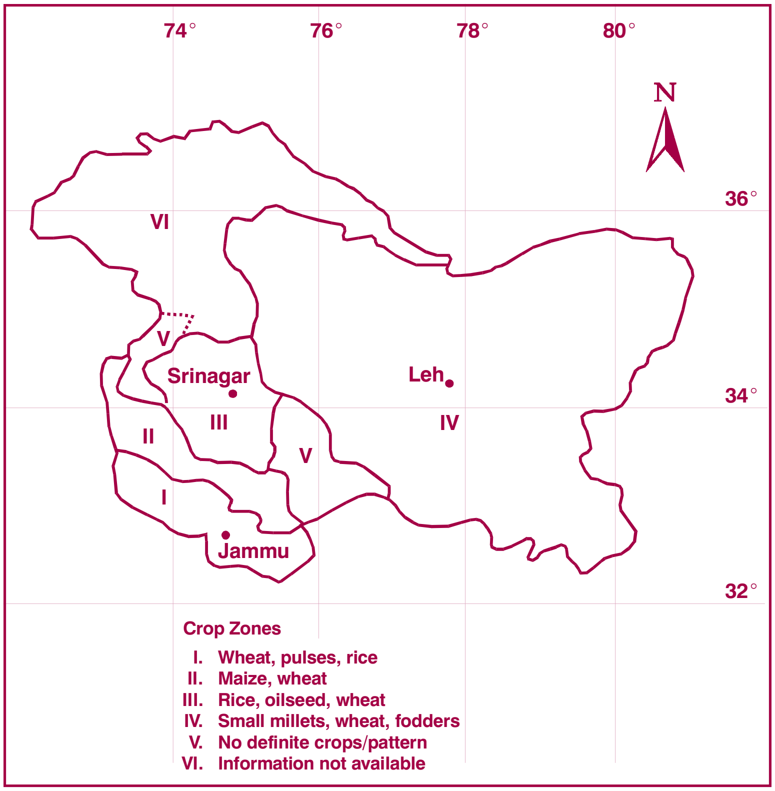

Figure 3. Crop zones of Jammu and Kashmir. Not to scale.

$$H(X) = q + pF(X)$$

where F(X) is the gamma distribution function, q is the probability of zero precipitation cases, and p = 1-q.

Eighteen stations have been analyzed in the state, and the results from representative stations of each zone are shown in Table 2. It is obvious from this table that different amounts of weekly rainfall are expected at different probability levels between the last week of April and the first week of October (i.e., meteorological weeks 17–40). Assured rainfall amounts decrease with the increase in probability levels from 30% to 70%. A zonal analysis of representative stations showed different trends. For example, in Jammu (representing subtropical zones) and Punch (representing intermediate zones), higher rainfall is expected between 26 and 36 meteorological weeks for the temperate zone, although the weekly totals were comparatively lower. For the cold arid zone, however, there is a very narrow time period of assured rainfall (17–20 meteorological weeks).

Table 3 depicts the forecast verification analysis recently carried out for precipitation at Shalimar (temperate zone). This was performed using the procedure mentioned earlier (Hasan and Kanth, 1997). The number of usable forecasts was higher during winter than summer (72.4% vs. 54.5%). In the present case, the precipitation events could be more reliably forecasted for day 2 and day 3 in both summer and winter, and this result is different from the trends observed earlier, wherein forecasts were more reliable for day 1 (Hasan and Kanth, 1997).

For agricultural planning and complex hydrological problems, knowledge of the characteristics of rainfall is a must. Long-term averages of annual, monthly, and weekly rainfall are quite useful and have widespread applications in regions/years of normal rainfall. But in regions of uncertain precipitation, like the one we have just reviewed, or in an arid/semiarid climate, one cannot fully depend on averages. Many agricultural operations revolve around the probability of receiving a definite amount of rainfall, and such an analysis can be useful for land use planning, identification of crop growing periods, choice of cropping pattern, and resource allocation.

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References

Anonymous. 1995. *Weekly Rainfall Probability for Selected Stations of India*, Vol. I and II. ADGM (Agric. Met.) IMD, Pune 411005, India.

FAO. 1983. “Guidelines: Land evaluation for rainfed agriculture.” *Soils Bulletin* 52, FAO, Rome.

Hasan, B.; and R. H. Kanth. 1997. “Climatic uncertainties and recent experience in medium-range weather forecasting over Kashmir.” *Drought Network News* 9(1): 12–14.

Sehgal, J.; D. K. Mandal; C. Mandal; and S. Vadivelu. 1992. *Agro-Ecological Regions of India*, II Edition. Tech. Bull., NBSS&LUP, Pub. 24, p. 130, NBSS&LUP, Nagpur 440 010, India.

Heat Waves and Floods across Asia: *Was El Niño, then La Niña the Cause?*

Unprecedented heat wave conditions occurred during May–June 1998 across Asia. Unusually high temperatures were recorded in western India, Pakistan, eastern China, Japan, and Southeast Asia. Even the United States, western Africa, eastern Canada, and western Australia experienced the blistering heat spell.

Some reports blame people for the global warming. The world is warming because of the burning of fossil fuels and deforestation, resulting in an increase in carbon dioxide in the atmosphere. The 1998 heat wave prompted the United Nations Environment Programme to issue an urgent warning and a wake-up call to limit the emission of global warming gases. The year 1998 may in fact be the hottest year of this millennium.

While one view clearly suggests "a discernible human influence on climate," another view blames the recent El Niño for the 1998 heat wave. Besides being associated with floods and droughts in its severe forms, El Niño can also affect other meteorological phenomena, possibly including abnormal increases in temperature. Scientists at the National Oceanic and Atmospheric Administration (NOAA) say that the recent El Niño is largely responsible for the record high temperatures in 1998. NOAA scientists also say that the El Niños are occurring more frequently and are progressively warmer. There is evidence to suggest that global temperature may be linked to stronger and more frequent El Niños.

During an El Niño, excess heat is concentrated in the waters of the tropical Pacific. The current El Niño reached its maximum peak around December 1997, when sea surface temperature (SST) anomalies (actual temperature minus the mean temperature) were maximum. Thereafter, SSTs continued to decrease, and after May 1998, the decrease was sharp. Figure 1 illustrates this point. This figure depicts SST anomalies from November 1997 through November 1998 for the region designated as NINO

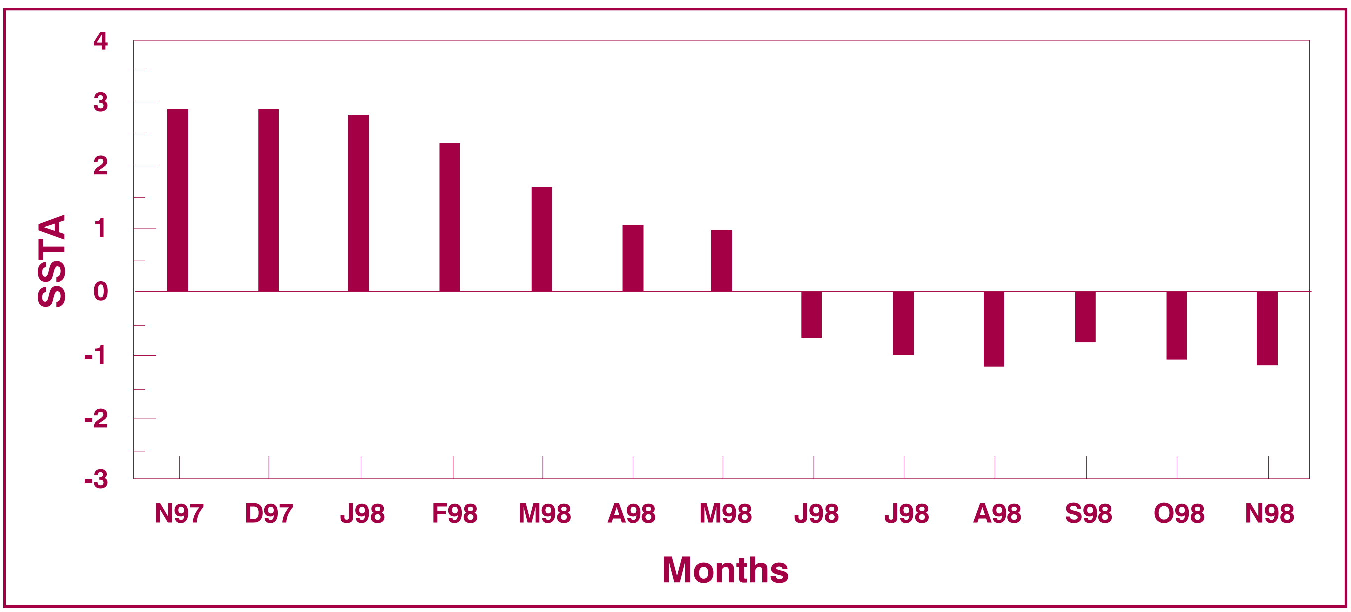

Figure 1. Monthly sea surface temperature anomalies (SSTA) over the NINO 3.4 (5° N–5° S, 170° W–120° W) region, November 1997–November 1998. Source: NOAA/NWS/NCEP, *Climate Diagnostics Bulletin 1998*, No. 98/11.

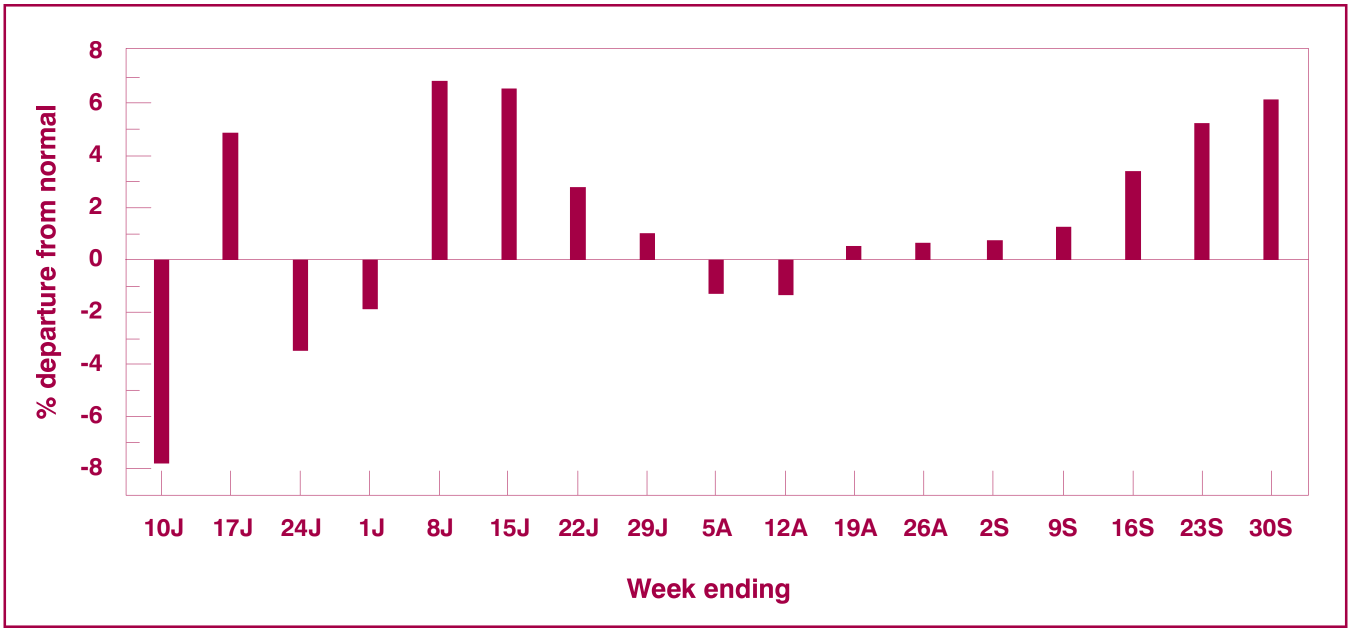

Figure 2. Weekly cumulative area weighted Indian monsoon rainfall (percentage departure from long-term mean) for week ending 10 June through 30 September 1998. Source: India Meteorological Department.

3.4 (5° N–5° S, 170° W–120° W). It shows that the temperatures have been declining, and after June 1998, moderate cold episode (La Niña) conditions commenced. Thus the weakening of the warm episode (El Niño) and the entry of the cold episode (La Niña) must have liberated a huge amount of heat from the tropical Pacific. The effects of this heat are carried around the globe by atmospheric circulation. This could be one reason for the unprecedented 1998 heat wave.

After the heat wave, which claimed thousands of lives in May and June, monsoon floods during July–September 1998 left a trail of death and destruction in their wake. Monsoon rains played havoc with parts of northern India, particularly the northeastern region. The world-famous Kaziranga National Park for animals was submerged under 18 feet of water, leaving no animals behind in the 430 square kilometers of the Park. Many other animals perished in the flooding, which was worse than the great flood of 1988. Floods in July–August 1998 inundated three-quarters of Bangladesh—the worst flooding in Bangladesh's history. China also experienced its worst flooding in decades. The flood peak in the Yangtze River was the second largest since 1954. In South Korea, flooding was caused by the heaviest August rains in 27 years. In Japan, the heaviest rain in more than 80 years (since 1914) deluged the north central part of the country. Borneo also reported floods after the torrential rains. Indonesia, which suffered devastating droughts and forest fires because of El Niño, was hit by heavy rains and floods. The entry of La Niña may have triggered these floods.

The Indian monsoon rainfall (IMR) was normal up to the end of July 1998. After that, the cumulative area weighted rainfall for India showed a monotonic increase. Figure 2 illustrates this point; it shows the cumulative rainfall, as percentage departure from normal, at the end of each week. The total seasonal IMR for the period June–September 1998 was 106% of the long-term average (905 mm, compared to the normal of 852 mm). The tropical Pacific entered into a La Niña phase after June (Figure 1), and the IMR showed a monotonic increase in rainfall after August (Figure 2). In a recent article published in *Drought Network News* (Kripalani and Kulkarni, 1998b), it was suggested that following the severe 1997 El Niño, the IMR for 1998 could be more than 900 mm.

An analysis of IMR for the period 1871–1998 reveals that the IMR exhibits epochal variability. The periods 1880–95 and 1930–63 are characterized by above-normal rainfall with very few droughts, while the periods 1895–1930 and 1963–90 depict below-normal rainfall with frequent droughts (see Kripalani and Kulkarni, 1996 and 1997). A study by Kripalani and Kulkarni (1997) has shown that whereas the impact of El Niño is more severe on IMR during the below-normal rainfall epochs, the impact of La Niña is more severe during the above-normal rainfall epochs. The IMR has entered into an above-normal epoch, with a turning point around 1990. This may be one reason that the impact of El Niño on IMR after the 1990s has not been severe (see Kripalani and Kulkarni, 1997 and 1998a). If the current La Niña conditions over the tropical Pacific continue until the 1999 monsoon (June–September), it will be conducive to very good monsoon activity over India since the above-normal rainfall epoch and the state of the ENSO (El Niño/Southern Oscillation) phenomenon in the tropical Pacific will be in the same phase.

From the above considerations, it appears that El Niño and La Niña were dominant factors in the blistering heat wave and the devastating floods.

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References

Kripalani, R. H.; and A. Kulkarni. 1996. "Assessing the impacts of El Niño and non-El Niño-related droughts over India." *Drought Network News* 8(3):11–13.

Kripalani, R. H.; and A. Kulkarni. 1997. "Climatic impact of El Niño/La Niña on the Indian monsoon: A new perspective." *Weather* 52:39–46.

Kripalani, R. H.; and A. Kulkarni. 1998a. "India, Indonesia experiencing opposite effects from 1997 El Niño." *Drought Network News* 10(1):6.

Kripalani, R. H.; and A. Kulkarni. 1998b. "No droughts over India following very strong El Niño episodes." *Drought Network News* 10(2):14.

Announcements

International Symposium on High Altitude and Sensitive Ecological Environmental Geotechnology

The International Symposium on High Altitude and Sensitive Ecological Environmental Geotechnology will be held at Nanjing University, Nanjing, People's Republic of China, August 24–27, 1999. The conference is jointly supported by the Advanced Computational Engineering Institute for Earth Environment (ACEI) of Nanjing University, China; Center for Environmental Engineering, Science and Technology (CEEST) of the University of Massachusetts, USA; Center for Water Environmental Studies, Ibaraki University, Japan; and China National Science Foundation, Beijing.

The purpose of the symposium is to foster the advancement of environmental geotechnology, with special reference to high altitude and sensitive ecological environment, by providing a forum for participants from diverse disciplines to exchange ideas and information. Topics include Arid Lands; Desert Regions; Antidesertification Measures; and Soil Water Conservation and Decontamination. For more information, contact Eleanor Nothelfer, Fritz Engineering Laboratory, Lehigh University, 13 E. Packer Avenue, Bethlehem, PA 18015–3176, USA; or Mr. Baojun Wang, Dept. of Earth Sciences, Nanjing University, Nanjing 210093, China.

5th International Symposium on Environmental Geotechnology and Global Sustainable Development

The 5th International Symposium on Environmental Geotechnology and Global Sustainable Development will be held August 17–21, 2000, in Belo Horizonte, Minas Gerais, Brazil. Representatives from mining companies, government agencies, and universities have collaborated to plan this symposium.

Geoenvironmental research advances, technological innovation, and appropriate technology transfer are important elements of sustainable development; this symposium will address relevant technical and policy issues to provide a forum for discussion and information exchange. Symposium topics include Agriculture and the Geoenvironment; Environmental Impact Assessment; Geotechnical Aspects of Regional Sustainable Development; Watershed Management and Land Use Planning; Global Warming Issues; Financial Impact of Environmental Techniques in Industrial and Agricultural Projects; Assimilative Capacity Modeling of Water Systems; Regional and Municipal Environmental Policies; National and International Environmental Policies; and Socioeconomic Aspects of Natural Resources Management. For more information, contact the Symposium Secretary, 5th International Symposium on Environmental Geotechnology and Global Sustainable Development, Departamento de Engenharia de Transportes e Geotecnia, Escola de Engenharia da Universidade Federal de Minas Gerais Avenida do Contorno, 842 sala 104, Belo Horizonte, Minas Gerais, CEP 30 110-060–Brazil; fax: +55 31 2381793; phone: +55 31 2381742; e-mail: cassia@etg.ufmg.br; WWW: http://www.5iseggsd.eng.ufmg.br.

10th Global Warming International Conference & Expo (GW10)

The 10th Global Warming International Conference & Expo (GW10) will be held in Fujiyoshida, Yamanashi, Japan, at the foot of Mt. Fuji, May 5–8, 1999. The conference is hosted by the Global Warming International Center (GWIC-USA) and the Yamanashi Institute of Environmental Sciences.

As a result of the UNCED in Rio de Janeiro in 1992 and the COP_3 in Kyoto in 1997, participants in industry and nongovernmental and governmental organizations are beginning to define and identify strategies, methods, and technologies to mitigate global warming and environmental pollution locally and globally. Sessions include Global Warming and Climate Change; Global and Regional Natural Resource Management; Strategies for Mitigation of Greenhouse Gas Emissions; Policy and Economics; Energy, Transportation, Minerals and Natural Resource Management; Global Warming and Public Health; Global Warming and Biometeorological Adaptation; Ocean and Global Warming; Natural Resource Management and Carbon Budget; Global Surveillance and Remote Sensing; and Sustainable Environment and Health for the 21st Century.

For more information, contact The Global Warming International Center, P.O. Box 5275, Woodridge, IL 60517, USA; phone: +1 (630) 910–1551; fax: (630) 910–1561; WWW: http://www.GlobalWarming.net.

New Book

The findings of a new book, *Climate, Change and Risk*, highlight the need for greater planning to cope with the forecast increase in risk of climatic hazards. The book is edited by Dr. T. E. Downing (Environmental Change Unit, University of Oxford), A. A. Olsthoorn, and R. S. J. Tol (both from the Institute of Environmental Studies, Vrije Universiteit, Amsterdam).

The recent increase in the number and cost of weather disasters around the world has caused widespread concern about the impacts of climatic hazards. *Climate, Change and Risk* brings together research on climatic hazards and climate change and focuses on societal responses and insurance rates. It considers the nature and scale of climate hazards in the future; impacts that will result from climatic hazards; the most effective responses; and the best methods of studying current climatic risks and future changes.

The book is intended for researchers and practitioners concerned with climate change adaptation, weather hazards, and disaster management. It is published by Routledge Press, Routledge Limited, 11 New Fetter Lane, London EC4P 4EE, United Kingdom.

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Drought Network News encourages readers to submit information on current episodes of drought and its impacts; timely reports of response, mitigation, and planning actions of governments and international organizations (successes *and* failures); recent research results and new technologies that may advance the science of drought planning and management; recent publications; conference reports and news of forthcoming meetings; and editorials. If references accompany articles, please provide *full bibliographic citations*. All artwork *must* be *camera-ready*—please provide clear, sharp copies (in black/gray and white only—we are unable to reproduce color artwork) that can be photocopied/reduced without losing any detail. Correspondence should be addressed to

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