DROUGHT MANAGEMENT AND PREVENTION IN PAKISTAN

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ABSTRACT

Pakistan has a long latitudinal extent, and the rainfall variability during different seasons is considerably high. Some regions of the country, in each season, remain drastically dry and are vulnerable to drought. If subsequent seasons also fail to generate significant precipitation, the drought conditions are then sure to take the regions in grip. Such conditions are often seen affecting the country, specifically the southern half of the country. The country recently remained under the grip of a severe drought during the period 1998 to 2000, which disrupted the economy badly, besides human and livestock killings.

In view of the fact that the country mostly consists of arid, semiarid and even hyperarid regions, the susceptibility of different regions to become drought-stricken is always very high. Drought is a natural event and the risk associated with drought is a product of both the region's exposure and the vulnerability of society to the event. For its management and prevention, the following aspects, thus, seem essential for study:

- *Drought vulnerable areas be identified, using the meteorological data.*
- *The causes of droughts be highlighted.*
- *Possible mitigation strategies be discussed .*

It has been tried to cover the above aspects in this paper, which would help promote further investigations in the field.

INTRODUCTION

Drought, in general, means dryness due to lack of precipitation over an extended period of time. Drought has the greatest potential impact, as compared to other major disasters like floods, tropical cyclones, earthquakes, etc., as the latter are mostly of short duration and geographically limited, while drought, by contrast, affects large geographical areas often covering the whole of the countries or even parts of continents.

Frequency of drought occurrence, when compared to other disasters, was found to be 2 to 3 times less, but the killings reported were much higher when seen on the global basis, as is shown in Annexure-I. Frequency of occurrence of drought in Pakistan, on the years. Pakistan has a previous history of droughts, too, but it was recently hit by a severe long spell of drought, during the period 1998-2000. Economic, social and environmental degradation costs and losses associated with the drought were very high. The Southern parts of the country below 30°N, particularly parts of Southern Punjab, Sindh & Balochistan, were adversely affected.

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Because of the long latitudinal extent of the country from 24°N to 37°N, the country has a diversified climate, which consist mostly of arid and semiarid regions, besides some hyper-arid regions, on account of the natural deserts within 25° to 30°N. There are two rainy seasons, namely winter (December to March) and summer monsoons (June to September) and two transition periods having almost insignificant rains. The rainfall pattern is highly variable. Estimated weighted precipitation over Pakistan and its provinces is shown in Annexure-II In each season, there is at least one region, which on the average, remains dry for more than 50% of the time and, even for the remaining period, rainfall is so insignificant that the region may be termed as vulnerable to drought. If the subsequent rainfall seasons also fail to generate sufficient rains, the region becomes drought-stricken. Such a situation can be predicted well before time if the monitoring and early-warning system is authentic and reliable. Drought is mostly referred to as a creeping disaster, as its effects often accumulate slowly. Consequently, forecasts of the order of atleast a season can be made and can help policy-makers at all levels in making critical management decisions.

DROUGHT-VULNERABLE AREAS

There are two marked rainfall seasons, namely winter (December to March) and summer monsoons (June to September). "April to May" and "October to November" are

the transition periods. Rainfall is significantly less during these transition periods, as compared to the rainy seasons in winter and summer.

A comparison of the weighted precipitation is shown in Table-1.

Table-1: Estimated Weighted Precipitation (1961-90)				
PERIOD	N.W.F.P.	PUNJAB	BALOCHISTAN	SINDH
Dec. to Mar	228.8	81.1	69.3	14.2
Jun to Sept.	252.9	260.3	64.2	137.5
Apr to May	106.5	36.5	20.1	5.5
Oct. to Nov	37.7	11.3	4.8	4.4

The table indicates high variability of rainfall in different provinces during various seasons, leaving at least some portions of the country remaining almost under stress for rains. Further, the rainfall variations in northern and southern Punjab and in Western, Central and Coastal areas of Balochistan are also very significant, as can be seen in the isohyetal maps for different seasons (Annexure III, V, VII & IX).

In order to mark drought-vulnerable areas, maps showing the driest periods, in percentage, have been prepared and annexed. (Annexure IV,VI,VIII & X). Areas remaining dry for more than 50% of the time have been termed as vulnerable to drought. Rainfall activity in different seasons over the country is discussed below.

N. and are responsible for bringing rainfall in the country. On their way lie the Himalayan mountains which, because of their topography, help in extracting the moisture from the western disturbances and make the belt within 34° N to 36 receive maximum rainfall. At times, these disturbances induce secondaries in the lower latitudes (25°-30°N). These pull moisture from the Arabian Sea and produce reasonably good amount of rainfall over submontane regions in the northern parts of the country, but comparatively much less rains over Southern Punjab and over parts of Balochistan. Most parts of the central, southern and eastern parts of Sindh which do not fall within the domain of winter rains, remain dry more than 50% of the time and are termed as a zone vulnerable to drought during this season. It is here clarified that a place remaining more than 50% dry means that, out of 30 years (the period of the data), the place received zero rainfall in more than 15 years. Even during the remaining part of 30 years, the rainfall remained drastically low.(See Annexure III & IV). A comparative statement of weighted precipitation over the different provinces during the winter season is shown in Table-2.

Table – 2: Weighted Winter Precipitation				
PERIOD	N.W.F.P.	PUNJAB	BALOCHISTAN	SINDH
Dec. to March.	228.8	81.1	69.3	14.2
No. of times higher than Sindh	16.1	5.7	4.9	1

Winter Rains

Western disturbances or the low-pressure systems, which have their origin in the Mediterranean Sea or Atlantic Ocean. travel eastwards in higher latitudes within 30° to 60°

The table shows drastically low precipitation over the province of Sindh which, on the average, received less rainfall by factor of 4.9, 5.7 & 16.1, less rainfall as compared to the

provinces of Balochistan, Punjab and N.W.F.P.

Summer Rains

The rains during summer (June to September) are brought by the monsoonal systems coming either from the Arabian Sea, called South westerly monsoon systems, or due to the Southereasterlies bringing intense monsoon lows or depressions from the Bay of Bengal. Pattern of the normal rainfall during the season is shown in Annexure--V. This isohyetal map and the map showing the driest periods in percentage (Annexure-VI) indicates that the Southeastern parts of Balochistan and some central portions of Balochistan and a small portion of Northwest Sind, around Jacobabad, Sukkur, Rohri & Larkana, do not fall within the monsoon rains and remain more than 50% of the time dry and are vulnerable to drought. The conditions get more severe towards Southwestern Balochistan, around Dalbandin, Nokkundi, Zahidan and Jiwani. The conditions are further apt to be worsened if the transition months of October and November and that of winter ahead do not bring sufficient rains. Comparison of rainfall over the "drought-vulnerable" parts with that of the other provinces is shown in Table-3.

Table - 3: Comparative Statement Of Weighted Precipitation Over Different Provinces During(Jun. - Sep.) Summer Period (1961-90)

Period	*Punjab*	*N.W.F.P*	*Balochistan*	*Sindh*	*Average rainfall over the vulnerable areas of Balochistan**
June to Sept.	260.3	252.9	64.2	137.5	21.4
No. of times higher than Balochistan (V).	12.2	11.8	3	6.4	1

*Note: *The areas include Nokkundi, Dalbandin, Panjgur, Jiwani, Pasni, Ormara, Kalat, & Quetta.(Mean normal precipitation over these areas is given).*

Rains During April And May

The rainfall during April to May drops drastically, when compared to the rainfall during summer & winter. The comparison is shown in Tables-4 and 5.

Table-4: Comparative Statement Of Weighted Precipitation During April to May, Compared With The Rainfall During Summer (June-Sept.)

	N.W.F.P.	*Punjab*	*Balochistan*	*Sindh*
June to Sept.	252.9	260.3	64.2	137.5
April to May	106.5	36.5	20.1	5.5
Ratio	**2.3**	**7.1**	**3.2**	**2.5**

Table-5: Comparative Statement Of Weighted Precipitation During April to May Compared With The Rainfall During Winter (Dec. – March)

	N.W.F.P.	*Punjab*	*Balochistan*	*Sindh*
Dec. to March.	228.8	81.1	69.3	14.2
April to May	106.5	36.5	20.1	5.5
Ratio	**2.1**	**2.2**	**3.4**	**2.6**

Table-6: Comparative Statement Of Weighted Precipitation Over Different Provinces During April & May.(1961-90)				
Period	*Punjab*	*N.W.F.P.*	*Balochistan*	*Sindh*
April to May	106.5	36.5	20.1	5.5
No. of times higher then Sindh	**19.4**	**6.6**	**3.7**	**1**

The rainfall when compared to summer rains is considerably less in Sindh & Balochistan. Rainfall figures reflect that practically the whole of the country is almost vulnerable to drought during the period. When the position is seen in the context of the driest periods in percentage, the whole of Sindh, part of Northeast Balochistan around Sibi & Kalat, coastal areas of Balochistan and the western limb of Balochistan around Nokundi remain dry for more than 50% of the time. (See Annexure-VII & VIII). During these months, the temperatures usually are quite high. The maximum temperatures often range from 105° F to 113 ^{o} F. Jacobabad is one of the hottest places of the world, which attained the highest temperature of 127.4 ^{o} F (53°C) on June 12, 1919. Here the province of Sindh is not that suffer the drought conditions. A comparative statement, showing rainfall in different provinces during these months is given in Table-6.

The rainfall over Sindh is 1/4, 1/7 & 1/19 (approximately) of that in Balochistan, NWFP and Punjab respectively. The drought-vulnerable areas in Balochistan receive similar type of precipitation as in Sindh. If the summer rains too fail, the conditions may get aggravated. However, the drought-conditions in this region subsided considerably due to the ground-water availability in the province.

Rains During October To November

The rainfall during October to November, vulnerable to drought, as sufficient ground-water availability can reduce the impact of drought in some areas where ground-water can be exploited easily. However, the areas in Balochistan are always at risk with regard to the drought- susceptibility, as even during the subsequent months of summer monsoons (June to September), these areas are apt to which is also termed as the post-monsoon period, further drops drastically when compared to the summer monsoon and winter rains. The comparison is shown in Tables-7 and 8.

Table-7: Comparative Statement of Weighted Precipitation During October to November with the Rainfall During Summer Monsoons (Jun - Sep.)				
	N.W.F.P.	*Punjab*	*Balochistan*	*Sindh*
June to Sept.	252.9	260.3	64.2	137.5
Oct. to November	37.7	11.3	4.8	4.4
Ratio	**6.7**	**23**	**13.4**	**31.3**

Table-8: Comparative Statement Of Weighted Precipitation During October To November With The Rainfall During Winter rains (Dec. - Mar)				
	N.W.F.P.	*Punjab*	*Balochistan*	*Sindh*
Dec. to March.	228.8	81.1	69.3	14.2
Oct. to November	37.7	11.3	4.8	4.4
Ratio	**6.1**	**7.2**	**14.4**	**3.2**

The rainfall in the post-monsoon period drops drastically in Punjab, Balochistan and Sindh. The position in southern Punjab would look

more serious when rains in the northern Punjab and Southern are seen separately. Infact, half of Pakistan below 30°N remains more than 50% dry. The isohyetal map and the map showing the driest periods in percentage are shown in Annexure-IX & X. A comparative statement of precipitation over different provinces during the months of November to December (1961-90) is given in Tabel-9.

The pattern clearly indicates that Balochistan & Sindh received approximately 1/3 and 1/9th rainfall of Punjab and NWFP provinces, respectively.

Table –9: Comparative Statement Of Weighted Precipitation Over Different Provinces During October To November (1961-90)

Period	*Punjab*	*N.W.F.P.*	*Balochistan*	*Sindh*
Oct. to Nov	11.3	37.7	4.8	4.4
Ratio	**2.6**	**8.6**	**1.1**	**1**

CAUSES OF DROUGHTS

Possible underlying causes include the following:

- El-Nino & La Nina Phenomena
- Increase of atmospheric Co_2 & other greenhouse gases etc.
- El-Nino and La-Nina are the recent discoveries in the field of Meteorology. El-Nino is associated with the quasi-periodic anomalous surface-warming of the equatorial eastern and central pacific ocean, which, in turn, induces changes in weather-systems over the globe. The strongest association of El-Nino is found near the equator, with anomalous high rainfall in the central pacific and equational eastern Africa, but anomalous low rainfall in Indonesia, Pakistan, India and equational north-eastern Brazil. 1982-83 was the strongest El-Nino year and Pakistan remained devoid of any significant flood in 1983. 1997-98 was the subsequent strongest El-Nino year on record and, again, there was a significant reduction in the flooding during the monsoons of 1988. La-Nina, which is a phenomena reverse to El-Nino and is associated with the temperatures over Pacific Ocean remaining below normal, has also been found to affect the weather of Pakistan. Pakistan went under the grip of La-Nina from mid 1988 to 2000 and the country had drastically low rains during the period. These results are yet to be established to confirm linkage of El-Nino and La-Nina events to the occurrence or otherwise of rains and floods. The existing studies rely on statistical associations between time-series of El-Nino indices e.g. anomalous Sea-surface temperatures over a sizeable areas of the equatorial pacific and time series of stream flows. With an El-Nino occurrence once every 4 to 7 years and the presence of a multitude of other climatic causes of enhanced regional flooding, the requirements for a long time series of stream flows for several streams over a region is necessary for reliable statistical associations.

- It has been found that the temperatures of the region of seasonal low, developing as a semi ermanent feature over parts of Sindh, Balochistan and adjoining areas of Southern Punjab, also contribute significantly towards pulling moisture from the Arabian Sea during monsoons. Statistical evidence shows a reasonably good linkage between the temperatures of May and the monsoon rains. Such changes in temperature may be associated with the increase in CO_2 and other greenhouse gases, but these factors are yet to be established.

TYPICAL ADVERSE EFFECTS ASSOCIATED WITH THE DISASTER

Drought has often been referred to as a creeping disaster, as the affects of drought often accumulate slowly over a considerable period of time and may linger for years together after the termination of the event. Such a state of affairs often keeps the people hopeful for the good times to come soon. Further, their attachments with their homes and surroundings make them hesitant to leave their home towns. Only under inevitable circumstances, some partial migration takes place. The drought brings

multitude of adverse effects in its wake, such as :-

- Killings of people and livestock due to famine.
- Diseases.
- Deterioration of nutritional status.
- Reduction in resources of drinking and irrigation-water.
- Decline in the ground-water tables, where available.
- Social disruption due to migration.
- Increased rates of inflation.
- Desertification.
- Environmental degradation, due to contamination of soil, water and atmosphere through the deaths of livestock and human beings.

MITIGATION MEASURES

A Drought-mitigation plan should have the following three primary components:-

1. Monitoring & Early-warning system.
2. Risk and impact-assessment and mitigation.
3. Post-disaster needs.

Monitoring & Early Warning System

Drought is the consequence of a natural reduction in the amount of precipitation over an extended period of time, usually a season or more. Other climatic factors (such as high temperatures, high winds and low relative humidity) are often associated with it in many regions of the world and can significantly aggravate the severity of the event. Similar conditions prevailed over the drought-stricken areas in Pakistan during 1998-2000. In Pakistan, different regions are vulnerable to drought during each season; as such, authentic early warning seasonal forecasts are required to make reliable risk-assessments. Unfortunately, no country over the globe is yet self-sufficient in producing authentic and really accurate forecasts.

Pakistan Meteorological Department has a good data-collection system for developing a sound early-warning system for ascertaining the drought conditions. Meteorological data are important, but represents only a part of a comprehensive monitoring system. Other physical indicators (e.g. ground water and stream flow) must also be monitored to reflect the impacts of drought on agriculture, households, industry, energy production and on water users. Helpful technology includes soil-moisture sensors, Automated Weather-Stations, and satellite imageries, such as digital data obtained from the Advanced Very High Resolution Radiometer(AVHRR), which is transmitted from the National Oceanic and Atmospheric Administration (NOAA) Satellites. Satellite data is useful in indicting areas where deficiencies of moisture are affecting vegetation growth.

Risk Assessments And Mitigation

Once the areas are declared to be drought-stricken a Risk-Assessment Committee (RAC) should be formulated. Its responsibility should be to assess sectors, population groups, ecosystems that are most at risk and identify appropriate and reasonable mitigation-measures, to address these risks. The members of RAC and that of its working committee, formulated under the aegis of the RAC, should be composed of technical specialists representing each of the sectors, groups or ecosystems. The overall responsibility of RAC would be to make recommendations to the Disaster-cell, for taking mitigation actions.

Post-Disaster Needs

The Government must keep the following measures in view, so as to meet the post-disaster needs, which inevitably appear as consequences of a drought:-

- Measures to maintain food-security.
- Food subsidies.
- General food distribution.
- Special programmes for livestock and pastoralists .
- Complementary water and health progammes.
- Price Stabilization.
- Rehabilitation.

SUGGESTIONS AND RECOMMENDATIONS

Some suggestions and recommendations to mitigate the disasters are given below:-

Early Warning System

The drought is a creeping disaster and offers sufficient time for early warnings, of the order of a few months or a season. Droughts can be predicted very accurately if early-warnings are

reliable and fully authentic. Institutions such as Pakistan Meteorological Department, which is the most suitable agency, need to be strengthened to achieve self-sufficiency in this field.

Role of Reservoirs

More and more reservoirs are required to be raised to store water during the rainy seasons. Areas vulnerable to draught need, if possible, to be linked with main acquifers through canal-links.

Anthrapogenic Activities

Deforestation, loss of vegetation due to over-grazing, etc., need to be curbed by imposing legal bindings on such activities. These and many such anthrapogenic activities have raised the global temperature over the last century by about 0.6° and the vulnerability of drought-prone areas has, presumably, further increased.

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4. W.M.O. Bulletin, Vol. 47 No.4, October, 1988.
5. Early Warning Systems for Drought Preparedness and Drought Management, WMO/t.d No.1037 W.M.O., 2000.

ANNEXURE-I

TYPE	*NO. OF EVENTS*	*NUMBER KILLED*
HURRICANE/TYPHOON	894	8,96,063
FLOODS	1358	3,04,870
FIRE	729	81,970
FAMINE	15	6,05,832
EARTHQUAKES	758	6,46,307
DROUGHT	430	13,33,728
LANDSLIDES	238	41,992
STORMS	819	54,500
EPIDEMICS	291	1,24,338

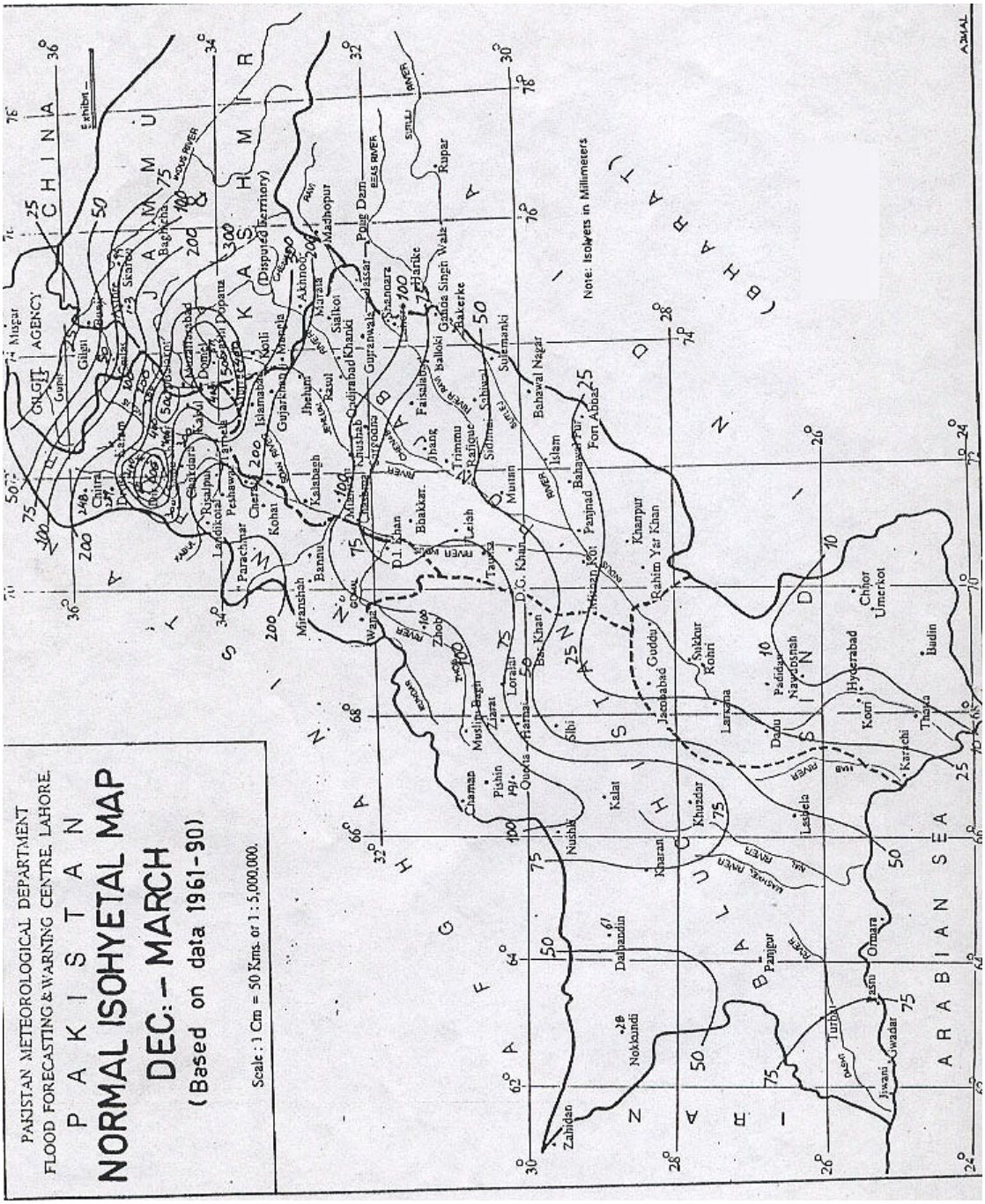
Note: The largest numbers Killed by Drought, with Hurricanes a close record.

ANNEXURE-II

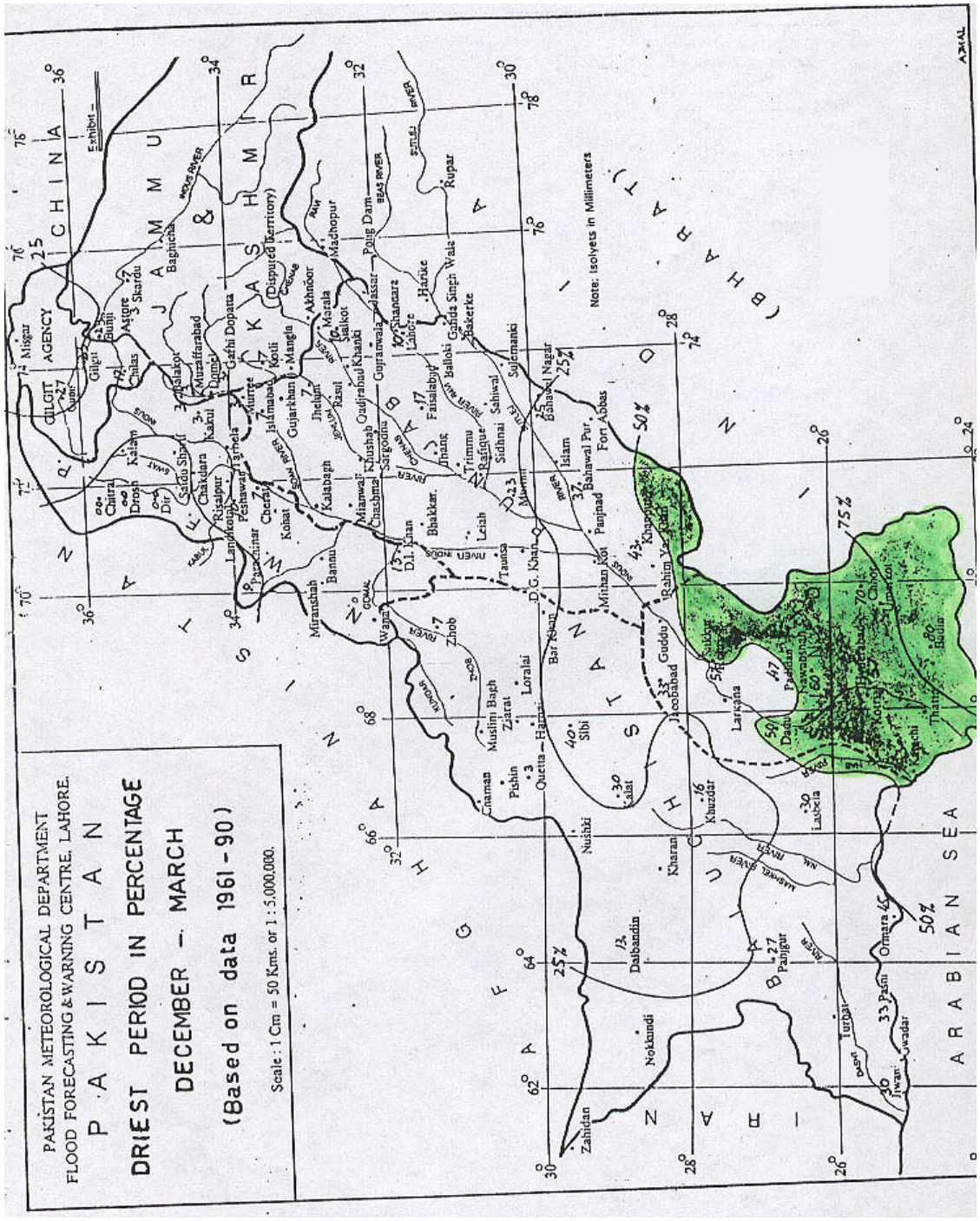
ESTIMATED WEIGHTED PRECIPITATION (IN MILLIMETERS) OVER PAKISTAN AND PROVINCES BASED ON THE NORMALS OF 1961-90

MONTH	*PAKISTAN*	*N.W.F.P.*	*PUNJAB*	*BALOCHISTAN*	*SINDH*
JANUARY	17.00	39.50	15.00	17.80	1.90
FEBRUARY	22.50	61.00	22.40	18.60	4.60
MARCH	31.00	95.30	32.00	22.00	5.10
APRIL	19.70	66.70	20.70	11.90	3.10
MAY	13.20	39.80	15.80	8.20	2.40
JUNE	14.00	27.70	24.60	5.40	10.00
JULY	62.50	95.40	108.40	28.60	56.90
AUGUST	55.40	94.00	93.60	23.00	52.40
SEPTEMBER	19.50	35.80	33.70	7.20	18.20
OCTOBER	5.70	21.10	6.40	2.10	2.40
NOVEMBER	4.90	16.60	4.90	2.70	2.00
DECEMBER	12.40	33.00	11.70	10.90	2.60
ANNUAL	**277.80**	**625.90**	**389.20**	**158.40**	**161.40**

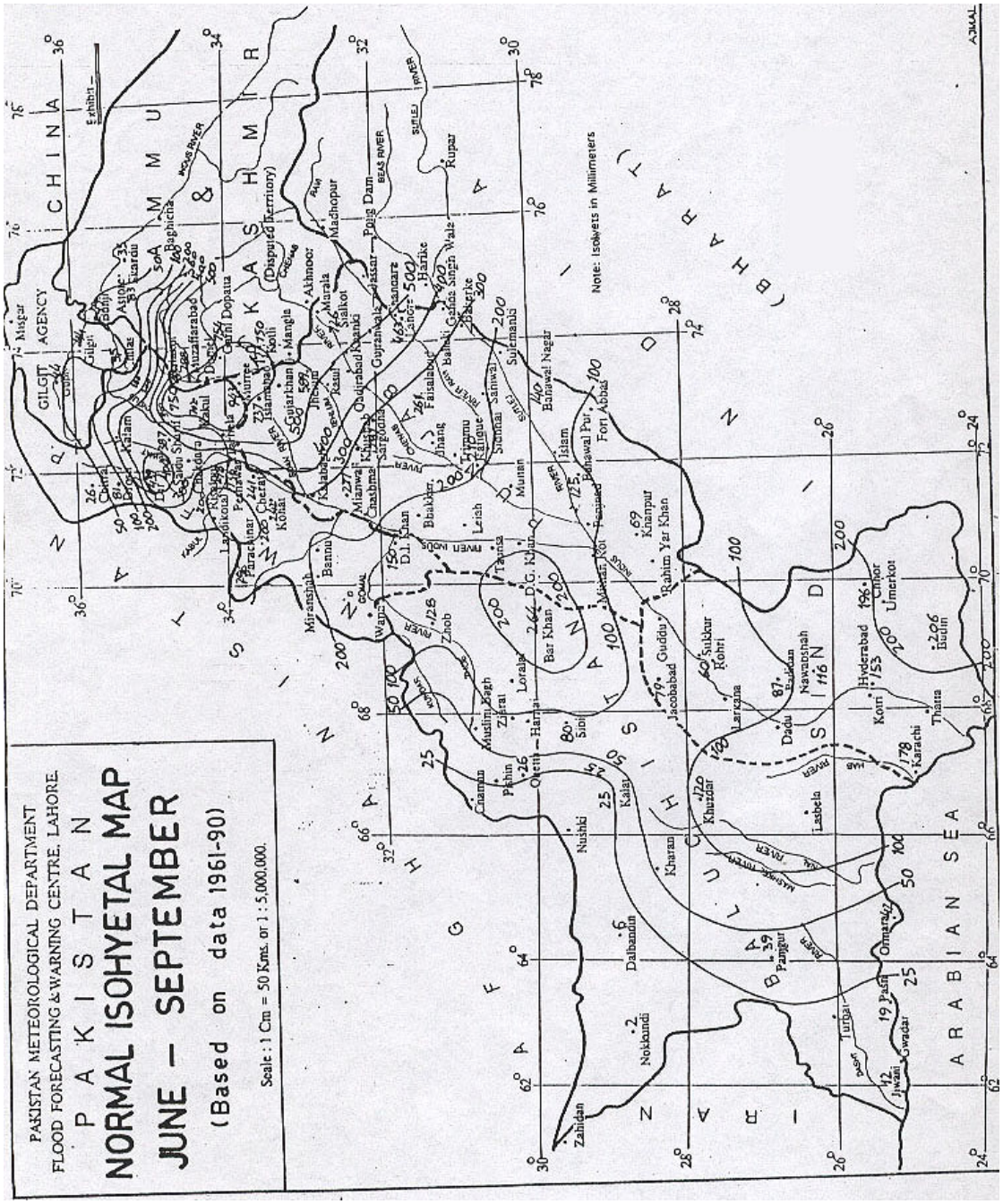
Annexure - III



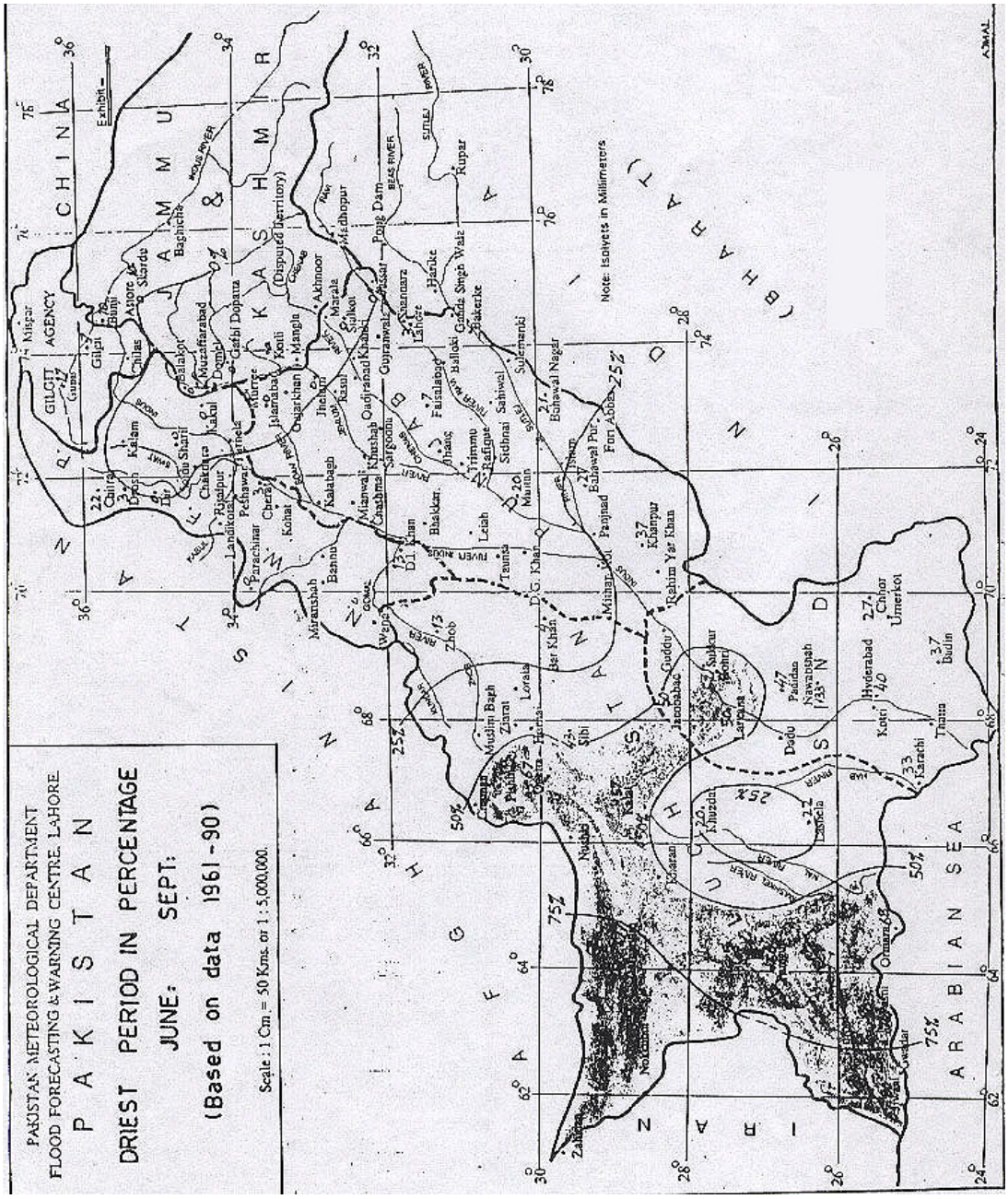
Annexure - IV


PAKISTAN METEOROLOGICAL DEPARTMENT
FLOOD FORECASTING & WARNING CENTRE, LAHORE.
PAKISTAN
DRIEST PERIOD IN PERCENTAGE
DECEMBER - MARCH
(Based on data 1961 - 90)
Scale : 1 Cm = 50 Kms. or 1 : 5,000,000.
Note: Isolyets in Millimeters
ARABIAN SEA

Annexure - V


PAKISTAN METEOROLOGICAL DEPARTMENT
FLOOD FORECASTING & WARNING CENTRE, LAHORE
P A K I S T A N
NORMAL ISOHYETAL MAP
JUNE – SEPTEMBER
(Based on data 1961-90)
Scale : 1 Cm = 50 Kms. or 1 : 5,000,000.
Note: Isohyets in Millimeters
CHINA
GILGIT AGENCY
ARABIAN SEA

Annexure - VI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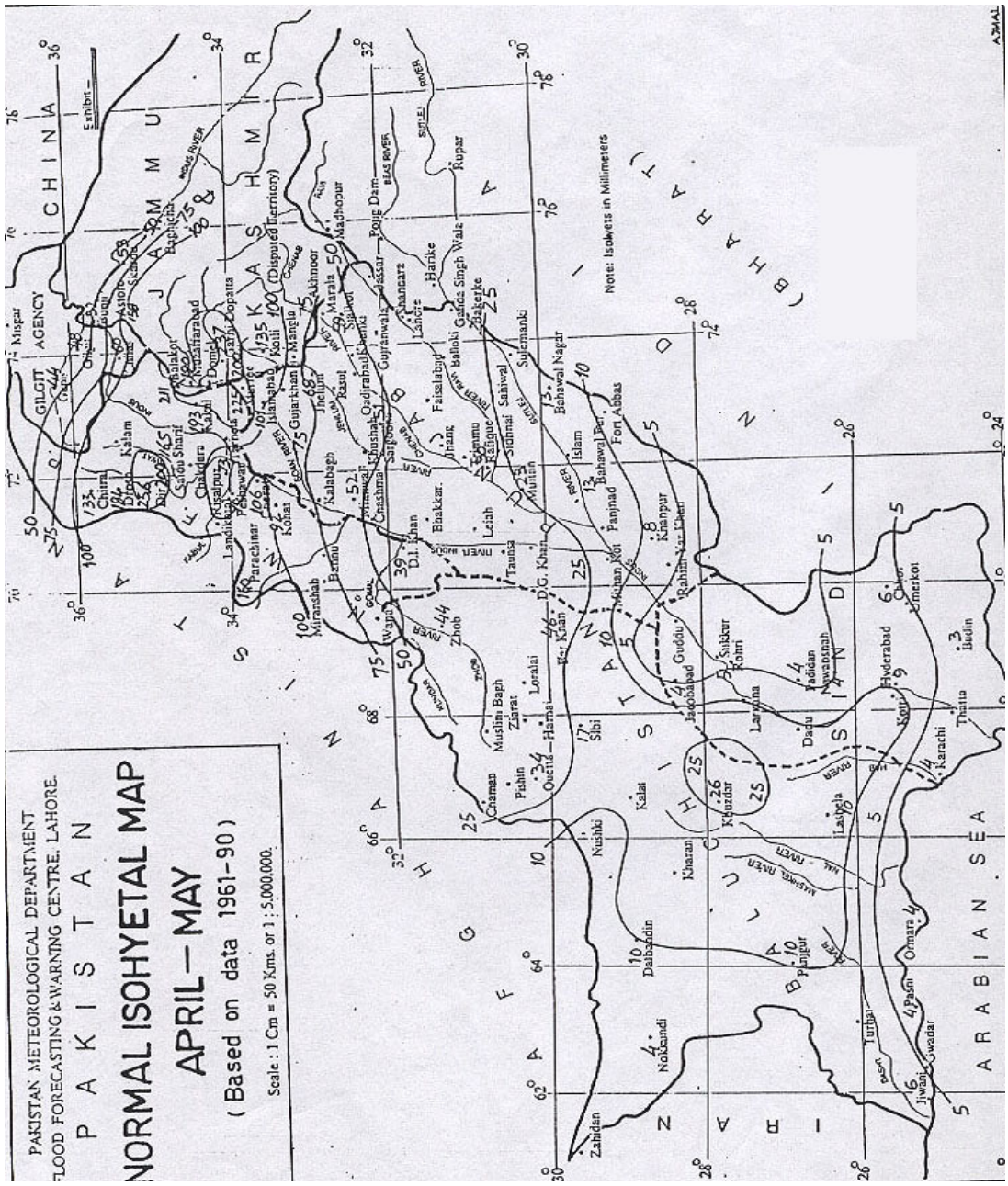
FLOOD FORECASTING & WARNING CENTRE, LAHORE
P A K I S T A N
DRIEST PERIOD IN PERCENTAGE
JUNE: SEPT:
(Based on data 1961-90)
Scale : 1 Cm. = 50 Kms. or 1 : 5,000,000.
Note: Isolvets in Millimeters
CHINA
ARABIAN SEA
Exhibit

Annexure - VII



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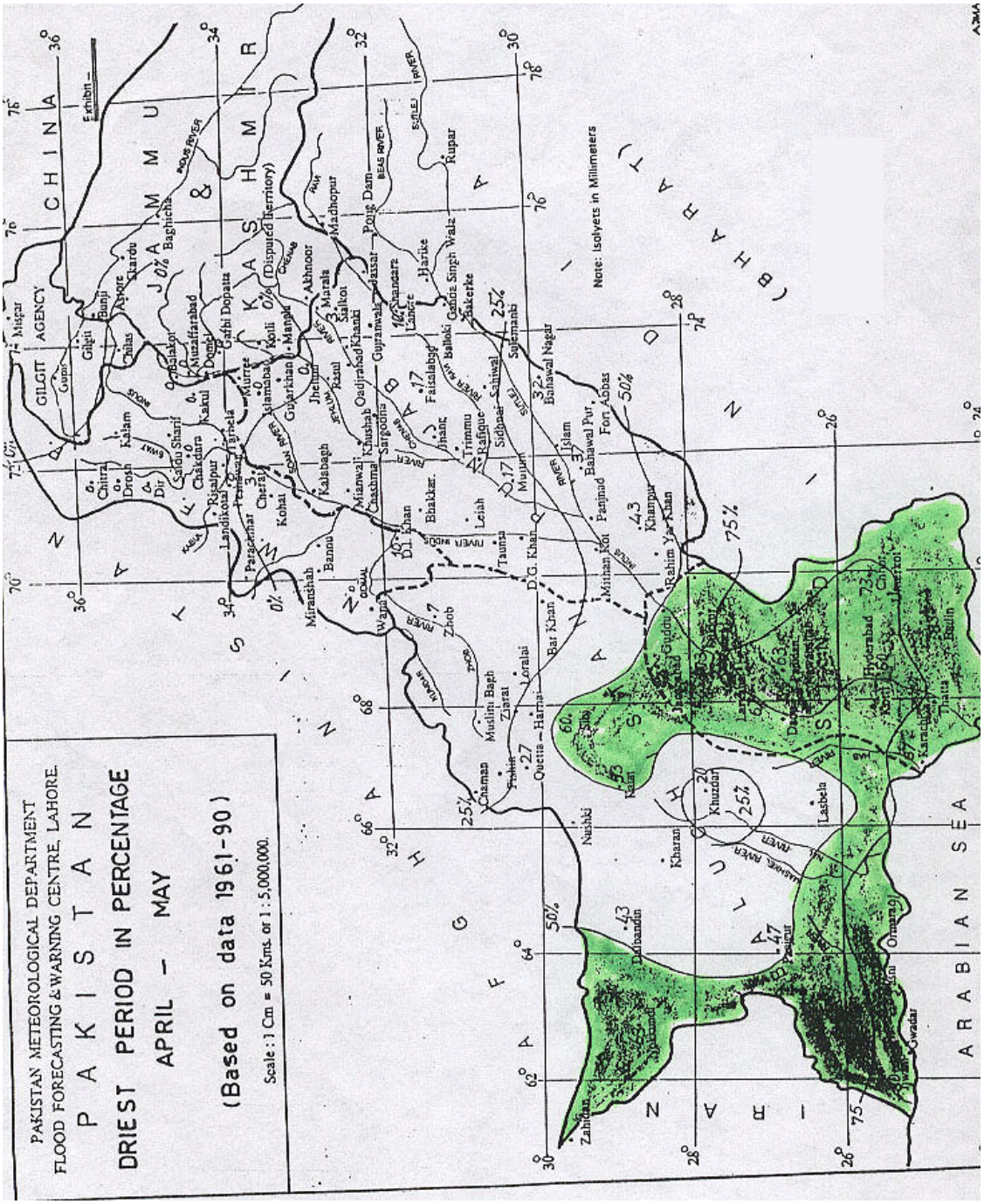

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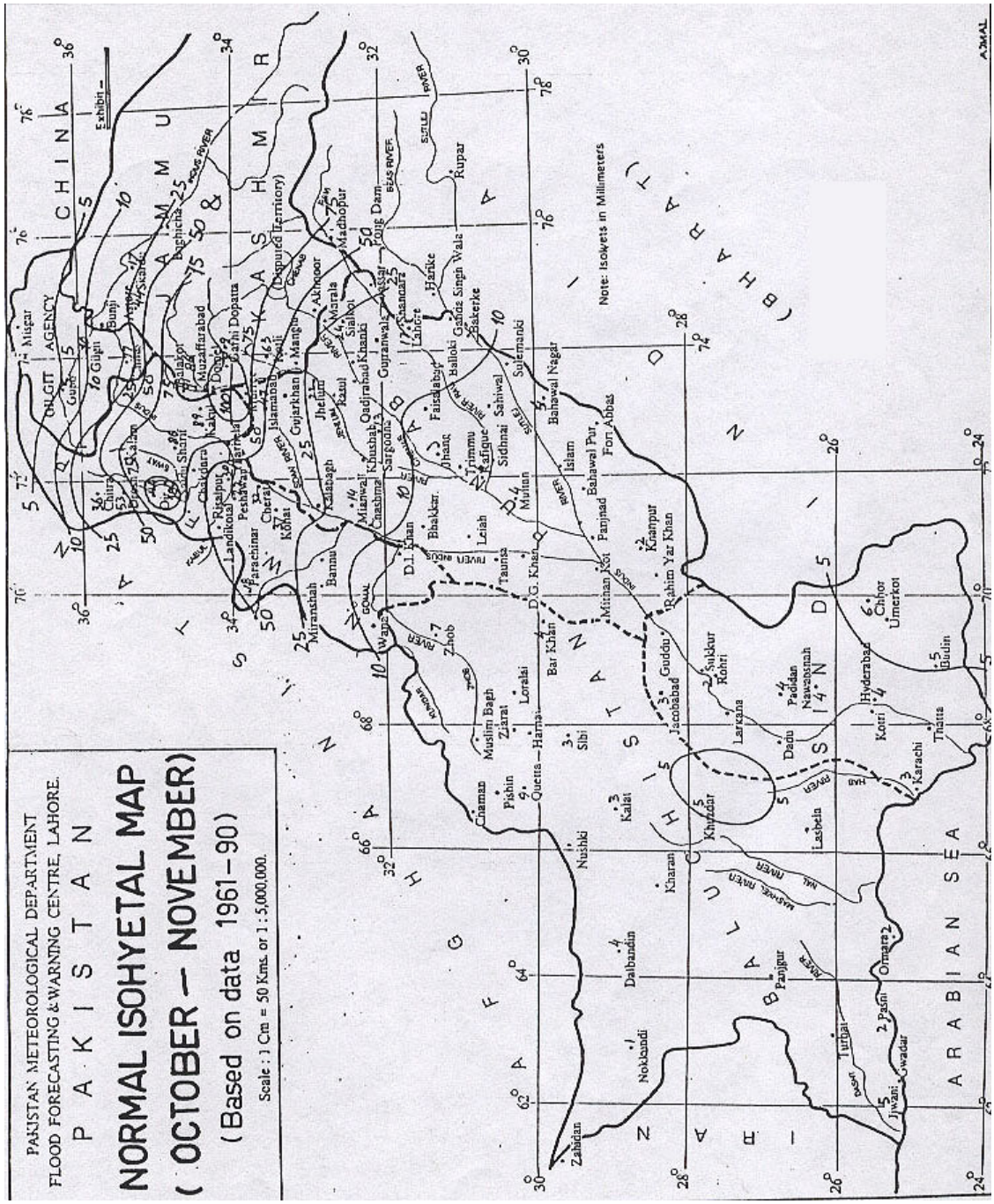
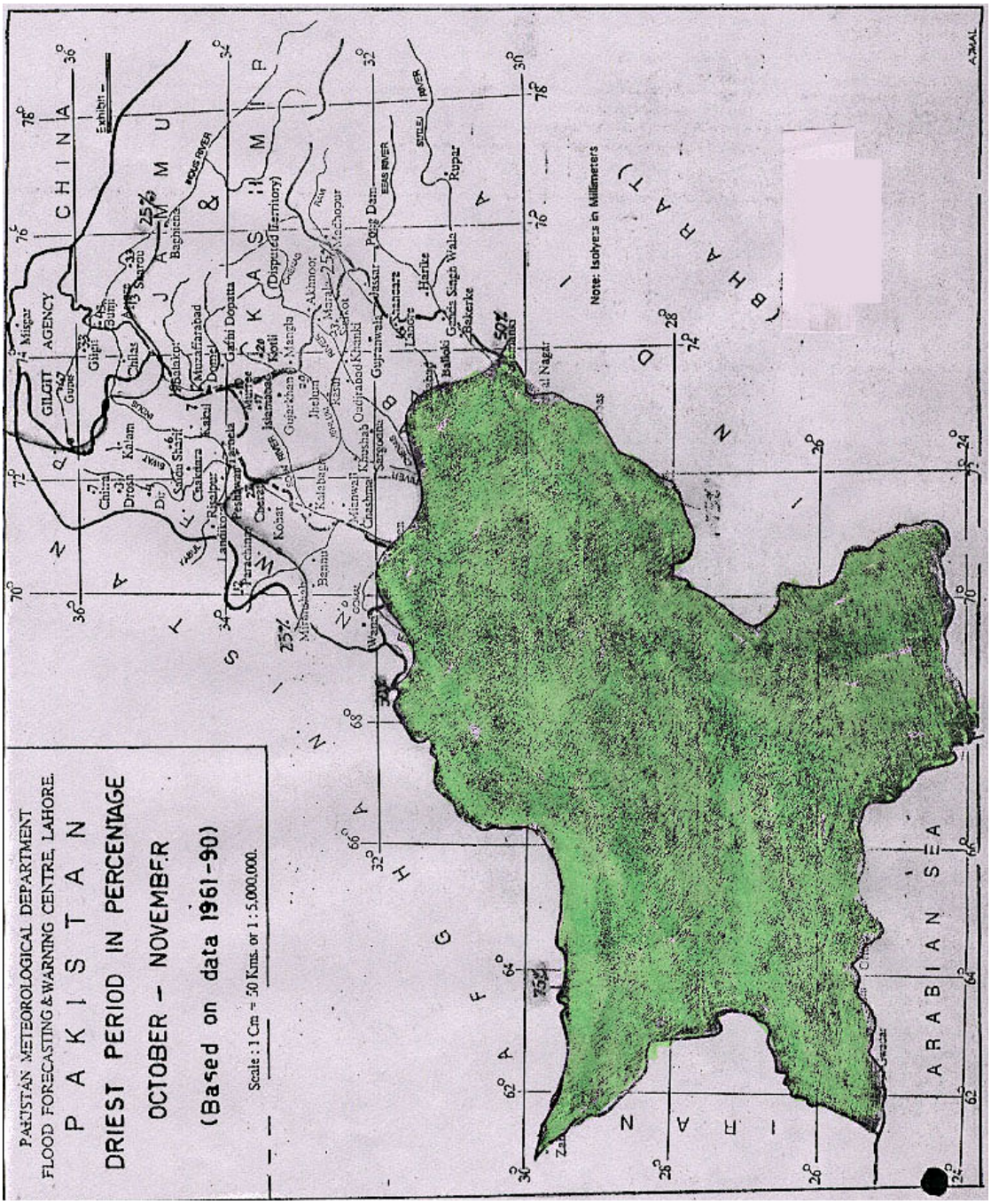

PAKISTAN METEOROLOGICAL DEPARTMENT
FLOOD FORECASTING & WARNING CENTRE, LAHORE.
P A K I S T A N
NORMAL ISOHYETAL MAP
(OCTOBER — NOVEMBER)
(Based on data 1961–90)
Scale : 1 Cm = 50 Kms. or 1 : 5,000,000.
Note: Isolvets in Millimeters
CHINA
ARABIAN SEA

Annexure - X


PAKISTAN METEOROLOGICAL DEPARTMENT
FLOOD FORECASTING & WARNING CENTRE, LAHORE.
PAKISTAN
DRIEST PERIOD IN PERCENTAGE
OCTOBER – NOVEMBER
(Based on data 1961-90)
Scale : 1 Cm = 50 Kms. or 1 : 5,000,000.
Note: Isolyets in Millimeters
CHINA
JAMMU & KASHMIR
(Disputed Territory)
GILGIT AGENCY
INDIA (BHARAT)
AFGHANISTAN
IRAN
ARABIAN SEA
25%
50%
75%
Exhibit