ANALYSIS OF DUST STORMS FREQUECNY OVER PAKISTAN DURING (1961-2000)

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Abstract:

More than 80% of Pakistan land is arid or semi arid. A dust storm is a meteorological phenomenon common on the arid and semi arid regions of the world. In this paper, normal dust storms frequency (1961-1990) over various meteorological stations of Pakistan situated in Punjab, Sindh, North Western Frontier Province, Balochistan and Northern Areas & Azad Jammu & Kashmir is discussed on seasonal as well as annual basis. The mean annual dust storms frequency (1991-2000) is compared with the normal annual frequency (1961-1990) and the dust storms frequency trend during 1991-2000 is also discussed. The graphical representation of the data is also given. The same is also shown in the form of maps (A to G) prepared by using Geographical Information System soft wares Arcview3.2 and ArcGIS at Institute of Geographical Information Systems, National University of Science & Technology, Islamabad.

Introduction:

A dust storm is a meteorological phenomenon common on the great plains of Arabia, North America, in the Gobi desert of Mangolia, the Taklamakan Desert of Northwest China, the Sahara desert of North Africa, the deserts of Indo-Pak subcontinent and other arid and semi arid regions of the world.

Pakistan is situated in South Asian region between longitudes 61º & 76º E and latitudes 24º & 37º N. The country possesses quite complicated and attractive physiographical features that include the northern high mountain ranges (the Himalayas, the Karakoram and the Hindukush), the western bordering highlands, the Salt range and Potohar Plateau, the Indus plains and the Balochistan Plateau. The geographical area of the country is 79.60 million hectares (mha) of which more than 80 % is Arid or Semi Arid (Majeed, et, al (2002)) including the following four deserts: the Thal (Central West Punjab), the Cholistan (South Eastern Punjab), the Thar (Eastern Sindh) and the Kharan (North Western Balochistan), which make for the frequent development of litho meteors over the region.

A dust storm is not only the most destructive of all litho meteors but also one of the major aviation hazards. A severe dust storm can reduce visibility to zero and can cause severe loss to life, property and economy. It can blow away valuable topsoil, while depositing soil in places where it may not be wanted.

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In this study effort has been made to analyze the dust storms frequency over Pakistan during 1961-2000. Data of 59 meteorological stations of Pakistan have been used, the Province / Region wise distribution of which is given as under:

Punjab: Bahawalnagar, Bahawalpur, Faisalabad, Islamabad, Jhelum, Khanpur, Lahore (PBO), Lahore (Airport), Mianwali, Multan, Murree, Sargodha, Sialkot and Shorkot (Rafique).

Sindh: Badin, Chhor, Hyderabad, Jacobabad, Karachi (Airport), Karachi (Faisal), Karachi (Masroor), Larkana, Moenjo Daro, Nawabshah, Padidan and Sukkur (Rohri).

North Western Frontier Province (N.W.F.P.): Balakot, Cherat, Chitral, Dera Ismail Khan, Dir, Drosh, Kakul, Kohat, Parachinar, Peshawar, Risalpur and Saidu Sharif.

Balochistan: Barkhan, Dalbandin, Jiwani, Kalat, Khuzdar, Nokkundi, Ormara, Panjgur, Pasni, Quetta, Sibbi and Zhob.

Northern Areas & Azad Jammu and Kashmir (AJK): Astore, Bunji, Chilas, Ghari Dupatta, Gilgit, Gupis, Kotli, Muzaffarabad and Skardu.

Definition of Dust Storm:

Generally, "a dust storm is defined to be a windstorm that sweeps clouds of dust across an extensive area." or "A windstorm that lifts up clouds of dust or sand especially in an arid region".

For meteorological purposes, however, such a windstorm can only be reported as a dust storm if wind speed becomes 22 knots or more and surface visibility reduces to less than one kilometer. For reporting of a dust storm both of these conditions are to be satisfied. If any one or both of the conditions are not satisfied, than the phenomenon may not be reported as a dust storm. In that case, it may be reported as blowing/drifting dust or sand / dust in suspension and etc. depending upon the prevailing weather conditions. Front of a dust storm especially in case of a severe storm may appear like a 'wall of dust' (fig.1).

Fig.1: *Front of a dust storm appears like a 'wall of dust' (www.en.wikipedia.org).*

The Causes of Formation & Physical Mechanism of Dust Storms:

The weather situations in favor of forming strong wind or severe wind, the source distribution of sand & dust and air unsteadiness condition are the major reasons of forming dust storms or strong dust storms. Severe wind is the dynamical force of a dust storm, while the source of sand and dust is the substance foundation of a dust storm. Unsteady thermal conditions benefit to enhance wind power level and advance the convection developing, which carry more dust and sand and blow them higher.

Besides these, aridity and less rain at prophase, warming weather and ascending air temperature become a special weather and climate condition of dust storms formation. The cellular circulation in front of the surface cold front develops to cloud mass or squall line, which makes for development of a dust storm and enhances mesoscale or microscale system (www.duststorm.com.cn).

Methodology:

- Dust storms data collected from Computerized Data Processing Center, (Pakistan Meteorological Department), Karachi.
- Compilation and Processing of dust storms data in to four seasons namely Winter (Dec., Jan., Feb. and Mar.), Pre Monsoon (Apr., May. and Jun.), Monsoon (Jul., Aug. and Sep.) and Post Monsoon (Oct. and Nov.) seasons and making graphs using MS excel software.
- The seasonal and yearly averages of data for the periods 1961-1990 and 1991-2000 are referred to as normal and mean respectively
- Ranking of various regions/met stations according to the observed number of dust storms days per year as follows:

Number of dust storm Days (Per year)	Ranking
≤ 1.0	Very Low Frequency
1.1 to 3.0	Low Frequency
3.1 to 6.0	Moderate Frequency
6.1 to 9.0	High Frequency
≥ 9.1	Very High Frequency

- Generating seasonal and annual maps for the period 1961-1990 and 1991-2000 by using ArcGIS software. In the maps, data of Lahore (PBO) and Karachi (Airport) are used for Lahore and for Karachi respectively.
- Discussion and derivation of results.

Discussion:

Firstly, the normal dust storms data of meteorological (met.) stations was discussed on seasonal as well as on annual basis and secondly, the mean annual data was compared with the normal annual data. Various regions/met. Stations are also classified as given in methodology.

Punjab

Winter Season: In Punjab, the seasonal normal dust storms (DS) frequency varies from zero (at Jhelum and Murree, the only hilly met. station of Punjab) to 1.4 days (at Bahwalnagar). The second and third highest normal values being 1.3 and 0.8 days for Shorkot (Rafique) and Multan respectively.

Pre Monsoon Pre Monsoon is the season when DS frequency is at the maximum in the whole Pakistan. In Punjab the seasonal normal DS frequency varies from zero

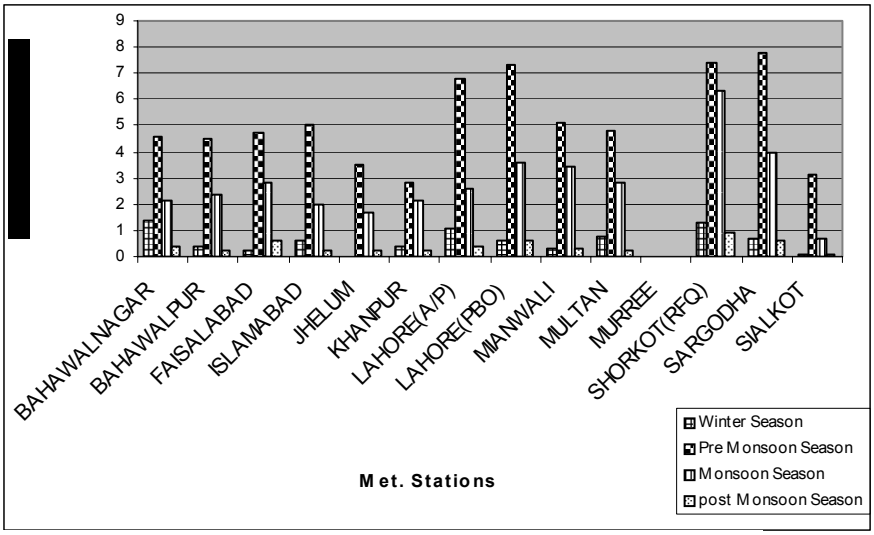


Fig.2: *Punjab: Seasonal Normal (1961-1990) DS frequency*

(at Murree) to 7.8 days (at Sargodha). The second and third highest values being 7.4 and 7.3 days for Shorkot (Rafique) and Lahore (PBO) respectively. Most of the met. stations of Punjab have 4.0 or more DS days during the season. Murree is the only met. station with zero DS frequency in the province.

Monsoon Season: After pre monsoon season, the normal DS frequency is observed to be the highest during monsoon season in Punjab. The normal DS

frequency varies from zero (at Murree) to 6.3 days (at Shorkot (Rafique)). The second and third highest normal values being 4.0 and 3.6 days for Sargodha and Lahore (PBO) respectively.

Post Monsoon: Normal DS frequency observed to be at minimum during this season in the country. In Punjab, normal DS frequency varies from zero (at Murree) to 0.9 days (at Shorkot (Rafique)). The second highest value being 0.6 days for each of Faisalabad, Lahore (PBO) and Sargodha. (fig.2).

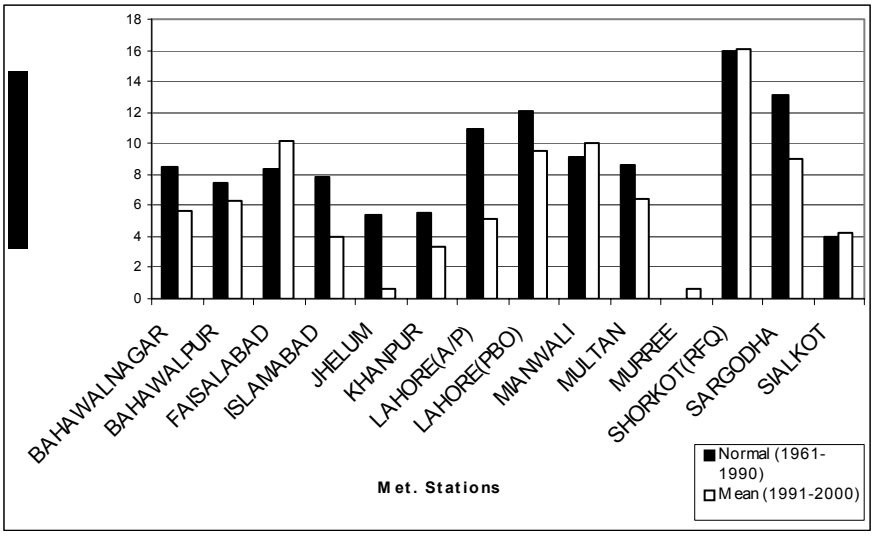


Fig.3: *Punjab: Annual DS frequency Normal versus Mean*

Annual: The annual normal DS frequency varies from zero (at Murree) to 15.9 days (at Shorkot (Rafique) in Punjab. The second and third highest values being 13.1 and 12.1 days for Sargodha and Lahore (PBO) respectively. The frequency of 15.9 days (at Shorkot (Rafique)) is also the highest in whole Pakistan.

The annual mean (1991-2000) DS frequency was compared with the respective normal (1961-190) frequency. Most of the met. Stations of Punjab showed decreasing tendency in DS frequency during 1991-2000. The significant drops were observed for Lahore (Airport) (-5.8 days), Jhelum (-4.4 days), Sargodha (-4.1 days) and Islamabad (-3.8 days). While Faisalabad, Mianwali, Shorkot (Rafique), Sialkot and Murree showed increase in DS frequency with highest increase being +1.8 days for Faisalabad, while for others it was less than +1.0 day. A net decrease of 22% in DS frequency was observed in Punjab during 1991-2000 (fig.3).

Shorkot (Rafique) (which has the highest DS frequency during (1961-1990) and (1991-2000)) is situated in the south / southeast of the Thal desert and among those met. stations, which are geographically, close to the desert. At Shorkot (Rafique) dust storms generally come from north. If we consider Shorkot (Rafique) as the

representative of the Thal desert with respect to the occurrence of dust storms, then year to year variations in the DS frequency at Shorkot (Rafique) (fig.4) and the Cholistan desert & surroundings (data of Bahawalnagar, Bahawalpur, Multan and Khanpur used for the purpose) (fig.5) during 1991-2000 become very interesting if seen in the perspective of history's worst drought conditions in Pakistan during 1998-2002 (Chaudhry, (2001) & Chaudhry, (2002)) and keeping in view the fact that globally 1998, 1997, 1995, 1990, 1999, 1991 and 2000 were the warm years (with 1998 being the warmest) of the 1991-2000 decade, which itself was the hottest in the past 140 years (WMO Bulletin, July-2001).

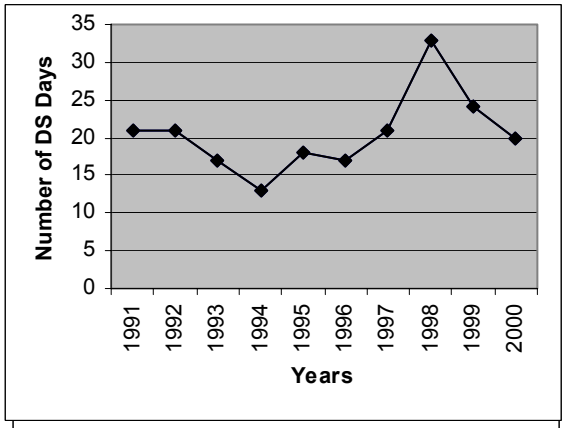


Fig.5: *Variations in DS frequency over the Cholistan & surroundings*

NWFP

Winter Season: In NWFP, most of the met stations are situated in the hilly areas of the province. During winters, DS frequency observed to be the least in NWFP. It varies from zero (at Balakot, Cherat, Chitral, Dir, Drosh, Kakul, Kohat and Parachinar) to 0.5 days (at D .I. Khan). The second and third highest values being

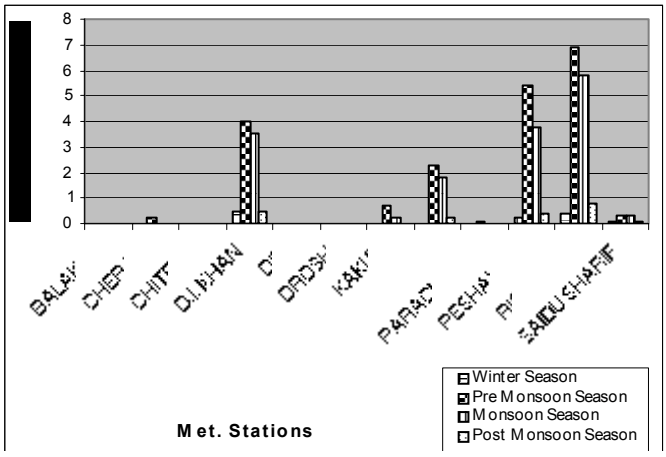


Fig.6*: NWFP: Seasonal Normal (1961-1990) DS frequency*

0.4 and 0.2 days for Risalpur and Peshawar respectively.

Pre Monsoon Season: During this season DS frequency observed to be highest in the province. It varies from zero (at Balakot, Chitral, Dir and Drosh) to 6.9 days (at Risalpur). The Second and third highest values being 5.4 and 4.0 days for Peshawar and D. I. Khan respectively.

Monsoon Season: During monsoon season, seasonal normal DS frequency varies from zero (at Balakot, Cherat, Chitral, Dir, Drosh and Parachinar) to 5.8 days (at Risalpur). The second and third highest values being 3.8 and 3.5 days for Peshawar and D.I Khan respectively.

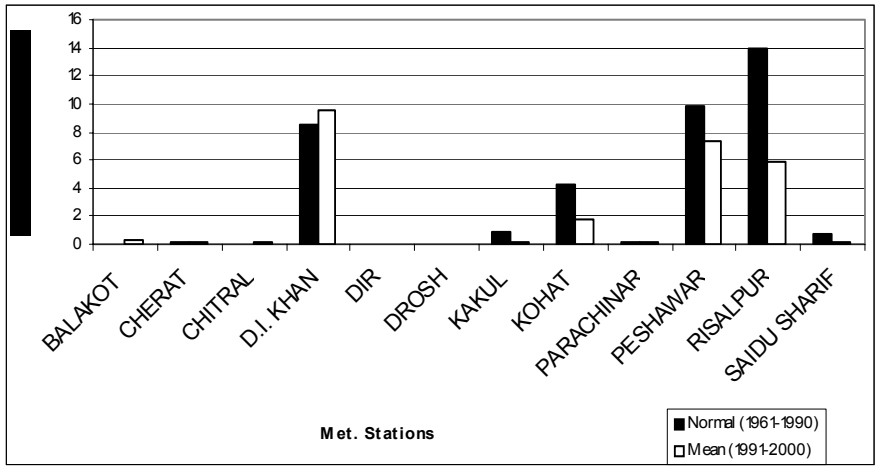


Fig.7*: NWFP: Annual DS frequency Normal versus Mean*

Post Monsoon Season: In post monsoon season, DS frequency varies from zero (at Balakot, Cherat, Chitral, Dir, Drosh, Kakul and Parachinar) to 0.8 days (at Risalpur). The second and third highest values being 0.5 and 0.4 days for D. I. Khan and Peshawar respectively (fig.6).

Annual: The annual normal DS frequency varies from 0.1 days (at Parachinar) to 13.9 days (at Risalpur) in NWFP. The second and third highest values being 9.8 and 8.5 days for Peshawar

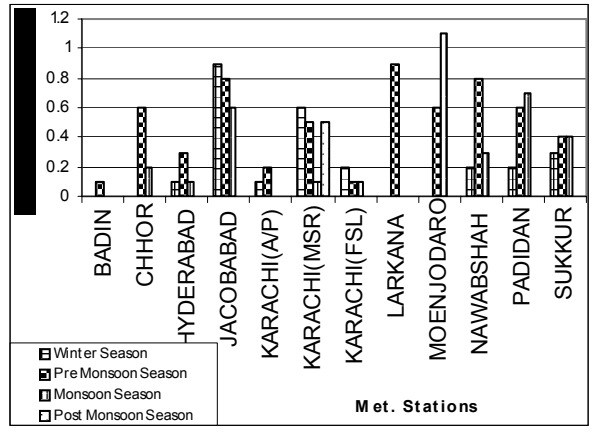


Fig.8*: Sindh: Seasonal Normal (1961-1990) DS frequency*

and D.I. Khan respectively. The normal value of 13.9 days (at Risalpur) is also the second highest (after Shorkot) in whole Pakistan. For Kohat the normal value is observed to be 4.3 days, while each of the other eight met. Stations (which mainly comprised of hilly areas), has its normal value either zero or less than one.

The annual mean (1991-2000) DS frequency was compared with the respective normal (1961-1990) frequency. Most of the met. Stations of NWFP showed decreasing tendency in the DS frequency during 1991-2000. The highest decrease was observed to be –8.1 days at Risalpur, which was also the highest decrease in whole Pakistan. The other significant decreases are –2.5 days (at Kohat) and –2.4 days (at Peshawar). While an increase in the DS frequency was observed at each of D.I. Khan (+1.1 days), Balakot (0.3 days) and Chitral (0.2 days). A net decrease of 34% in DS frequency was observed in the province during 1991-2000 (fig.7).

SINDH

Winter Season: In winters, normal DS frequency varies from zero (at each of Badin, Chhor and Monjodaro) to 0.9 days (at Jacababad). The second highest value being 0.3 days for Sukkur.

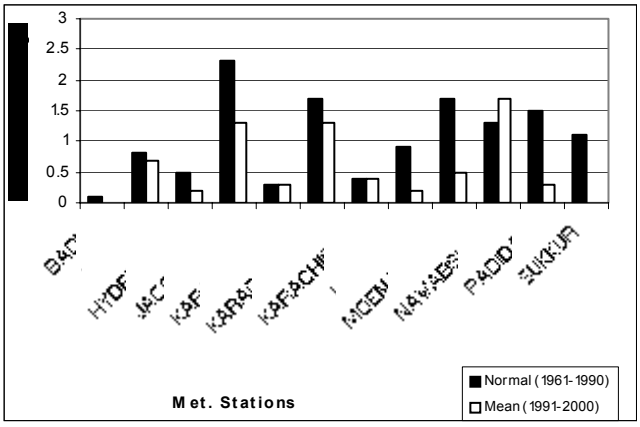


Fig.9: *Sindh: Annual DS frequency Normal versus Mean*

Pre Monsoon Season: During pre monsoon season, normal DS frequency is also the highest in Sind but still much less than that of Punjab and NWFP in the same season. It varies from 0.1 (at Badin) to 0.8 days (at Jacababad and Nawabshah). The second highest value being 0.6 days (for Chhor, Moenjodaro and Padidan). There is no met. station in Sindh, which has zero DS frequency during the season.

Monsoon Season: In monsoon season, the normal DS frequency varies from zero (at Badin, Karachi (Airport) and Larkana) to 1.1 days (at Moenjodaro). The second

and third highest values being 0.7 and 0.6 days for Padidan and Jacobabad respectively.

Post Monsoon Season: In post monsoon season, seasonal normal DS frequency observed to be zero for all the met. Stations of Sindh except Karachi (Masroor), which has 0.5 days of DS frequency for the season (fig.8).

Annual: Annual normal DS frequency varies from 0.1 (at Badin) to 2.3 days (at Jacobabad) in Sindh. The second and third highest values being 1.7 days (for Karachi (Masroor) and Moenjodaro) and 1.5 days (for Padidan). There is no met station in Sindh, which has zero DS frequency.

The annual mean (1991-2000) DS frequency was compared with the respective

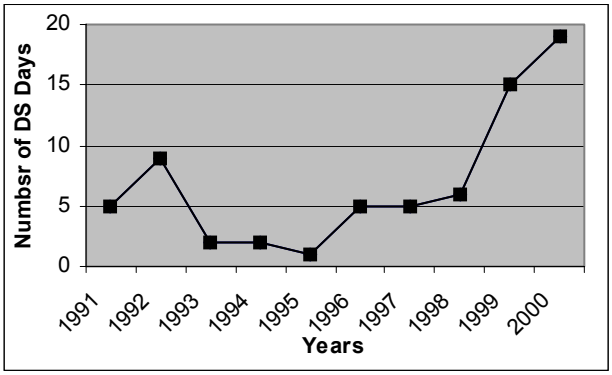


Fig.10: *Variations in DS frequency over Sindh during 1991-2000.*

normal (1961-1990). All the met. Stations of Sindh (except Karachi (Airport), Karachi (Faisal) and Nawabshah) showed a decreasing tendency in DS frequency during 1991-2000. The highest decreases observed to be -1.2 days (for each of Moenjodaro and Padidan) and -1.1 days for Sukkur (Rohri). Nawabshah is the only station in Sindh that showed slight increase of +0.4 days in DS frequency, while for each of Karachi (Airport) and Karachi (Faisal), the mean value observed to be equal to the respective normal. No dust storms observed at Rohri and Badin during 1991-2000 (fig.9). A net decrease of 45% in DS frequency was observed in Sindh during 1991-2000 (fig.9). Variations in DS frequency over Sindh during 1991-2000 are shown the fig.10 (please also see fig.4 & 5).

BALOCHISTAN

Winter Season: In winters, normal DS frequency varies from zero (at Barkhan, Kakat, Khuzdar, and Zhob) to 1.4 days (at Dalbandin). The second and third highest normal values being 1.1 and 0.7 days for Nokkundi and Pasni respectively.

Pre Monsoon Season: During pre monsoon season, normal DS frequency varies from zero (at Kalat and Khuzdar) to 1.6 days (at Nokkundi). The second and third highest values being 1.3 days for Pasni and 1.2 days for each of Dalbandin and Ormara.

Monsoon Season: For monsoon season, normal DS frequency varies from zero (at Barkhan, Kalat and Zhob) to 1.8 days (at Nokkundi). The second and third highest normal values being 1.3 and 0.8 days for Quetta and Sibbi respectively.

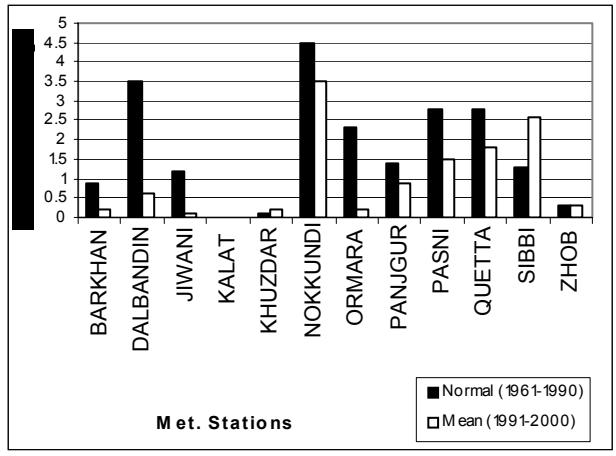


Fig.12: *Balochistan: Annual DS frequency Normal versus Mean*

Post Monsoon Season: In post monsoon season, DS frequency observed to be minimum in Balochistan, however it is comparatively more in coastal areas of the province. It varies from zero (at Barkhan, Kalat, Khuzdar, Nokkundi and Zhob) to 0.3 days (at Jiwani and Pasni). The second highest normal value being 0.2 days for each of Dalbandin, Ormara, and Quetta (fig.11).

Annual: Kalat is the only met. station in Balochistan with zero annual normal DS frequency. For other stations the frequency varies from 0.1 (at Khuzdar) to 4.5 days (at Nokkundi). The second and third highest values being 3.5 days (for Dalbandin) and 2.8 days (for Pasni and Quetta). Nokkundi and Dalbandin (having proximity to the Kharan desert) have comparatively greater DS

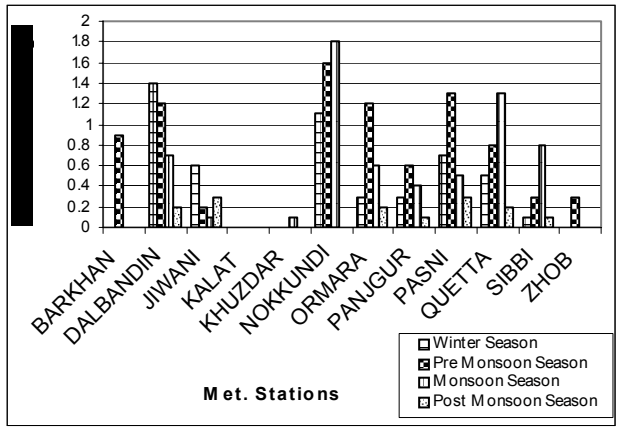


Fig11*: Balochistan: Seasonal Normal (1961-1990) DS frequency*

frequency than those of the other stations in Balochistan.

When the annual mean (1991-2000) DS frequency was compared with the respective normal (1961-1990) frequency. All the met. stations (except Sibbi, Khuzdar and Zhob) of Balochistan showed a decreasing tendency in the DS frequency during 1991-2000. The highest decrease observed to be –2.9 days (for Dalbandin) and -2.1 days (for Ormara). Sibbi and Khuzdar were the only stations, which showed a rise in the DS frequency with increase being +1.3 and +0.1 days respectively. While for Zhob, its mean frequency observed to be equal to the normal. A net decrease of 48% in DS frequency was observed in the province during 1991-2000 (fig.12).

NORTHERN AREAS & AJK

Winter Season: In winter season, DS frequency is least in Northern Areas and AJK. Only two met. Stations namely Skardu and Gilgit reported dust storms during 1961-1990, with seasonal normal DS frequency being 0.2 and 0.1 days respectively, while the frequency is zero for each of the other met stations in the region.

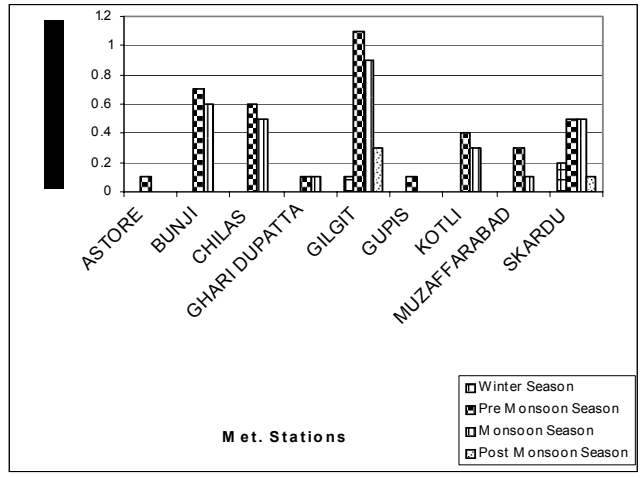


Fig.13: *N/ Areas & AJK: Seasonal Normal (1961-1990) DS*

Pre Monsoon Season: During pre monsoon season, normal DS frequency varies from 0.1 (at Astore) to 1.1 days (at Gilgit). The second and third highest values being 0.7 and 0.6 days for Bunji and Chilas respectively, with no station having zero frequency during the season.

Monsoon season: In monsoon season, normal DS frequency varies from zero (at Astore and Gupis) to 0.9 days (at Gilgit). The second and third highest values being 0.6 days for Bunji and 0.5 days for each of Chilas and Skardu.

Post Monsoon Season: In post monsoon season, only two met. stations namely Gilgit and Skardu reported DS during (1961-1990) with DS frequency being 0.3 and 0.1 days respectively. While seasonal normal values are zero for all other stations of the region fig.13).

Annual: Annual normal DS frequency varies from 0.1 (at Astore and Gupis) to 2.4 days (at Gilgit) in Northern Areas & AJK. The second highest value being 1.3 days (for each of Bunji and Skardu) with no station having zero normal.The annual mean (1991-2000) DS frequency was compared with the respective normal (1961-1990). All the met. stations (except Chilas, Kotli and Muzaffarabad) showed decreasing tendency in DS frequency during 1991-2000. The highest decreases observed to be –1.9 days for Gilgit and –1.3 days for Bunji. While only two met. Stations i.e. Chilas and Muzaffarabad showed slight increase in the DS frequency. The increase observed to be +0.5 and +0.2 days respectively. For Kotli, its mean DS frequency was equal to the normal. A net decrease of 42% in DS frequency was observed in the region during 1991-2000 (fig.14).

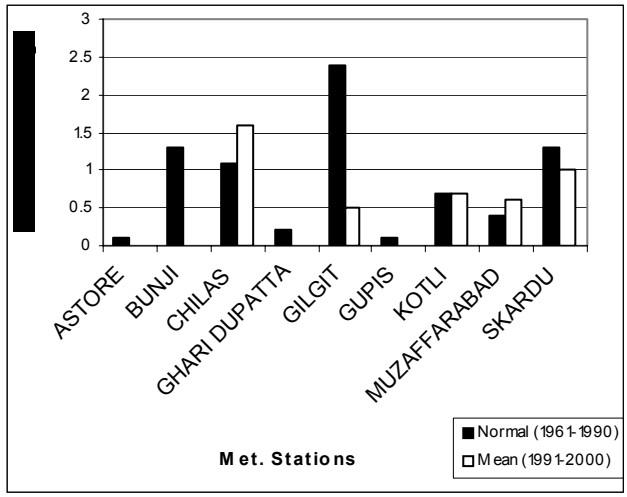
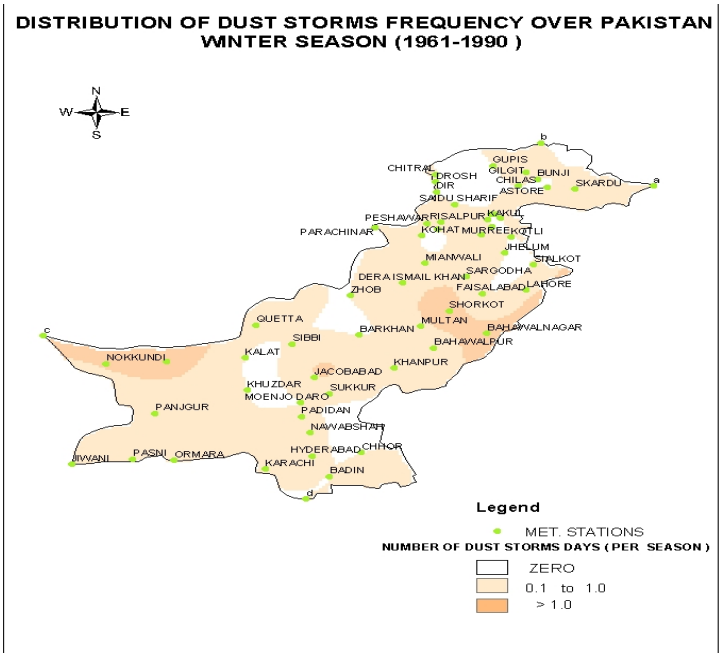


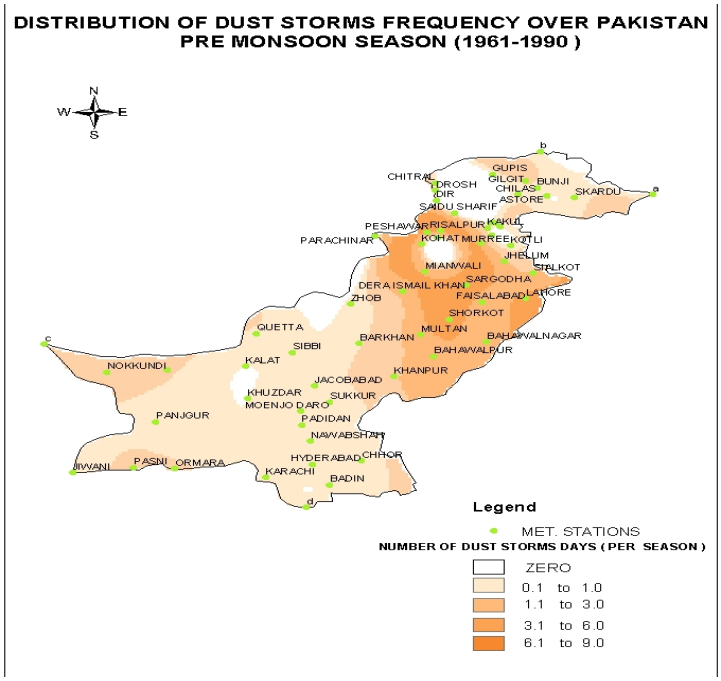
Fig.14: *N/Areas & AJK: Annual DS frequency Normal versus Mean.*

Ranking of Met Stations with Respect to the Observed Number of Dust Storms Days

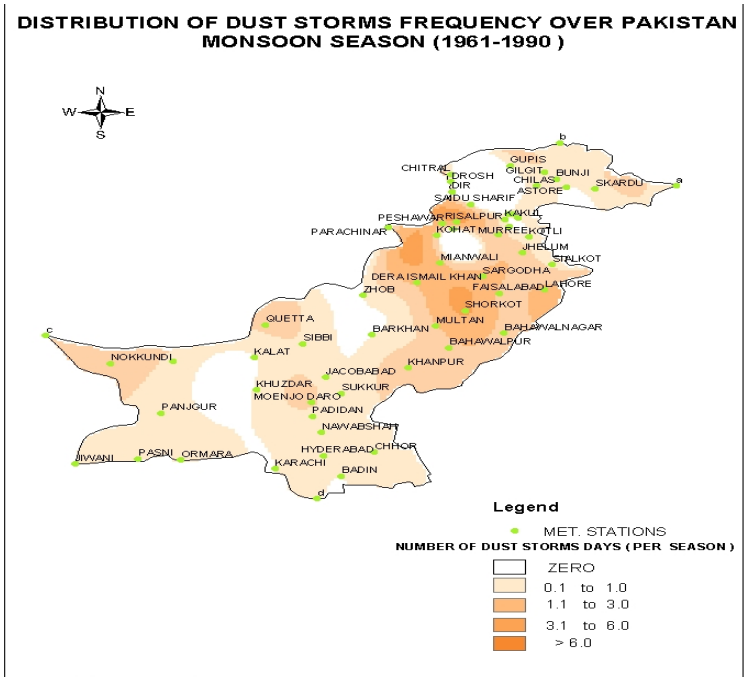
RANKING	NORMAL (1961-1990)	MEAN (1991-2000)
Very High Frequency (DS days > 9.0)	Punjab: Shorkot (RFQ), Sargodha, Lahore (PBO), Lahore (A/P), Mianwali. NWFP: Risalpur, Peshawar and	Punjab: Shorkot (RFQ), Sargodha, Lahore (PBO) & Mianwali. NWFP: D.I. Khan.
High Frequency (DS days 6.1 to 9.0)	Punjab: Multan, Bahawalnagar, Faisalabad, Islamabad & Bahawalpur NWFP: D. I. Khan,	Punjab: Sargodha, Multan & Bahawalpur NWFP: Peshawar
Moderate Frequency (DS days 3.1 to 6.0)	Punjab: Khanpur, Jhelum, and Sialkot NWFP: Kohat Balochistan: Nokkundi & Dalbandin.	Punjab: Bahawalnagar, Lahore (A/P), Islamabad, Sialkot, Khanpur & Jhelum. NWFP: Risalpur Balochistan: Nokkundi
Low Frequency (DS days 1.1 to 3.0)	Sindh: Jacobabad, Karachi (MSR), Moenjodaro, Padidan, Nawabshah & Sukkur (Rohri) Balochistan: Pasni, Quetta, Ormara, Panjgur, Sibbi & Jiwani N. Areas & AJK: Gilgit, Skardu, Bunji, & Chilas	Sindh: Nawabshah, Jacobabad & Karachi (MSR). NWFP: Kohat Balochistan: Sibbi, Quetta & Pasni N. Areas & AJK: Chilas
Very Low Frequency (a) (DS days 0.1 to1.0)	NWFP: Kakul, Saidu Sharif, Cherat, Parachinar. Sindh: Larkana, Chhor, Hyderabad, Karachi (A/P), Karachi (FSL), & Badin Balochistan: Barkhan, Khuzdar & Zhob N. Areas & AJK: Kotli, Muzaffarabad, Ghari Dupatta, Astore, & Gupis	Punjab: Murree NWFP: Kakul, Saidu Sharif, Cherat, Parachinar, Balakot, Chitral. Sindh: Larkana, Chhor, Hyderabad, Karachi (A/P), Karachi (Faisal), Moenjodaro & Padidan. N. Areas & AJK: Gilgit, Skardu, Kotli, Muzaffarabad
(b) (No DS day)	Punjab: Murree NWFP: Balakot, Chitral, Dir & Drosh. Balochistan: Kalat.	NWFP: Dir & Drosh Sindh: Sukkur (Rohri) & Badin Balochistan: Kalat. N. Areas & AJK: Astore, Bunji, Ghari Dupatta & Gupis


DISTRIBUTION OF DUST STORMS FREQUENCY OVER PAKISTAN
WINTER SEASON (1961-1990)
N
W
E
S
CHITRAL
GUPIS
GILGIT
BUNJI
DROSH
DIR
CHILAS
ASTORE
SKARDU
SAIDU SHARIF
PESHAWAR
RISALPUR
KAKUL
PARACHINAR
KOHAT
MURREE
KOTLI
JHELUM
MIANWALI
SIALKOT
SARGODHA
DERA ISMAIL KHAN
FAISALABAD
LAHORE
ZHOB
SHORKOT
QUETTA
MULTAN
BARKHAN
BAHAWALNAGAR
SIBBI
BAHAWALPUR
NOKKUNDI
KALAT
KHANPUR
JACOBABAD
KHUZDAR
SUKKUR
MOENJO DARO
PANJGUR
PADIDAN
NAWABSHAH
HYDERABAD
CHHOR
PASNI
ORMARA
KARACHI
BADIN
Legend
MET. STATIONS
NUMBER OF DUST STORMS DAYS (PER SEASON)
ZERO
0.1 to 1.0
> 1.0

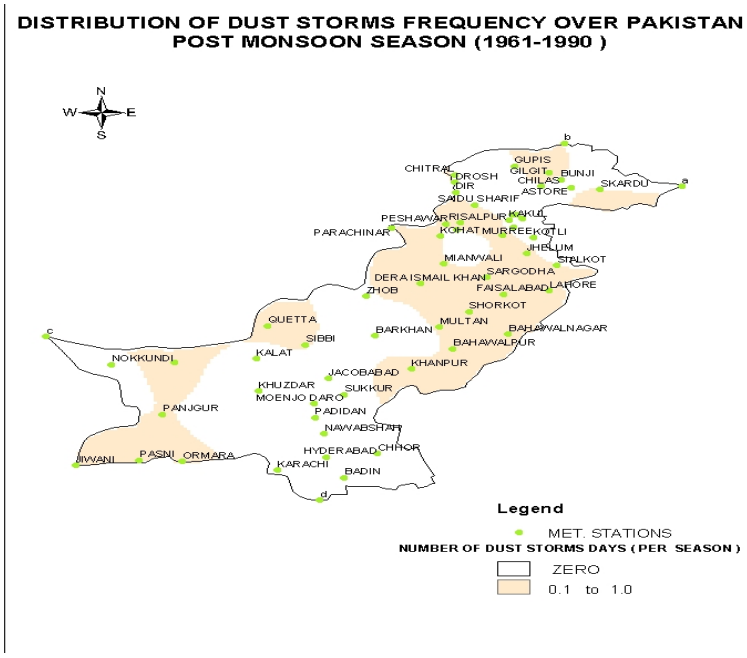
Map. A


DISTRIBUTION OF DUST STORMS FREQUENCY OVER PAKISTAN
PRE MONSOON SEASON (1961-1990)
N
W
E
S
CHITRAL
GUPIS
GILGIT
BUNJI
DROSH
DIR
CHILAS
ASTORE
SKARDU
SAIDU SHARIF
PESHAWAR
RISALPUR
KAKUL
PARACHINAR
KOHAT
MURREE
KOTLI
JHELUM
MIANWALI
SIALKOT
SARGODHA
DERA ISMAIL KHAN
FAISALABAD
LAHORE
ZHOB
SHORKOT
QUETTA
MULTAN
BARKHAN
BAHAWALNAGAR
SIBBI
BAHAWALPUR
NOKKUNDI
KALAT
KHANPUR
JACOBABAD
KHUZDAR
SUKKUR
MOENJO DARO
PANJGUR
PADIDAN
NAWABSHAH
HYDERABAD
CHHOR
PASNI
ORMARA
KARACHI
BADIN
Legend
MET. STATIONS
NUMBER OF DUST STORMS DAYS (PER SEASON)
ZERO
0.1 to 1.0
1.1 to 3.0
3.1 to 6.0
6.1 to 9.0

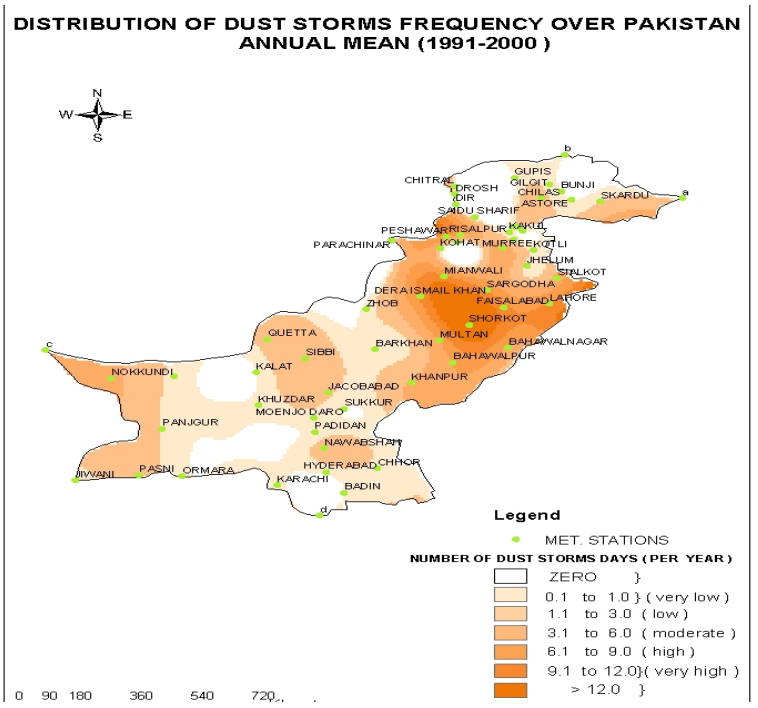
Map. B


DISTRIBUTION OF DUST STORMS FREQUENCY OVER PAKISTAN
MONSOON SEASON (1961-1990)
N
W
E
S
CHITRAL
GUPIS
GILGIT
BUNJI
DROSH
CHILAS
DIR
SKARDU
ASTORE
SADU SHARIF
PESHAWAR
RISALPUR
KAKUL
PARACHINAR
KOHAT
MURREE
KOTLI
JHELUM
MIANWALI
SIALKOT
SARGODHA
DERA ISMAIL KHAN
ZHOB
FAISALABAD
LAHORE
SHORKOT
QUETTA
MULTAN
BARKHAN
BAHAWALNAGAR
SIBBI
BAHAWALPUR
NOKKUNDI
KALAT
KHANPUR
JACOBABAD
KHUZDAR
SUKKUR
MOENJO DARO
PANJGUR
PADIDAN
NAWABSHAH
HYDERABAD
CHHOR
MIANI
PASNI
ORMARA
KARACHI
BADIN
Legend
MET. STATIONS
NUMBER OF DUST STORMS DAYS (PER SEASON)
ZERO
0.1 to 1.0
1.1 to 3.0
3.1 to 6.0
> 6.0

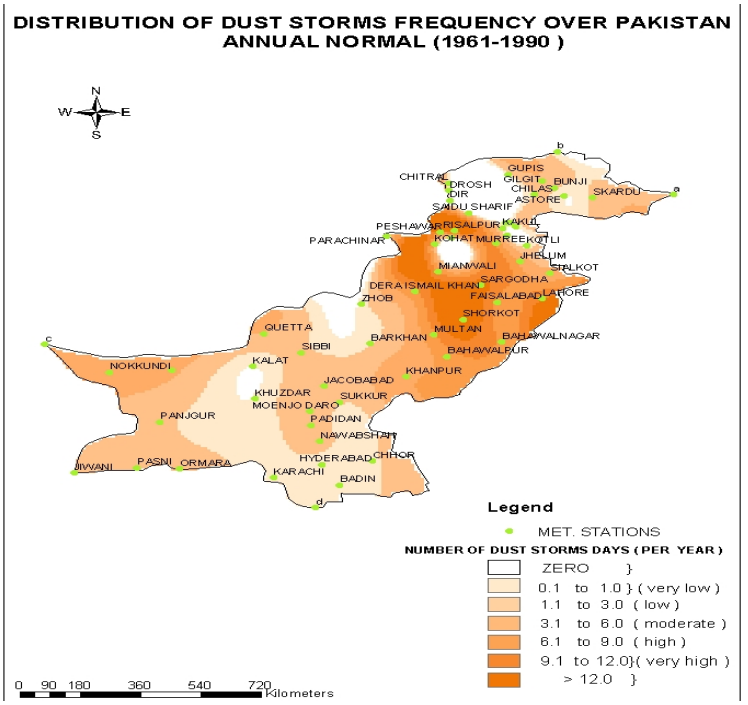
Map. C


DISTRIBUTION OF DUST STORMS FREQUENCY OVER PAKISTAN
POST MONSOON SEASON (1961-1990)
N
W
E
S
CHITRAL
GUPIS
GILGIT
BUNJI
DROSH
CHILAS
DIR
SKARDU
ASTORE
SADU SHARIF
PESHAWAR
RISALPUR
KAKUL
PARACHINAR
KOHAT
MURREE
KOTLI
JHELUM
MIANWALI
SIALKOT
SARGODHA
DERA ISMAIL KHAN
ZHOB
FAISALABAD
LAHORE
SHORKOT
QUETTA
MULTAN
BARKHAN
BAHAWALNAGAR
SIBBI
BAHAWALPUR
NOKKUNDI
KALAT
KHANPUR
JACOBABAD
KHUZDAR
SUKKUR
MOENJO DARO
PANJGUR
PADIDAN
NAWABSHAH
HYDERABAD
CHHOR
MIANI
PASNI
ORMARA
KARACHI
BADIN
Legend
MET. STATIONS
NUMBER OF DUST STORMS DAYS (PER SEASON)
ZERO
0.1 to 1.0

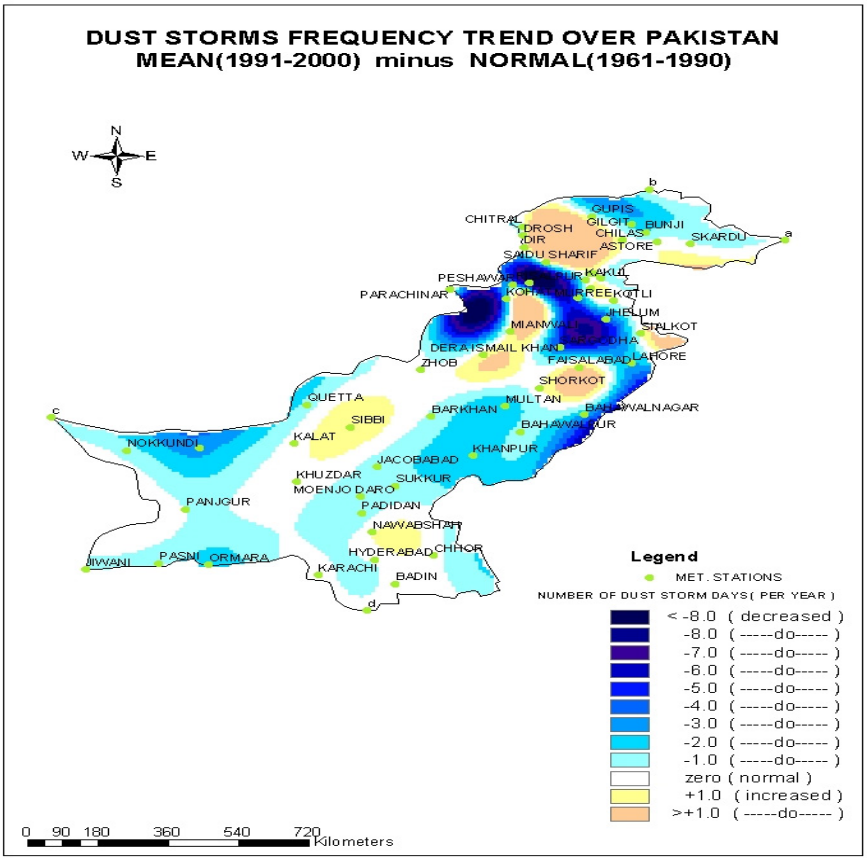
Map. D


DISTRIBUTION OF DUST STORMS FREQUENCY OVER PAKISTAN
ANNUAL MEAN (1991-2000)
N
W
E
S
CHITRAL
GUPIS
GILGIT
CHILAS
BUNJI
SKARDU
DROSH
DIR
ASTORE
SADU SHARIF
PESHAWAR
RISALPUR
KAKUL
PARACHINAR
KOHAT
MURREE
KOTLI
JHELUM
MIANWALI
SIALKOT
DERA ISMAIL KHAN
SARGODHA
ZHOB
FAISALABAD
LAHORE
SHORKOT
QUETTA
MULTAN
BARKHAN
BAHAWALNAGAR
SIBBI
BAHAWALPUR
KALAT
NOKKUNDI
KHANPUR
JACOBABAD
KHUZDAR
SUKKUR
MOENJO DARO
PANJGUR
PADIDAN
NAWABSHAH
HYDERABAD
CHHOR
JIWANI
PASNI
ORMARA
KARACHI
BADIN
Legend
MET. STATIONS
NUMBER OF DUST STORMS DAYS (PER YEAR)
ZERO }
0.1 to 1.0 } (very low)
1.1 to 3.0 (low)
3.1 to 6.0 (moderate)
6.1 to 9.0 (high)
9.1 to 12.0}(very high)
> 12.0 }
0 90 180 360 540 720

Map. E


DISTRIBUTION OF DUST STORMS FREQUENCY OVER PAKISTAN
ANNUAL NORMAL (1961-1990)
N
W
E
S
CHITRAL
GUPIS
GILGIT
CHILAS
BUNJI
SKARDU
DROSH
DIR
ASTORE
SADU SHARIF
PESHAWAR
RISALPUR
KAKUL
PARACHINAR
KOHAT
MURREE
KOTLI
JHELUM
MIANWALI
SIALKOT
DERA ISMAIL KHAN
SARGODHA
ZHOB
FAISALABAD
LAHORE
SHORKOT
QUETTA
MULTAN
BARKHAN
BAHAWALNAGAR
SIBBI
BAHAWALPUR
KALAT
NOKKUNDI
KHANPUR
JACOBABAD
KHUZDAR
SUKKUR
MOENJO DARO
PANJGUR
PADIDAN
NAWABSHAH
HYDERABAD
CHHOR
JIWANI
PASNI
ORMARA
KARACHI
BADIN
Legend
MET. STATIONS
NUMBER OF DUST STORMS DAYS (PER YEAR)
ZERO }
0.1 to 1.0 } (very low)
1.1 to 3.0 (low)
3.1 to 6.0 (moderate)
6.1 to 9.0 (high)
9.1 to 12.0}(very high)
> 12.0 }
0 90 180 360 540 720
Kilometers

Map. F



Map (G)

While generating Maps A to G, the data of Lahore (PBO) and Karachi (Airport) were used for Lahore and Karachi respectively. Four dummy stations namely 'a', 'b', 'c' and 'd' were introduced in the extreme East, North, West and South of Pakistan respectively for getting the interpolation of DS frequency for the whole Pakistan. The data assigned to each of these stations was in approximation to the data of the nearest station.

In Map (G) +1.0 (increase) stands for +0.6 to +1.4
Zero (normal) stands for +0.5 to -0.5
-1.0 (decrease) stands for -0.6 to -1.4
-2.0 (decrease) stands for -1.6 to -2.4 and so on.

Findings:

→ A net decrease of 29.5% in DS frequency was observed over Pakistan during 1991-2000 when compared with the normal (1961-1990). But still the DS frequency was higher in the drought and warmer years of 1991-2000 as compared to the lesser warm and drought less years of the decade.

→ DS frequency is much higher in the pre monsoon and monsoon seasons as compared to the winter and post monsoon seasons over Pakistan. Pre monsoon and monsoon seasons are actually the sub divisions of the summer months over major part of the country. Thermal conditions particularly during day time advance the convection developing and favor forming of strong wind especially in the late afternoon, which lift up the available loose sand and dust and blow them higher resulting in the formation of a dust storm and thus increasing the DS frequency during these seasons.

→ DS frequency is comparatively much higher over the deserts of Punjab (i.e. The Thal and The Cholistan) and adjoining areas. Especially, the Thal desert seemed to be more 'active' with respect to the formation of dust storms. The desert is not so by itself alone, it is its geographical location that plays a major role in making it so 'alive'. It has geographical proximity to the foothills of the great Himalayas. In the regions north of the desert, the temperatures are comparatively low (and keep on decreasing towards north), while within itself and in the south, the temperatures are high that give rise to the temperature gradient and unsteady thermal conditions especially during pre monsoon and monsoon seasons. These enhance the convection and wind power level, which sweeps clouds of dust and sand, thus forming dust storms frequently.

→ Punjab is more vulnerable to the dust storms, obviously, due to the presence of deserts of the Thal and the Cholistan. DS frequencies observed to be moderate to very high in plain areas of the province. It shared 59.4% & 65.5% of the total DS frequency over Pakistan during 1961-1990 and 1991-2000 respectively.

→ Shorkot (Rafique), where the DS frequency observed to be the highest in Pakistan, is one of the met. stations of Pakistan Air Force (Met. Branch). At this station, dust storms generally come from north (i.e. from the Thal desert). Now Pakistan Meteorological Department has established a met. Observatory at Jhang, which is at about 50 kilometers towards north of Shorkot. So it can be said with high degree of confidence that Jhang shall also be amongst those stations having very high DS frequency.

→ In NWFP, DS frequency observed to be moderate to very high in the plain areas (especially which are in the vicinity of the Thal), while it is very low in the hilly regions of the province. Its share to the total DS frequency (over Pakistan) observed to be 19.6% & 18.4% during 1961-1990 and 1991-2000 respectively.

→ DS frequency observed to be moderate in the northwestern parts of Balochistan (the Kharan desert and adjoining areas) and very low to low in the rest of the province. It shared 10.7% & 7.9% of the total DS frequency over Pakistan during 1961-1990 and 1991-2000 respectively.

→ In Sindh, DS frequency was found to be very low or low. Its share to the total DS frequency (over Pakistan) observed to be 6.4% & 5.0% for the periods 1961-1990 and 1991-2000 respectively.

→ The reason of DS frequency not being high in Sindh and Balochistan (although much loose dust and sand is available in the vast lands of the provinces) is that the wind power level/wind speed which is the dynamical force of a dust storm generally does not become high enough to form dust storms due to the lesser temperature gradient over the region. This makes the regions more vulnerable to the litho meteors other than dust storms i.e. blowing/drifting dust, dust in suspension and at times, dust devils and etc.

→ DS frequency found to be very low or low in Northern Areas & AJK also. It was 3.9% & 3.2% of the total DS frequency over Pakistan during 1961-1990 and 1991-2000 respectively. This region mainly consists of wet and snow covered hilly areas and green valleys. The source of dust or sand, which is the substance foundation of a dust storm, is lacking over there, thus making the chances of formation of dust storms minimum.

Conclusion:

A net decrease of 29.5% in the DS frequency over Pakistan during the warmest decade 1991-2000, can mainly be attributed to the climate change in the region and partly to the land use & land cover changes since last several decades due to the increase in the cultivated and irrigated land (irrigated area of Pakistan has increased from 10 (mha) to 18 (mha) since 1960) (Majeed, et, al (2002)), population growth, urbanization trend and etc.

A slight increase in DS frequency observed over central parts and hilly areas of Punjab, some areas of Balochistan, Sindh, NWFP and Northern Areas & AJK, is mainly because of drought and warm years during 1991-2000.

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Majeed, A., M. Azam and A. Mumtaz (2002). Drought and Water Management Strategies in Pakistan. Proceedings of the SAARC Workshop on Drought and Water Management Strategies (September 16-18, 2002 Lahore-Pakistan). Pakistan Council of Research in Water Resources, Islamabad, Pakistan.

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