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Weather

MONSOON SEASON (JUNE - SEPTEMBER 1977)

Chief features

For the third year in succession, the monsoon activity was good resulting in normal or excess rainfall over most of the country. The excess was significant over northwest India and Gujarat and serious floods affected Haryana, Delhi, Rajasthan and north Gujarat during this season. Rainfall defect by 20 per cent or more was only in Telangana and Marathwada. The rainfall distribution is given in Fig. 1.

There were two spells of weak monsoon over the central parts of the country — once in the middle of July and again in the middle of August — each time for about 10 days. In the spell of weak monsoon in August, there was a 'break' from 15 to 18 August.

The advance of the monsoon into north Peninsula and central parts of the country was delayed by 7 to 10 days. The withdrawal of the monsoon from northwest India and Gujarat was also delayed by 7 to 10 days.

Two depressions and one severe cyclonic storm developed during this season. Their tracks are given in Fig. 2.

The mean monthly circulation in the month of July was nearly normal in the lower tropospheric levels ; while in the middle troposphere the monsoon trough was much more marked than normal and at the western end of the trough over Rajasthan and Gujarat, there was a well-marked circulation which is an unusual feature in July. Another significant anomaly during August was that the western end of the monsoon trough upto 500 mb was north of the normal position.

Advance of the monsoon

The southwest monsoon advanced into south Kerala by 30 May which is near the normal date. The advance over Kerala was not in association with any major system like a depression either in the Arabian Sea or Bay of Bengal. The synoptic features associated with the onset were the existence of a trough of low and a cyclonic circulation in the middle troposphere off Kerala-Karnataka coasts in the last week of May.

In the trough off the west coast, a low pressure area formed on 7 June off Karnataka-Goa-south Maharashtra coasts and concentrated into a depression on 9th. The depression intensified into a severe cyclonic storm and moved away to Oman coast by 13th. In association, the monsoon advanced into north Kerala, Karnataka and south Konkan between 7 and 10 June. A few stations in coastal Karnataka reported very heavy rain on 8th. Honavar recorded 22 cm of rain on that day.

The monsoon also advanced into Assam and adjacent States on 7 June. This was in association with a low pressure area over northeast Madhya Pradesh and adjoining Bihar and a westerly trough in mid-troposphere moving eastwards across Sub-Himalayan West Bengal and north Assam between 5th and 7th. According to press reports, floods in the *Brahmaputra* and the *Barak* affected many parts of Assam during the first week of June causing damage to standing crops and some houses.

There was a lull in the advance of the monsoon for about a week. A depression formed off Andhra coast on 15 June, moved north and weakened into a low near Orissa coast the next day. The low continued to travel northwards upto Bihar and weakened further by 22nd. This system took the monsoon to Andhra Pradesh, Orissa, West Bengal, Bihar and south Madhya Pradesh between 15 and 22 June. Heavy to very heavy rain occurred in Gangetic West Bengal and Orissa from 17th to 19th. Some parts of Assam were affected by a second wave of floods in the *Brahmaputra* in the third week. Simultaneously the Arabian Sea current also commenced its travel northwards and covered north Konkan, Gujarat and interior parts of Maharashtra by 25th. This advance was caused by the development of a cyclonic circulation over south Maharashtra between 1·5 and 6 km a.s.l. and its northward movement to Kutch by 25th. Konkan, Goa and coastal Karnataka experienced heavy to very heavy rain from 16th to 21st. Shirali and Honavar in coastal Karnataka

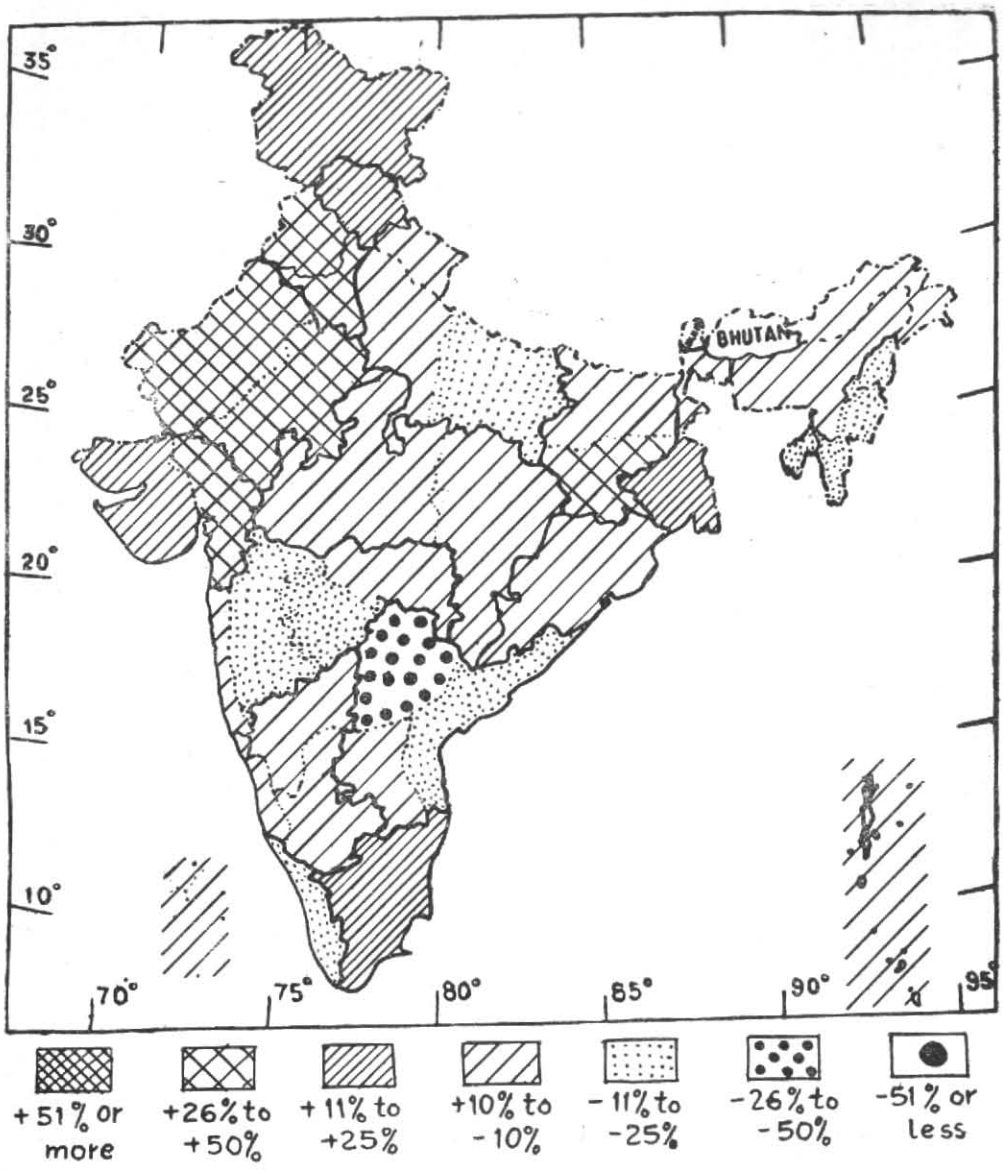

Fig. 1. Rainfall for the period 1 June to 30 September 1977
(Percentage departure from normal)

recorded 40 cm and 26 cm respectively on 16th. Goa (Dhabolim) recorded 24 cm on 17th.

A well marked low pressure area moved very slowly from northeast Madhya Pradesh and adjoining southeast Uttar Pradesh to southwest Rajasthan and neighbourhood between 23rd and 30th. It moved away further westwards to Oman coast by 2 July. This system took the monsoon to north Madhya Pradesh, Uttar Pradesh and northwest India by 1 July, thereby covering the entire country. Heavy to very heavy rain occurred in Madhya Pradesh ,Gujarat and Rajasthan on many days during the above period. Erinpura Road in Rajasthan recorded an exceptionally heavy fall of 28 cm on 25th.

While the onset of the monsoon into Kerala and its advance into northwest India were near the normal date, its advance into north Peninsula and the central parts of the country was delayed by 7 to 10 days. This delay resulted in deficiency of rainfall over these areas upto the third weak of June. However, with the subsequent advance of the monsoon, the rainfall over the country by the end of June was normal to excess except over the plains of Bihar and Uttar Pradesh where the deficiency of rainfall exceeded 25 per cent.

During the advancing phase of the monsoon, the disturbances in the westerlies continued in the north. Nine western disturbances and three induced circulations moved eastwards across

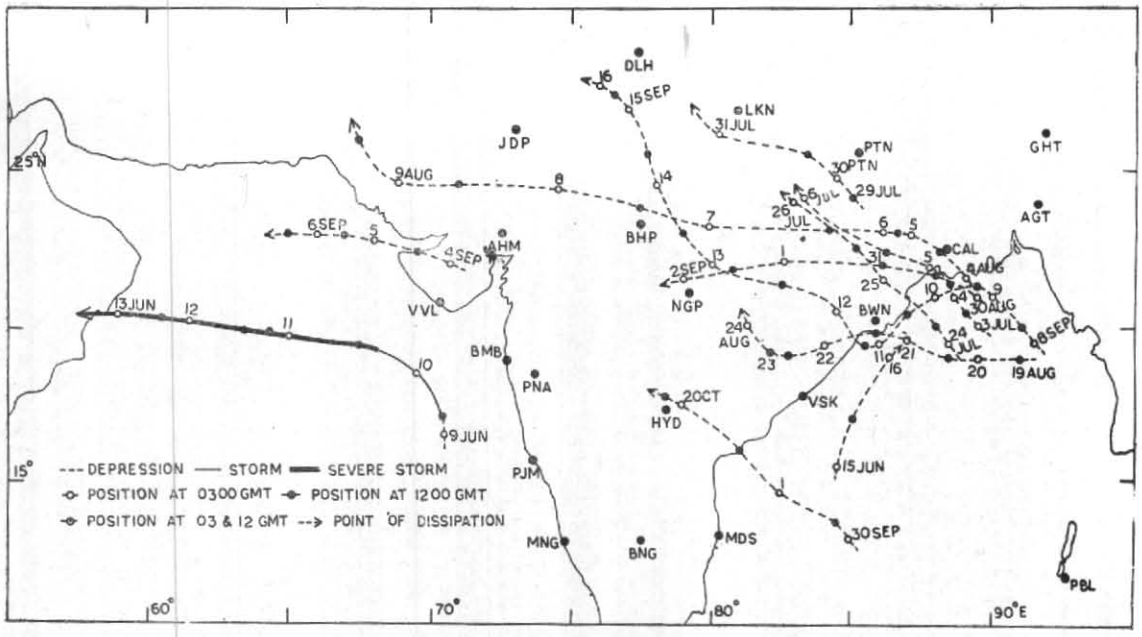

Fig. 2. Tracks of storms/depressions during June—September 1977

northwest India during this period and some of them were active, leading to excess rainfall over many parts of northwest India.

Activity of the monsoon

The monsoon was generally active over the country during July and in the first and last week of August leading to normal or excess rainfall over most parts of the country during these two months. The activity continued over northwest India and adjoining parts of Uttar Pradesh and Madhya Pradesh till the third week of September.

A low which formed over the north Bay on 1 July, concentrated into a depression on 3rd; it moved to northeast Madhya Pradesh on 6th and weakened into a low the next day. The low moved further to west Uttar Pradesh and adjoining Haryana by 8th and later merged with the monsoon trough. A cyclonic circulation developed over north Gujarat and south Rajasthan in lower troposphere on 5th, persisted there upto 8th and moved northwards to Punjab. Haryana and neighbourhood by 12th. Four western disturbances also moved eastwards across the Western Himalayas between 1st and 13th. In association with the above systems, very heavy rains occurred in northwest India, Gujarat region and western Maharashtra on a few days between 1 and 12 July. Amritsar, Jullundar and Hoshiarpur districts of Punjab and Jalore district of Rajasthan were affected by floods which caused damage to crops and houses. Mahabaleswar had a record rainfall of 44 cm on 7th.

A depression formed over northewest Bay on 24 July. Crossing north Orissa coast, the depression moved to northeast Madhya Pradesh and weakened into a low on 26th, which merged with the seasonal monsoon trough the next day. A cyclonic circulation extending to the middle troposphere lay over Gangetic West Bengal and neighbourhood on 28th and 29th. It move westwards and another depression formed over Bihar on 30th. This depression moved westnorthwestwards and weakened into a low over west Uttar Pradesh by 31st. In association with these systems, heavy to very heavy rain occurred in Gangetic West Bengal, Bihar Plateau and east Uttar Pradesh on a few days between 28th and 31st. Flood affected many parts of Gangetic West Bengal causing damage to irrigation works.

A cyclonic circulation extending to the middle troposphere lay over south Rajasthan and adjoining north Gujarat from 24 to 27 July. It moved slowly to the Western Himalayas by 30th and dissipated. A western disturbance also moved eastwards across Jammu and Kashmir between 24th and 27th. In association with these systems, heavy to very heavy rain occurred in east Rajasthan, Gujarat State and Himachal Pradesh on many days during this period. Radhanpur in Gujarat recorded an exceptionally heavy fall of 33 cm on 27th. According to press reports, many parts of Rajasthan and Gujarat State were seriously affected by floods resulting in dislocation of road and telecommunications and damage to crops and houses.

Konkan, coastal Karnataka and Kerala experienced heavy to very heavy rain on many days in the second fortnight of July, 29 cm at Honavar on 19th and 30 cm at Devgarh on 21st. Mangalore recorded 25 cm on 21st. Very heavy rain in Bombay disrupted the city life on 21st and 22nd. Many houses collapsed in Mangalore due to very heavy rains on 21st. Floods also affected some parts of north Kanara and Bijapur districts in the last week of July. Damage to roads and irrigation works due to floods and heavy rain in Karnataka was estimated at about Rs. 9 lakhs.

A low which was over west Uttar Pradesh on 31 July moved slowly to east Rajasthan by 3 August and merged with the monsoon trough on 4th. A depression which formed on 4 August over Sundarbans moved practically westwards across the whole length of the country and merged into the seasonal low by 10th. The depression was deep between 7th and 9th. Another low moved from northwest Bay and adjoining north Orissa to northeast Madhya Pradesh and thence northwards to northeast Uttar Pradesh between 8th and 12th and merged with the monsoon trough on 13th. Heavy to very heavy rain occurred in Madhya Pradesh on many days and in northwest India, Gujarat, Bihar, West Bengal and Orissa on a few days during this period. In the first half of August serious floods affected Haryana and Delhi and some parts of east Rajasthan causing damage to crops and houses. Broach district in Gujarat was also affected by floods. Floods in the *Narmada* submerged the road bridge at Mandla and disrupted road communications between Seoni and Mandla. Some parts of Bihar were also affected by floods resulting in some damage to crops and houses.

A deep depression formed over northeast Bay moved to southeast Madhya Pradesh across south Orissa between 19 and 23 August, weakened into a low and persisted over central India upto 27th. The low merged with the monsoon trough on 28th. As the depression moved westwards to Madhya Pradesh, the eastern end of the monsoon trough shifted northwards and passed from Bihar plains to Assam and adjacent States from 25th to 28th. Assam and adjacent States had very heavy rains from 25th to 27th. Dhubri recorded an exceptionally heavy fall of 32 cm on 27th. River *Indravathi* (a tributary of the *Godavari*) rose in spate. Athgarh block of Cuttack district was affected by floods. Floods in the *Brahmaputra* affected some 500 villages in north Assam causing damage to crops and houses.

Five western disturbances moved eastwards across the Western Himalayas during August.

A low which lay over north Bay on 29 August concentrated into a depression on 30th, moved westwards and weakend into a low over west Madhya Pradesh on 3 September. This low moved to Rajasthan by 5th and merged with the monsoon trough. Another depression formed over Saurashtra on 4th, moved westwards and weakened over north Arabian Sea by 7th. These systems caused heavy to very heavy rain in Gangetic West Bengal and Orissa from 29 to 31 August and in Madhya Pradesh, Maharashtra and Gujarat States on some days in the first week of September. Porbandar had a record rainfall of 51 cm on 4th.

A low which lay over north Bay from 5 to 7 September concentrated into a depression on 8th, which became deep on 11th off Orissa coast. It moved northweastwards to northeast Rajasthan by 16th and merged with the monsoon trough by 18th. Heavy to very heavy rain occurred in Orissa and Madhya Pradesh on a few days during the above period. According to press reports, floods on the *Narmada* and *Indravathi* disrupted road communications on the Agra-Bombay and Jagdalpur-Raipur section.

During July and August, there were two spells of weak monsoon over the central parts of the country, the first from 13 to 22 July and the second from 13th to 21st in August. Break conditions prevailed between 15 and 18 August. The monsoon was also weak over many parts of the Peninsula particularly during September.

In the first spell covering the period 13 to 22 July, the monsoon trough was north of its normal position on most days and passed through Punjab, Uttar Pradesh, Bihar plains and Assam & Meghalaya. In this trough, a low formed over Gangetic West Bengal and adjoining Bihar on 14th, moved to west Uttar Pradesh and adjoining Haryana by 18th and merged with the monsoon trough. These systems caused good rainfall in the Western Himalayas, Punjab, Haryana, Uttar Pradesh, Bihar, West Bengal, Assam & Meghalaya and Orissa on some days during the above period. Some parts of Assam and Uttar Pradesh were affected by floods. While the seasonal monsoon trough shifted northwards (as discussed above), two weak low pressure systems moved westwards across south Bay to the east coast of the Peninsula—the first one between 17th and 20th causing good rainfall in Tamil Nadu on a few days.

In the second spell during August, the monsoon trough shifted northwards on 13th and lay close to the foot of the Himalayas from 15th to 21st. A low level north-south trough moved eastwards from West Bengal to Assam and adjacent States

on 17th and 18th. These systems caused generally widespread rain with heavy to very heavy falls in Assam & adjacent States and Sub-Himalayan West Bengal & Sikkim from 14th to 18th. Pasighat in Assam reported an exceptionally heavy fall of 32 cm on 16th. Floods in the *Brahmaputra* affected seven districts in Assam causing damage to crops and houses. A north-south trough lay over Andhra Pradesh and Tamil Nadu from 10th to 20th. A cyclonic circulation in the middle troposphere moved westwards from southeast Bay to east central Arabian Sea across the Peninsula between 8th and 14th. Subsequently an east-west trough lay over extreme south Peninsula at 500 mb level upto 18th. These systems caused scattered to fairly widespread rain in Tamil Nadu and Andhra Pradesh on many days during the above period with isolated heavy falls over these areas on a few days.

The weak monsoon condition in the Peninsula during September was mainly due to absence of cyclonic disturbances moving across that part of the country.

Eight western disturbances moved across the Western Himalayas during September.

Withdrawal of the monsoon

By the middle of September, a change-over began to be noticed in the upper air flow over the country. Characteristic features of the withdrawing phase of the southwest monsoon appeared. The upper tropospheric westerlies over Srinagar attained speed of 60 kt or more on a few days even in the first fortnight. The mid-latitude westerlies gradually penetrated southwards to northwest India by the third week of the month and the upper tropospheric westerlies over the extreme north of the country reached upto 80 kt by the third week. Movement of westerly troughs over the extreme north of the country also became more conspicuous. In consonance with the changes in the upper troposphere, the surface and low level seasonal trough was also establishing in the southern latitudes extending from Andaman Sea to east central Arabian Sea across central Peninsula by the last week. The upper easterlies over the Peninsula also progressively weakened.

With these changes in the circulation pattern, the withdrawal of the southwest monsoon commenced from northwest India. The southwest monsoon withdrew from northwest India and west Uttar Pradesh between 23 and 26 September and from Gujarat State on 30th. It withdrew from the rest of the country outside south Peninsula by 12 October. The withdrawal of the monsoon from northwest India and Gujarat was behind schedule by 7 to 10 days.

POST MONSOON SEASON (OCTOBER-DECEMBER 1977)

Chief features

The cyclonic disturbance activity in the Indian seas during this season was exceptional in the following respects. As many as 12 cyclonic disturbances as compared to the normal frequency of 5 for the season developed. Out of the five cyclonic storms the cyclone which hit coastal Andhra Pradesh in the middle of November was the severest to strike that area during the last 100 years. It caused colossal loss of life and property. Another storm in the same month had an unusually long life of about a fortnight as well as an unusual track. The tracks of the storms and depressions are given in Fig. 3.

The southwest monsoon activity continued over the central parts of the country upto the first week of October and over the Peninsula and northeast India upto about 12 October. Thereafter the northeast monsoon set in over south Peninsula. The northeast monsoon was quite active over Tamil Nadu both during October and November leading to large excess of rainfall for the season. The other parts of the Peninsula and the central parts of the country had also excess of rainfall for the season. This excess over these parts was mainly due to the abnormal cyclonic disturbance activity. The rainfall for the season over the country in terms of percentage departure from normal is depicted in Fig. 4.

Cyclonic disturbances

Of the 12 cyclonic disturbances in the season, there were 3 cyclonic storms and 3 depressions in the Bay of Bengal and 2 cyclonic storms and 4 depressions in the Arabian Sea. There was no cyclonic disturbance in December.

The first depression of the season affected Andhra Pradesh in the first week of October. This system after weakening into a low over Vidarbha on 3rd, recurved northeastwards under the influence of a westerly trough and reintensified into a depression on 5th morning over Bihar plains. It weakened again into a low the same evening and moved away eastwards across Assam and adjacent States by 8th. Under the influence of these systems there was a good spell of rainfall in north Peninsula, Madhya Pradesh, Uttar Pradesh and northeast India in the first week with some heavy to very heavy falls in Andhra Pradesh, east Uttar Pradesh and many parts of northeast India.

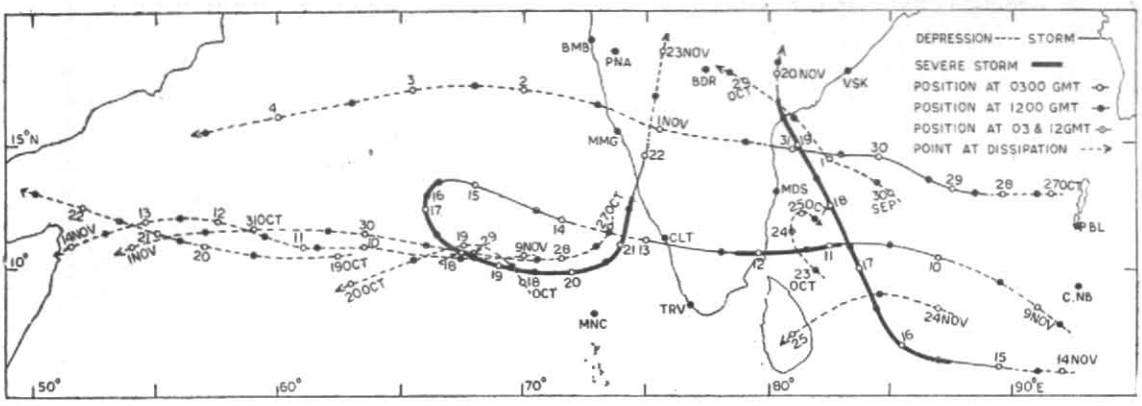

Fig. 3 Tracks of storms/depressions during October-December 1977

A low formed over Lakshadweep on 16 October, concentrated into a depression on the 18th over southeast Arabian Sea and weakened over southwest Arabian Sea by 20th. This system in the initial stages caused widespread rain in Kerala from 16th to 18th with heavy to very heavy falls on 17th and 18th. According to press reports very heavy rain in Trivandrum on 17th, inundated low lying areas and damaged standing crops.

A deep depression formed over the central parts of Arabian Sea on 19 October and moved away westwards to Gulf of Aden by 22nd. It attained the intensity of a storm from 20th evening to 21st morning. It did not affect the weather over the country.

A depression formed on the evening of 23 October over southwest Bay. It moved northwards to west central Bay and weakened by 26th morning. Under the influence of this system, active to vigorous northeast monsoon conditions prevailed over Tamil Nadu between 23rd and 26th.

A well marked low lay over Lakshadweep from 23 to 26 October. This formed into a depression over Lakshadweep on the next morning and moved away slowly to Somalia coast by 2 November. This system as a low pressure area caused widespread rain with heavy to very heavy falls in Kerala from 24th to 26th and in south Interior Karnataka on 25th and 26th. Rainfall was also generally widespread in Lakshadweep from 25th to 28th.

A depression formed over east central Bay and adjoining areas on 27 October, intensified into a cyclonic storm on the next day and crossed south Andhra coast near Kavali by midday of 31st. It weakened into a depression that evening and moving westwards across the Peninsula and Arabian Sea, dissipated off Arabia coast on 5 November. Parts of Andhra Pradesh, Maharashtra State and north Interior Karnataka received good rainfall on 1 and 2 November. Some damage was reported due to this storm in Kavali Udayagiri, Atmakur and Kovur taluks of Nellore district and in Kandukur, Kanigiri and Podili taluks of Prakasam district. Damage due to wind was confined to Kavali taluk and parts of Udayagiri taluk.

Two depressions developed almost simultaneously around 9 November, one over southeast Arabian Sea and the other over southeast Bay. Both systems travelled westwards. While the Arabian Sea depression weakened over Somalia coast on 14th, the Bay depression intensified into a severe cyclonic storm and crossed Tamil Nadu coast near Nagapattinam on 12th. It retained its severe intensity inland upto Tiruchirappalli and emerged into Lakshadweep on 13th as a cyclonic storm. This storm caused generally widespread rain in Tamil Nadu and Rayalaseema from 12th to 14th with very heavy falls in Tamil Nadu during this period. Damage to crops, life and other property was reported in Thanjavur, Tiruchirappalli, Pudukottai, Madurai, Salem, south Arcot and Chingleput districts of Tamil Nadu and in Pondicherry. The loss of human life was estimated to be 560 and the damage to property around 150 crores of rupees. Gales of 80 to 120 kmph lashed Thanjavur, Tiruchirappalli and Pudukottai districts. Loss of life was mainly due to flash floods and house collapses. The railway bridge on river *Amaravati* near Karur was washed away. Train services in the southern railway were disrupted for a number of days.

The cyclonic storm which emerged into Lakshadweep on 13th, reintensified into a severe cyclonic storm on 15th evening over the east Arabian Sea. The storm made a loop and moved eastwards to Lakshadweep by 21st. Later moving northnortheastwards, it crossed coast near Honavar on the early morning of 22nd, weakened

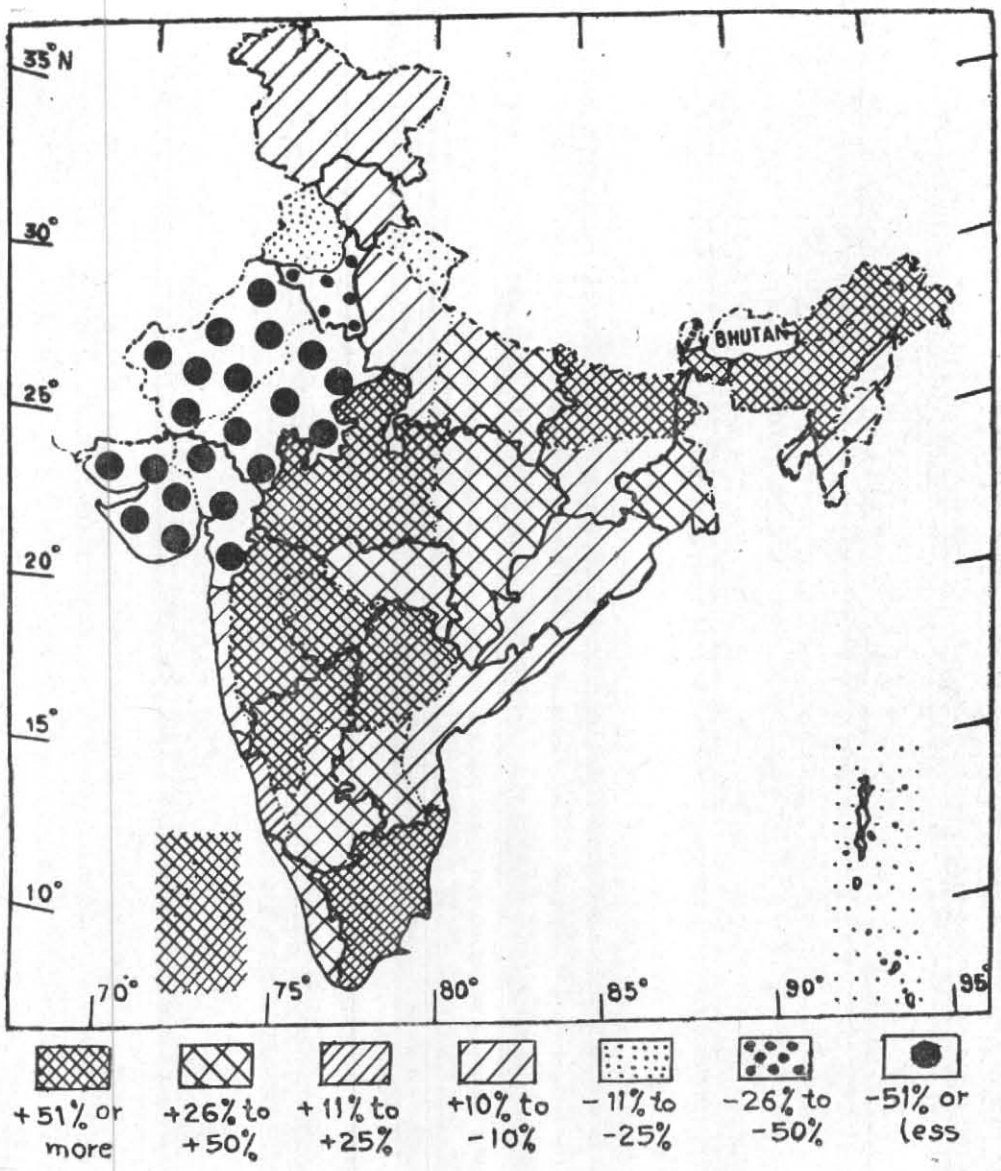

Fig. 4. Rainfall for the period 1 October to 31 December 1977
(Percentage departure from normal)

into a depression and lay over central parts of Maharashtra on 23rd. Subsequently it moved away eastnortheastwards as a low to south Assam by 28th and dissipated there. This system as it emerged into the Arabian Sea, caused fairly widespread rain in Kerala on 13th and 14th and in Lakshadweep on 15th with heavy to very heavy falls in Kerala. Subsequently during its detour, it caused widespread rain in Lakshadweep, Kerala, Karnataka, Maharashtra, Madhya Pradesh, Bihar Plateau and in Gangetic West Bengal on a few days between 19th and 26th. Heavy to very heavy rain occurred in Kerala, Lakshadweep, Maharashtra, and Madhya Pradesh. Due to this cyclone widespread damage was reported in the coastal belt of Kerala from Quilon to Kasargode. About 70 persons were reported to have died. About 8400 houses were totally damaged and another 19,000 partially damaged. Crops over 87,000 acres were also affected. Tidal waves were reported to have damaged 620 fishing vessels. Total damage was estimated at Rs. 10 crores. In Lakshadweep, Kalpeni island was the worst hit. About a lakh of coconut trees, the main cash crop of the island were uprooted. Many houses were also damaged. No damage was reported from Karnataka.

A low pressure area which moved into south Andaman Sea from the east on 11 November, concentrated into a depression on the 14th morning over southeast Bay. Moving in a westerly direction, it intensified into a severe cyclonic

storm on the evening of 15th and developed a core of hurricane winds o. 16th. Later moving northwestwards, the storm crossed Andhra coast near Nizamapatnam (between Ongole and Masulipatnam) on the afternoon of 19th and dissipated over southeast Madhya Pradesh and adjoining Orissa by 21st evening. Ship *Jagat Swamini* which passed through the eye of the storm reported a wind speed of 90 knots and a central pressure of 940 mb at 12 GMT of 17th. This system caused generally widespread rain with heavy to very heavy falls in coastal Andhra Pradesh from 19th to 21st and in Telangana on 20th. Fairly widespread rain also occurred in Orissa and Gangetic West Bengal on 21st and 22nd. Guntur, Krishna, west and east Godavari and Prakasam districts were very severely affected by the cyclone. Divi taluka in the mouth of river *Krishna* experienced tidal waves of height 5 to 6 metres. The tidal waves affected as far as 15 km inland. The anemometer at Gannavaram airport was blown off. The maximum wind speed associated with this cyclone was estimated to be about 200 kmph. Guntur had a record rainfall of 40 cm on 20th. About 10,000 people and 27,000 heads of cattle were reported killed. 8000 people died in Divi taluk alone. Damage to crops and other property was estimated to be around 350 crores of rupees. This storm was given the highest classification (T 7/7) in Dvorak's scale based on satellite pictures for the Indian area so far. This is equivalent to a maximum wind speed of 135 kt (250 kmph).

A low, moving westwards from Andaman Sea concentrated into a depression on 24 November over southwest Bay. The depression moved westwards across Sri Lanka and weakened into a low over Comorin and adjoining Sri Lanka on 25th evening. Under its influence, generally widespread rain occurred in Tamil Nadu from 25th to 27th with isolated heavy to very heavy falls on 25th and 26th.

Northeast monsoon activities

Apart from the cyclonic disturbances discussed above, which caused good rainfall in the Peninsula, there were other low pressure systems which led to active northeast monsoon conditions in the Peninsula.

Five low pressure areas moved westwards across south Peninsula and Comorin — four in October and one in the first week of November. These systems caused generally widespread rain in Tamil Nadu, Kerala and parts of Karnataka on most days during the above period with heavy to very heavy falls on some days. One of the these systems which moved across the central parts of the Peninsula, gave scattered to fairly widespread rain with a few heavy falls in Konkan and Madhya Maharashtra from 6 to 8 October. Atirampattinam in Tamil Nadu recorded 28 cm of rainfall on 23 October. Madras city received 51 cm of rain during the period 21st to 26th, which is almost three fourths of the entire season's total normal rainfall for that place. This spell of heavy rain in Madras damaged hutments and dislocated road and rail traffic. Irrigation tanks and reservoirs in Tamil Nadu were reported to be full and overflowing.

A trough of low lay over southeast Arabia Sea and Lakshadweep from 3rd to 6th. It caused fairly widespread rain in Kerala from 3rd to 6th and in Lakshadweep on 4th, with isolated heavy falls in Kerala from 3rd to 5th.

A well marked trough lay off the west coast from 25th to 29th. In this trough a low pressure area formed off Karnataka coast on 26th and moved north to off Maharashtra-south Gujarat coasts by 28th and weakened later on. In association with these, rainfall was generally widespread in Kerala, coastal and south Interior Karnataka from 25th to 27th, in Maharashtra from 27th to 29th and in west Madhya Pradesh on 28th and 29th.

Northeast monsoon was weak over south Peninsula during December.

Western disturbances

Fifteen western disturbances affected northwest India during this season — six in October, four in November and five in December. Their activity was marked mainly in December. Kangra and Dalhousie in Himachal Pradesh reported a very heavy rainfall of 14 cm on 26 December. An induced low moved eastwards from west Rajasthan to Assam and adjacent States across Madhya Pradesh between 24 and 30 December. This system caused generally widespread rainfall in Uttar Pradesh, Bihar State, West Bengal & Sikkim and Assam & adjacent States on some days during this period. As per press reports, many places in Jammu & Kashmir and Himachal Pradesh had heavy snowfall on 25th. Darjeeling and Gangtok also reported snowfall on 28th. Darjeeling has not experienced such a heavy snowfall in living memory.

Many parts of northeast India had three spells of good rainfall, 13 to 16 October, 26 to 31 October and 3 to 7 November under the combined influence of a low level east-west trough extending from Bihar to Assam and passage of troughs in the middle tropospheric westerlies across that area.

Temperature

Day temperatures were appreciably above normal in Gujarat State, west Madhya Pradesh and north Maharashtra State on many days in the second fortnight of October. Night temperatures were generally above normal over most parts of the country in November. In the wake of an active western disturbance in the last week of December, day and night temperatures were appreciably below normal in many parts of northwest India, Madhya Pradesh, Maharashtra and Gujarat States between 28 and 31 December with moderate cold wave conditions over west Madhya Pradesh, Gujarat region and north Madhya Maharashtra on 30th.

WINTER SEASON (JANUARY AND FEBRUARY 1978)

Chief features

The winter precipitation in north India in association with western disturbances was in excess in Rajasthan, east Uttar Pradesh, Madhya Pradesh, Vidarbha and Bihar and deficient over the rest of north India. The winter rainfall was also in excess in Interior Maharashtra, Andhra Pradesh, north Interior Karnataka and Kerala. The rainfall over the country during this season in terms of percentage departure from normal is in given Fig. 5.

There was a high incidence of hailstorm activity in Uttar Pradesh in February causing extensive damage to standing crops in that State.

There were no prolonged spells of cold wave over the country during this winter.

Western disturbance activity

Thirteen western disturbances (7 in January and 6 in February) affected northwest India. Most of them were upper air systems. But one of them intensified into a depression over Punjab in the middle of February. The Western Himalayas, received fairly widespread rain or snow in five spells covering the periods 13 to 15 January, 28 to 31 January, 6 and 7 February, 13 February and 15 to 18 February. Punjab, Haryana and the plains of west Uttar Pradesh experienced fairly widespread rainfall only on 3 days in the season in the middle of February and this was in association with a western depression.

Seven induced lows moved eastwards across the plains of north India during this season—3 in January and 4 in February. Out of these, four moved eastwards from Rajasthan to Bihar and neighbourhood while the other three formed in south Rajasthan and adjoining west Madhya Pradesh and dissipated without appreciable movement. In association with the above systems, scattered to fairly widespread rain or thundershowers occurred in Madhya Pradesh, Vidarbha, east Uttar Pradesh, Bihar State and Gangetic West Bengal on a few days in the second and third weeks of January and in the second week of February and in Rajasthan on 16 and 17 February.

A well marked east-west wind discontinuity upto 0·9 km a.s.l. lay over Madhya Pradesh and Bihar from 2 to 4 and from 14 to 17 February.

A trough in the mid-tropospheric westerlies also moved eastwards across the central parts of the country and northeast India between 3 and 5 February. In association with these systems scattered to fairly widespread rain or thundershowers occurred in Madhya Pradesh, east Uttar Pradesh, Bihar, Gangetic West Bengal and Orissa on a few days during the above period.

A cyclonic circulation in the low levels moved from east Uttar Pradesh to Arunachal Pradesh between 17 and 21 February causing fairly widespread rain or thundershowers in east Uttar Pradesh, Bihar plains and Sub-Himalayan West Bengal & Sikkim on 17th and 18th and scattered to fairly widespread thundershowers in Assam and adjacent States from 18th to 20th.

Moderate to severe hailstorms occurred in different parts of Uttar Pradesh on 21 January, 7 and 8 February and from 16 to 18 February causing considerable damage to standing crops. Jhansi experienced hailstorm on 12 February. Hailstorms were also reported from Amraoti on 10th, Akola on 11th and Patan tehsil in Jabalpur district on these days, resulting in damage to standing crops.

Other systems

A north-south wind discontinuity upto 0·9 km a.s.l. lay over the interior parts of the Peninsula during the periods 6th to 11th and 23 to 28 January and the first and third weeks of February. This discontinuity shifted westwards off the west coast on 22 February, in association with a low level trough in the easterlies moving westwards across extreme south Peninsula between 21 and 24 February and persisted upto 25th. Many parts of the Peninsula had generally isolated rainfall on some days during the above period. The rainfall was, however, scattered to fairly widespread in Marathwada on 25 and 26 January, in Marathwada and Madhya Maharashtra on 3 and 6 February, in Telangana on 9 and 10 January, in Telangana and coastal Andhra Pradesh from 19 to 21 February, in Kerala on 23 and 24 February and in Lakshadweep on 25 February. An isolated heavy rainfall of 9 cm was reported from Visakhapatnam on 24 January and 8 cm from Kottayam on 24 February.

East Hayatnagar in Hyderabed taluk was reported to have experienced hailstorm and

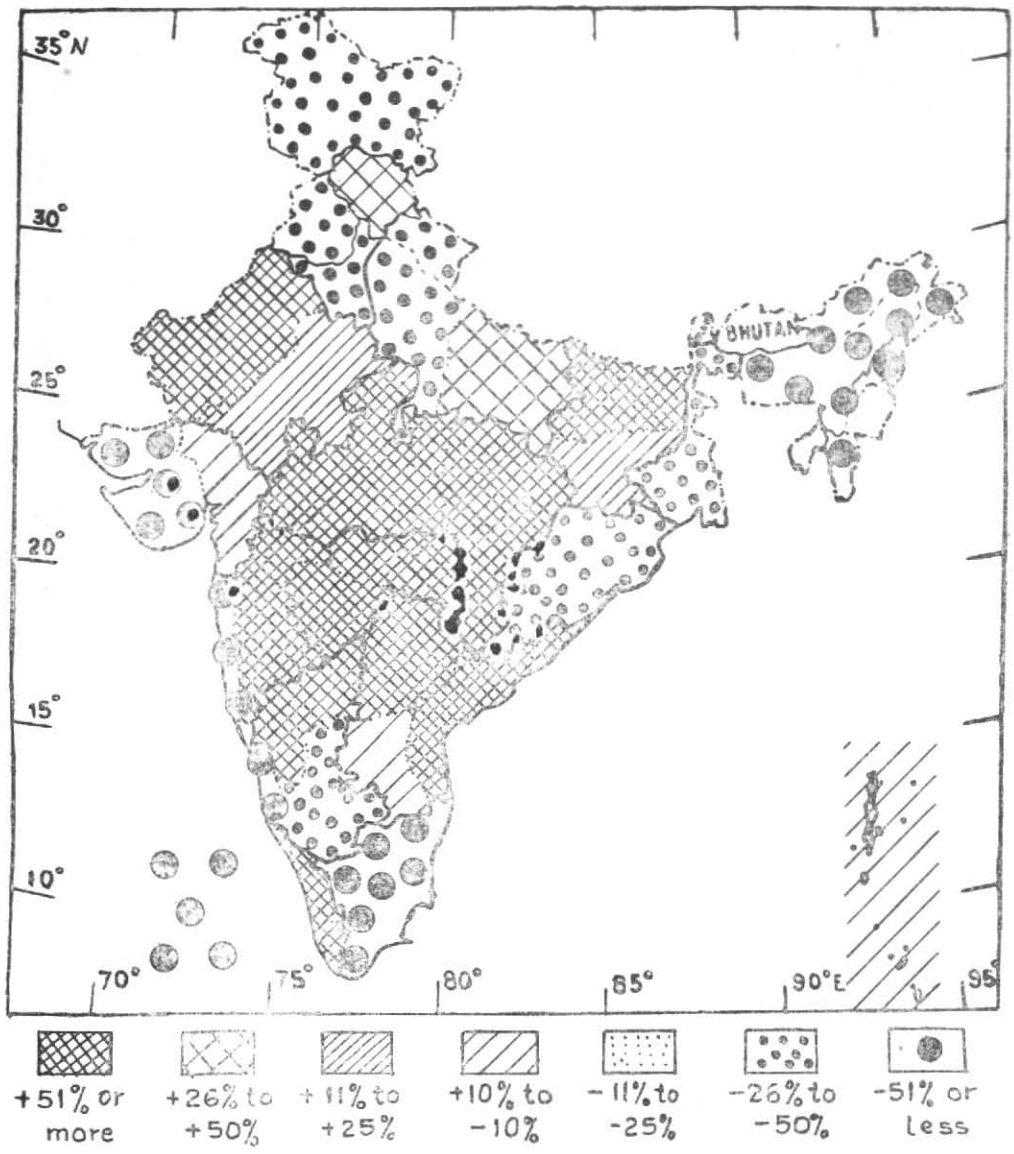

Fig. 5. Rainfall for the period 1 January to 28 February 1978 (Percentage departure from normal)

squall between 17 and 19 February. 10,000 birds (poultry) perished. The loss to poultry farms was estimated to be rupees five lakhs. Grape gardens over 100 acres near Hyderabad were severely damaged. Some buildings of Defence Laboratories in south Hyderabad suffered structural damage. The southern parts of Hyderabad city also experienced hail on 20th.

Andaman and Nicobar Islands had four spells of scattered to fairly widespread rainfall, two in January and two in February, mainly in association with troughs of low moving westwards across Andaman Sea to south Bay. Long Island reported a very heavy rainfall of 14 cm on 8 January. Mayabandar recorded 6 cm of rain on that day and Port Blair 6 cm on the previous day.

Temperature

Maderate to severe cold wave conditions prevailed in many parts of Rajasthan on 19 and 20 January. Moderate cold wave conditions also prevailed in northwest India on 9 February and in some parts of Rajasthan, Gujarat State and Interior Maharashtra on a few days in the first and last week of January and in the third week of February and in Madhya Pradesh and Uttar Pradesh on a few days in the first and last week of January.

Upper air features

In January the contour heights were lower than normal by 40 to 80 gpm in the upper troposphere over north India and the westerly jet was stronger by 20 to 30 kt as compared to the normal. In February the troposphere in general was colder than normal by 3 to 5°C over north India and north Peninsula. The westerly jet speed was nearly normal.