

Cyclonic storms and Depressions over the north Indian Ocean during 2019*

1. Introduction

During 2019, in all 12 intense low pressure systems formed over the Indian Seas. These include; one Super cyclonic storm (KYARR), one extremely severe cyclonic storm (FANI), 4 very Severe Cyclonic Storms (VAYU, HIKAA, MAHA & BULBUL), 2 Cyclonic Storms (PABUK & PAWAN), 3 Deep Depressions and 1 Depression. Out of these 12 systems, 4 systems formed over the Bay of Bengal and 8 over the Arabian Sea. Arabian Sea remained exceptionally active in terms of cyclogenesis this year, especially in the post monsoon season. The season-wise distribution had been one cyclonic storm in winter, one in pre-monsoon season, 2 depressions and 2 very severe cyclonic storms during the monsoon season and 4 cyclonic storms and 3 depressions in Post monsoon season.

The details of these systems are summarised below in Tables 1-3 and the tracks are shown in Fig. 1.

2. Details of the systems

2.1. Cyclonic storm 'PABUK' over Andaman Sea (4 - 8 January, 2019)

2.1.1. A cyclonic storm 'PABUK' lay over south China Sea in the morning of the 3rd January. It moved west-northwestwards and lay centred at 0300 UTC of 4th January over Gulf of Thailand and adjoining Thailand near Lat. 8.3° N/Long. 101.0° E. It further moved west-northwestwards and lay centred at 1200 UTC of 4th January over Thailand near Lat. 8.5° N/Long. 99.7° E. It further moved west-northwestwards and lay centred at 0000 UTC of 5th January over Thailand and neighbourhood, near Lat. 8.9° N/Long. 98.7° E. It moved west-northwestwards and lay centred at 0300 UTC of 5th January over Andaman Sea and neighbourhood, near Lat. 9.1° N/Long. 98.1° E. Further moving northwestwards it lay centred at 1200 UTC of 5th January over Andaman Sea and neighbourhood, near Lat. 9.8° N/Long. 97.1° E. It moved west-northwestwards and lay at 0300 UTC of 6th January over Andaman Sea near Lat. 11.1° N/Long. 94.6° E, weakened into a deep depression at 0600 UTC of 6th January and crossed Andaman Islands as a deep depression near Lat. 11.6° N/Long. 92.7° E, close to south of Port Blair close to south of Port Blair between 1300 & 1500 UTC of 6th January. It lay centered at 1500 UTC of 6th January, over southeast Bay of Bengal

near Lat. 11.6° N/Long. 92.6° E, about 15 kms southwest of Port Blair. It moved nearly northwards and weakened into a depression and lay centred at 0000 UTC of 7th January over southeast Bay of Bengal close to Andaman Islands near Lat. 12.6° N/Long. 92.0° E. It moved nearly northwards and lay centred at 0300 UTC of 7th January near Lat. 12.8° N/Long. 92.0° E and lay centred at 1200 UTC of 7th January near Lat. 13.1° N/Long. 92.0° E. It further moved northeastwards and weakened into a well marked low pressure area over eastcentral Bay of Bengal and adjoining north Andaman Sea off Myanmar coast at 0000 UTC of 8th January.

2.1.2. Other features observed

Over the Andaman Sea, the peak intensity of the system was 70-80 kmph gusting to 90 kmph during 0300 - 1500 UTC of 5th). The lowest estimated central pressure was 1000 hPa with pressure drop of about 8 hPa.

2.1.3. Realized weather

According to IMD-NCMRWF merged satellite and rain gauge observation on 6th January, heavy rainfall occurred at isolated places over north Andaman Sea and Andaman Islands. Moderate rainfall occurred over Andaman and Nicobar Islands on 7th. On 8th, the cloud mass was sheared northeastwards and light to moderate rainfall occurred at a few places over eastcentral Bay of Bengal and adjoining Myanmar. The system crossed Andaman Islands as a deep depression with a wind speed of 55-65 kmph gusting to 75 kmph.

Chief amount of 24 hrs accumulated rainfall (≥ 7 cm) ending at 0300 UTC of date during 4-7 January is presented below:

7th January

Andaman & Nicobar Islands : Hut Bay 10 and Maya Bandar & Port Blair 7 each

2.2. Extremely Severe Cyclonic Storm (ESCS) 'FANI' over the Bay of Bengal (26 April - 4 May, 2019)

2.2.1. Under the influence of the trough of low at mean sea level over equatorial Indian Ocean and adjoining southeast Bay of Bengal, a low pressure area formed over

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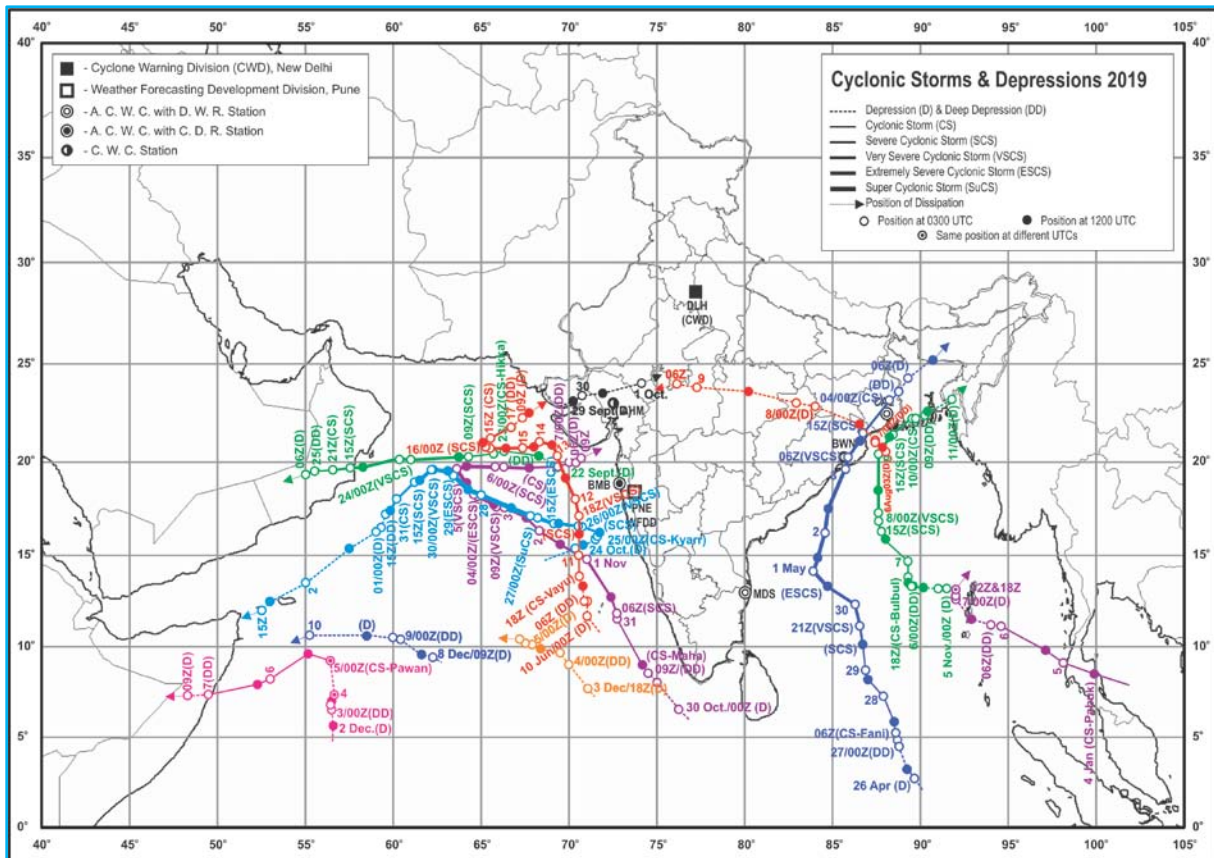


Fig. 1. Tracks of storms and depressions over during the year 2019

east Equatorial Indian Ocean & adjoining southeast Bay of Bengal at 0000 UTC of 25th April. It lay as a well marked low pressure area over the same region at 0300 UTC of 25th April. Associated cyclonic circulation extended upto mid-tropospheric levels. It concentrated into a depression over the same region and lay centred at 0300 UTC of 26th April, near Lat. 2.7° N/Long. 89.7° E. It further moved northwestwards and lay centered at 1200 UTC of 26th April near Lat. 3.2° N/Long. 89.2° E. It continued to move northwestwards and intensified into a **deep depression** and lay centered at 0000 UTC of 27th April, near Lat. 4.5° N/Long. 88.0° E. It further moved north-northwestwards and lay centered at 0300 UTC of 27th April, near Lat. 4.9° N/Long. 88.0° E. It further moved northward and intensified into **cyclonic storm 'FANI'** over southeast Bay of Bengal and adjoining east equatorial Indian Ocean and lay centred at 0600 UTC of 27th April, near Lat. 5.2° N/Long. 88.5° E. It further moved northwards and lay centred at 1200 UTC of 27th April, near Lat. 5.9° N/Long. 88.5° E over southeast Bay of Bengal & neighbourhood. It further moved north-northwestwards and lay centred at 0300 UTC of 28th April, near Lat. 7.3° N/Long. 87.9° E over southeast Bay of Bengal & neighbourhood. It

moved north-northwestwards and lay centred at 1200 UTC of 28th April, near Lat. 8.2° N/Long. 87.0° E over southeast Bay of Bengal and neighbourhood. It further moved northwards and lay centred at 0300 UTC of 29th April, near Lat. 8.7° N/Long. 86.9° E over southeast Bay of Bengal and neighbourhood. It further moved north-northwestwards, intensified into a **severe cyclonic storm** and lay centred at 1200 UTC of 29th April, near Lat. 10.1° N/Long. 86.7° E over southeast and adjoining southwest Bay of Bengal. It continued to move north-northwestward and intensified into a **very severe cyclonic storm** and lay centred at 0000 UTC of 30th April, near Lat. 11.7° N/Long. 86.5° E over southeast and adjoining southwest Bay of Bengal. It further moved north-northwestwards and lay centred at 0300 UTC of 30th April, near Lat. 12.3° N/Long. 86.2° E over southeast and adjoining southwest Bay of Bengal. It moved north-northwestwards and lay centred at 0600 UTC of 30th April, near Lat. 12.6° N/Long. 85.7° E over southwest and adjoining southeast Bay of Bengal. It further moved west-northwestwards and intensified into an **extremely severe cyclonic storm** and lay centred at 1200 UTC of 30th April,

TABLE 1

Brief Summary of Cyclonic Storms and depressions over Indian Seas and neighbourhood during 2019

S. No.	Category	Life Period	Place/Time of landfall	Lowest Estimated central Pressure (hPa)	Max. wind Estimated (kts)	Highest "T" No.
1.	Cyclonic storm 'PABUK'	4 - 8 January	Crossed Andaman Islands near Lat. 11.6° N/Long. 92.7° E close to south of Port Blair between 1300 & 1500 UTC of 6 th January. Weakened into well marked low pressure area over eastcentral Bay of Bengal and adjoining north Andaman Sea off Myanmar coast at 0000 UTC of 8 th January	1000	40	2.5
2.	Extremely severe cyclonic storm 'FANI'	26 April - 4 May	Crossed Odisha coast close to Puri near Lat. 19.75° N/ Long. 85.7° E between 0230 and 0430 UTC of 3 rd May. Weakened into well marked low pressure area over central Assam and neighbourhood at 1800 UTC of 4 th May	932	115	6.0
3.	Very severe cyclonic storm 'VAYU'	10 - 17 June	Weakened into well marked low pressure area over northeast Arabian Sea and adjoining Saurashtra and Kutch at 1800 UTC of 17 th June	970	80	4.5
4.	Deep depression	6 - 9 August	Crossed north Odisha- west Bengal coast close to north of Balasore between 0800 & 0900 UTC of 7 th August. Weakened into well marked low pressure area over southeast Rajasthan and neighbourhood at 1200 UTC of 9 th August	986.1	14	-
5.	Very severe cyclonic storm 'HIKAA'	22 - 25 September	Crossed Oman coast near Lat. 19.7° N/Long. 57.7° E close to north of Duqm between 1400 & 1500 UTC of 24 th September. Weakened into well marked low pressure area over south Oman and adjoining Saudi Arabia at 0900 UTC of 25 th September	978	75	4.5
6.	Depression	29 September - 1 October	Weakened into well marked low pressure area over southeast Rajasthan and neighbourhood at 0300 hrs UTC of 1 st October	1004.1	10	-
7.	Super cyclonic storm 'KYARR'	24 October - 2 November	Weakened into well marked low pressure area over westcentral and adjoining southwest Arabian Sea off north Somalia coast at 1800 UTC of 2 nd November	922	130	6.5
8.	Extremely severe cyclonic storm 'MAHA'	30 October - 7 November	Weakened into well marked low pressure area over northeast Arabian Sea and adjoining south Gujarat coast at 1200 UTC of 7 th November	956	100	5.5
9.	Very severe cyclonic storm 'BULBUL'	5 - 11 November	Crossed West Bengal coast close to Sunderban Dhanchi forest during 1500 to 1800 UTC of 9 th November. Weakened into well marked low pressure area over southern parts of Tripura and neighbourhood at 0300 UTC of 11 th November	976	75	4.5
10.	Cyclonic storm 'PAWAN'	2 - 7 December	Crossed Somalia coast near Lat. 7.4° N/Long. 49.6° E during 0200 to 0300 UTC. Weakened into well marked low pressure area over north Somalia coast and adjoining Ethiopia at 1200 UTC of 7 th December	998	40	2.5
11.	Deep depression	3 - 5 December	Weakened into well marked low pressure area over eastcentral Arabian sea and neighbourhood at 1200 UTC of 5 th December	1000	30	2.0
12.	Deep depression	8 - 10 December	Weakened into well marked low pressure area over southwest Arabian sea at 0600 UTC of 10 th December	1009	13	-

over southwest and adjoining westcentral and southeast Bay of Bengal near Lat. 13.3° N/Long. 84.7° E. It moved west-northwestwards and lay centred at 1500 UTC of 30th April, over westcentral and adjoining southwest Bay of Bengal near Lat. 13.4° N/Long. 84.5° E. It further moved northwestwards and lay centred at 0300 UTC of 1st May, over westcentral Bay of Bengal, near Lat. 14.1° N/

Long. 83.9° E. It moved north-northeastwards and lay centred at 1200 UTC of 1st May, over westcentral Bay of Bengal, near Lat. 14.9° N/ Long. 84.1° E. It further moved north-northeastwards and lay centred at 0300 UTC of 2nd May, over westcentral Bay of Bengal near Lat. 16.2° N/Long. 84.6° E. It moved northwards and lay centred at 1200 UTC of 2nd May, over

TABLE 2
Storms/Depressions statistics 2019

Name of the system	Winter		Pre Monsoon			Monsoon				Post Monsoon			Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Over the Bay of Bengal													
Depressions/deep depressions	-	-	-	-	-	-	-	1	-	-	-	-	1
Cyclonic storms	1	-	-	-	-	-	-	-	-	-	-	-	1
Severe cyclonic storms	-	-	-	-	-	-	-	-	-	-	-	-	-
Very severe cyclonic storms	-	-	-	-	-	-	-	-	-	-	1	-	1
Extremely severe cyclonic storms	-	-	-	1	-	-	-	-	-	-	-	-	1
Super cyclonic storms	-	-	-	-	-	-	-	-	-	-	-	-	-
Land Depression													
Depressions/deep depressions	-	-	-	-	-	-	-	-	-	-	-	-	-
Over the Arabian sea													
Depressions/deep Depressions	-	-	-	-	-	-	-	-	1	-	-	2	3
Cyclonic storms	-	-	-	-	-	-	-	-	-	-	-	1	1
Severe cyclonic storms	-	-	-	-	-	-	-	-	-	-	-	-	-
Very severe cyclonic storms	-	-	-	-	-	1	-	-	1	-	-	-	2
Extremely severe cyclonic storms	-	-	-	-	-	-	-	-	-	1	-	-	1
Super cyclonic storms	-	-	-	-	-	-	-	-	-	1	-	-	1
Grand total (Nos.)	1	-	-	1	-	1	-	1	2	2	1	3	12

westcentral Bay of Bengal, near Lat. 17.5° N/ Long. 84.8° E. It moved north-northeastwards and lay centred at 2100 UTC of 2nd May, over northwest and adjoining westcentral Bay of Bengal near latitude 18.6° N and longitude 85.2° E. It continued to move north - northeastwards and lay centred at 0300 UTC of 3rd May, over northwest Bay of Bengal, near Lat. 19.6° N/ Long. 85.7° E, about 25 km south- southwest of Puri (Odisha), 90 km east-southeast of Gopalpur (Odisha), about 300 km east-northeast of Vishakhapatnam (Andhra Pradesh) and 330 km southwest of Digha (West Bengal). Landfall Process of the system started at 0230 UTC and the system crossed the coast close to Puri between 0800 to 1000 hours IST of 3rd May. It further moved north-northeastwards and crossed Odisha coast close to Puri, between 0230 & 0430 UTC of 3rd May. It further weakened into a very severe cyclonic storm and lay centred at 0600 UTC of 3rd May, over Coastal Odisha, near Lat. 20.2° N/Long. 85.9° E, about 10 km east of Bhubaneswar (Odisha) and 30 km south of Cuttack (Odisha). It moved further north-northeastwards and lay centred at 1200 UTC of 3rd May, over coastal Odisha near Lat. 21.1° N/Long. 86.5° E, about 60 km southwest of

Balasore (Odisha) and 160 km southwest of Midnapore (West Bengal). It moved further north-northeastwards and weakened into a **severe cyclonic storm** and lay centred at 1500 UTC of 3rd May, over coastal Odisha near Lat. 21.5° N/Long. 86.7° E, about 20 km west of Balasore (Odisha), 120 km west-southwest of Midnapore (West Bengal) and 200 km west-southwest of Kolkata (West Bengal). It continued to move north-northeastwards and weakened into a **cyclonic storm** and lay centred at 0000 UTC of 4th May, over Gangetic West Bengal near Lat. 23.1° N/Long. 88.2° E, about 120 km north-northeast of Midnapore and 60 km northwest of Kolkata (West Bengal). It moved further east-northeastwards and weakened into a **deep depression** and lay centred at 0300 UTC of 4th May, over Bangladesh and adjoining Gangetic West Bengal near Lat. 23.6° N/Long. 88.8° E, about 40 km east-northeast of Krishnanagar (West Bengal). It moved northeastwards and weakened into a **depression** and lay centred at 0600 UTC of 4th May, over Bangladesh near Lat. 24.3° N/Long. 89.3° E, about 120 km north-northeast of Dhaka (Bangladesh) and 200 km south-southwest of Dhubri (Assam). It further moved east-northeastwards and lay centred at 1200 UTC

TABLE 3
Ships Observations during 1st January to 31st December, 2019

Call Sign	Date/ Time (UTC)	Position of the Ship		Wind		Pressure
		Lat. (Deg. N)	Long. (Deg. E)	Dir. (Deg.)	Speed (kts)	PPPP (hPa)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(A) Cyclonic storm 'PABUK' over Andaman Sea (4 - 8 January)						
NIL						
(B) Extremely severe cyclonic storm 'FANI' over eastcentral Equatorial Indian Ocean and adjoining southeast Bay of Bengal (26 April - 4 May)						
VTFG	260300	9.5	92.8	240	04	1007.6
VIWS	270000	12.4	82.8	190	16	1007.1
VRHE3	270600	6.1	92.8	160	27	1018.1
VTFG	270600	8.3	92.9	350	21	-
ZDNC6	281200	5.1	84.6	270	15	1006.8
VTWS	281200	11.8	89.3	140	18	1006.2
DFKM2	290300	5.9	89.6	200	22	1009.6
AMOHK02	291200	7.6	85.8	-	-	1006.3
VRG08	300000	7.2	88.3	190	18	1006.8
ONFN	300000	6.0	85.8	210	20	1011.0
AUYR	300600	11.3	82.8	270	25	1003.2
(C) Very severe cyclonic storm 'VAYU' over southeast & adjoining east central Arabian Sea and Lakshadweep (10 - 17 June)						
VTJAP	100000	9.8	68.3	280	22	1007.0
DJAZ2	100600	9.1	69.2	280	34	1004.4
9V2737	110000	11.2	70.6	-	-	1004.0
WADP	110000	9.8	66.3	270	34	1005.7
V7OE5	110000	17.5	66.6	240	21	1004.0
WMHA	111200	18.7	70.6	090	14	997.8
WMHA	111800	18.5	68.6	360	21	998.4
VRWQ2	120600	19.5	69.4	040	22	998.0
WMHA	120600	18.0	64.9	320	24	999.0
TBWUK70	120600	20.4	66.2	290	19	999.0
VRWQ2	121200	19.0	69.6	040	25	979.0
WMCU	122100	21.1	65.1	270	20	997.3
VRPN6	130000	17.2	70.3	210	32	998.2
WMCU	130000	20.2	65.4	330	25	997.1
PDHP	140000	18.9	68.6	240	40	993.2
9V9375	140000	20.8	65.3	340	34	997.0
PDHP	140300	19.0	68.2	250	36	995.6
WMCU	140300	19.8	70.1	250	20	997.4
Ship	141200	19.4	66.2	280	40	994.3
Ship	150000	18.8	71.4	220	32	999.0
Ship	150900	16.7	66.3	280	33	1001.5
Ship	170000	19.8	63.2	260	27	1000.2
Ship	171200	20.3	66.6	260	25	1000.3
(D) Very severe cyclonic storm 'HIKAA' over eastcentral and adjoining northeast Arabian Sea (22 - 25 September)						
FAUFH	221200	18.4	67.8	290	20	999.0
TBWUK48	230000	16.6	66.2	190	32	1005.5

TABLE 3 (Contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
FAUFH	230000	17.0	69.8	230	12	1003.0
TBWUK48	240000	21.5	61.7	100	22	1004.8
WMKN	250300	17.5	60.5	160	04	1008.2
WMKN	250600	17.4	59.9	180	13	1009.4
(E) Super cyclonic storm 'KYARR' over eastcentral Arabian Sea (24 October - 2 November)						
VRFZ5	290300	19.7	69.8	300	34	1014.7
WNTL	291200	15.8	65.6	180	26	1007.6
KLIG	300000	21.2	67.5	110	12	1011.7
V70E5	300000	18.8	58.4	360	26	1006.3
VRED4	300000	14.8	63.9	200	17	1008.0
WNTL	301200	16.2	57.0	350	17	1007.3
C6WJ4	301200	22.8	65.8	110	12	1012.3
AUYN	311200	19.7	61.2	120	15	1011.5
AUYN	010000	19.7	61.2	060	23	1010.5
(F) Extremely severe cyclonic storm 'MAHA' over eastcentral & adjoining westcentral Arabian Sea (30 October - 7 November)						
OWNQ2	300000	6.3	76.3	200	30	1007.0
DJDS2	301200	9.0	70.0	320	20	1007.7
TBWUK70	040300	18.6	68.6	140	15	1016.1
V70E5	060000	20.1	62.9	360	15	1008.1
DGHX	060000	21.0	69.0	150	10	1009.2
V7DI9	060000	17.7	69.1	180	11	1007.9
DGHX	060300	20.2	69.7	130	05	1010.7
DGHX	061200	18.7	70.3	200	11	1008.3
V70E5	070000	17.0	66.3	320	14	1009.1
9HA3490	070300	21.1	69.1	090	19	1009.1
DGHX	070300	18.3	72.2	200	25	1009.3
DGHX	070600	18.3	72.2	140	12	1009.3
(G) Very severe cyclonic storm 'BULBUL' over eastcentral, adjoining southeast Bay of Bengal and north Andaman Sea (5-11 November)						
'NIL'						
(H) Cyclonic storm 'PAWAN' over southwest Arabian sea (2-7 December)						
DIDK2	021200	9.5	66.6	230	03	1007.7
VRPJ7	021200	13.7	51.1	080	20	1010.4
DIDK2	030000	10.3	63.2	060	14	1007.7
ONHA	030300	8.9	64.6	090	11	1008.3
SHIP	031200	11.1	65.2	050	12	1006.3
EUMDE03	040300	11.6	54.4-	-	-	1009.1
EUMDE03	041200	11.6	56.6	-	-	1006.3
9HA3553	050000	11.5	53.4	010	26	1012.0
OYGN2	050000	13.0	57.0	070	27	1007.0
EUMDE03	050300	11.0	60.5	-	-	1014.0
EUMDE03	051200	10.8	63.0	-	-	1010.1
VRLA2	061200	10.6	54.5	070	28	1017.1
PDHP	070300	12.9	48.2	050	28	1013.6

of 4th May, over western Meghalaya and adjoining Bangladesh near Lat. 25.2° N/Long. 90.7° E, about 110 km southeast of Dhubri (Assam) and 130 km west-southwest of Guwahati (Assam). Further it moved northeastwards and weakened into a Well Marked low pressure area over central Assam and neighbourhood at 1800 UTC of 4th May.

2.2.2. Other features observed

The peak Maximum Sustained Surface Wind speed of the cyclone was 200-210 kmph (115 knots) gusting to 230 kmph during 0900 UTC to 2100 UTC of 2nd May over the westcentral Bay of Bengal. The lowest estimated central pressure was 932 hPa 0900 UTC to 1200 UTC of 2nd May. The system crossed Odisha coast close to Puri with maximum sustained wind speed of 175-185 kmph (100 knots) gusting to 205 kmph between 0230 & 0430 UTC of 3rd May.

2.2.3. Realized weather

Under the influence of ESCS FANI, heavy to very heavy & extremely heavy rainfall occurred over coastal Odisha and heavy to very heavy rainfall over coastal Andhra Pradesh and Gangetic West Bengal on 3rd May, heavy rainfall at a few places over north coastal Odisha, Gangetic West Bengal and adjoining Bangladesh on 4th and heavy rainfall at a few places over Bangladesh and adjoining areas of northeastern states of Assam, Meghalaya & Arunachal Pradesh on 5th May.

Chief amount of 24 hrs rainfall (≥ 7 cm) ending at 0830 hrs IST of date during 26 April - 4 May is presented below:

3rd May

Odisha : Berhampur 30, Gopalpur & Banki 17 each, Chhatrapur 15, Mundali 12, Purushottampur, Mohana, Puri, Ranpur & R. Udaigiri 11 each, Rajghat 10, Nuagada 9, Tirtol, Digapahandi, Balasore & Gania 8 each and Banpur, Aska, NH-5 Gobindpur, Khandapara, Narsinghpur, Naraj, & Niali 7 each

Coastal Andhra Pradesh : Ichchapuram 18, Sompeta 17, Palasa 15, Mandasa 13, Tekkali 12 and Kalingapatnam 9

4th May

Arunachal Pradesh : Tuting 9

Assam and Meghalaya : Williamnagar 8 and Mawsynram 7

Nagaland, Manipur, Mizoram & Tripura : Arundhuti nagar 9, Sonamura 8 and Agartala AERO, Amarapur & Kamalpur 7 each

Gangetic West Bengal : Bankura 16, Kalaikunda 15, Kansabati Dam 14, Harinkhola & Phulberia 13 each, Hetampur & Suri 12 each, Bankura, Suri & Durgapur 11 each, Rampurhat 10, Sri Niketan, Jhargram, Simula, Kharidwar, Berhampore, Asansol & Tantloi 9 each, Midnapore, Mohanpur, Asansol & Lalgah 8 each and Tusuma, Tilpara Barrage, Durgachack, Bagati, Purulia, Burdwan, Canning, Alipore and Purihansa 7 each

Odisha : Chandikhol 18, Bhuban & Bhubaneswar 16 each, Jajpur 15, Binjharpur & Samakhunta 14 each, Cuttack & Jenapur 13 each, Hindol & Remuna 12 each, Korei & Kaptipada 11 each, Keonjhar, Sukinda & Rairangpur 10 each, Nilgiri & Jaleswar 9 each, Soro 8 and Dhenkanal, Joshipur & Bari 7 each

Jharkhand : Ghatsila, Messenjo & Maheshpur 9 each, Dhanbad 8 and Maithon, Rajmahal, Jarmindi & Moharo 7 each

5th May

Assam & Meghalaya : Cherrapunji 41, Mawsynram 33, Cherrapunji 28, Williamnagar 17, Shillong C. S. O. 13, Guwahati City 11, Kheronighat & Barapani 9 each, Guwahati, Dharamtul, Barpathar & Kampur 8 each and Jia Bharali N T Xing, Bokajan, Karimganj, Shella and Numaligarh 7 each

Nagaland, Manipur, Mizoram & Tripura : Tamenglongi 13 and Sabroom 9

2.3. *Very Severe Cyclonic Storm (VSCS) "VAYU" over the Arabian Sea (10 - 17 June, 2019)*

2.3.1. Under the influence of a cyclonic circulation over Lakshadweep area & adjoining Southeast Arabian Sea, a low pressure area formed over southeast Arabian Sea and adjoining Lakshadweep area & eastcentral Arabian Sea on 9th June. Associated cyclonic circulation extended upto mid-tropospheric levels. It lay as a **well marked low pressure area** over the same region at 1200 UTC of 9th June. It concentrated into a **depression** over southeast Arabian Sea and adjoining Lakshadweep and eastcentral Arabian Sea and lay centred at 0000 UTC of 10th June, near Lat. 11.7° N/Long. 71° E, about 200 kms west-northwest of Amini Divi (Lakshadweep). It moved northwards and lay centred at 0300 UTC of 10th June, over eastcentral and adjoining southeast Arabian Sea and Lakshadweep area, near Lat. 12.5° N/Long. 71.0° E. It moved north-northwestwards and intensified into a **deep depression** and lay centred at 0600 UTC of 10th June, near Lat. 12.5° N/Long. 70.9° E over eastcentral and adjoining southeast Arabian Sea and Lakshadweep area. It continued to move north-northwestwards and lay centred at 1200 UTC of 10th June, near Lat. 13.3° N/Long. 70.8° E over eastcentral and adjoining southeast Arabian Sea and Lakshadweep area. It intensified into **cyclonic storm 'VAYU'** at 1800 UTC of 10th June and lay centred at Lat. 13.9° N/Long. 70.6° E over eastcentral & adjoining southeast Arabian Sea. It moved northwards and lay centred at 0000 UTC of 11th June, near Lat. 14.7° N/Long. 70.6° E over Eastcentral Arabian Sea. It further moved northwards and lay centred at 0300 UTC of 11th June, near Lat. 15.0° N/Long. 70.6° E over eastcentral Arabian Sea. It further moved northwards and intensified into **severe cyclonic storm** and lay centred at 1200 UTC of 11th June, near Lat. 16.1° N/Long. 70.6° E over eastcentral Arabian Sea. It continued to move northwards & intensified into **very severe cyclonic storm** and lay centred at 1800 UTC of 11th June, near Lat. 17.1° N/Long. 70.6° E over eastcentral Arabian Sea. It moved north-northwestwards and lay centred at 0300 UTC of 12th June, near Lat. 18.0° N/Long. 70.3° E over eastcentral Arabian Sea. It continued to move north-northwestwards and lay centred at 0300 UTC of 12th June, near Lat. 18.0° N/Long. 70.3° E over eastcentral Arabian Sea and lay centred at 1200 UTC of 12th June, near Lat. 19.1° N/Long. 69.9° E over east central & adjoining Northeast Arabian Sea. Then moving north-northwestwards and lay centred at 0300 UTC of 13th June, near Lat. 20.4° N/Long. 69.4° E over northeast & adjoining eastcentral Arabian Sea, about 160 km south-southwest of Diu, 110 km southwest of Veraval (Gujarat) and 140 km nearly south of Porbandar (Gujarat). It moved northwestwards and lay centred at 1200 UTC of 13th June, near Lat. 20.9° N/Long. 69.0° E over the same region. It moved westwards and lay centred at 0300 UTC of 14th June,

near Lat. 21.0° N/Long. 68.3° E over northeast & adjoining eastcentral Arabian Sea, about 150 kms west-southwest of Porbandar (Gujarat), 210 kms west of Veraval (Gujarat) and 270 kms west-northwest of Diu. During this period, the system had been moving nearly west-northwestwards skirting the Saurashtra coast affecting Porbandar & Devbhoomi Dwarka and Gir Somnath and Junagarh. It then moved westwards and lay centred at 0600 UTC of 14th June, near Lat. 21.0° N/Long. 68.2° E over northeast & adjoining eastcentral Arabian Sea. It then moved west-south westwards and lay centred at 1200 UTC of 14th June, near Lat. 20.8° N/Long. 68.0° E over the same region. It continued to move nearly westwards and lay centred at 0000 UTC of 15th June, near Lat. 20.7° N/Long. 67.4° E over northeast and adjoining eastcentral Arabian Sea. It further moved nearly westwards and lay centred at 0300 UTC of 15th June, near Lat. 20.7° N/Long. 67.2° E over northeast & adjoining eastcentral Arabian Sea, about 275 km west-southwest of Porbandar (Gujarat), 330 km west-southwest of Veraval (Gujarat) and 385 km west of Diu. It continued to move westwards and lay centred at 1200 UTC of 15th June, near Lat. 20.7° N/Long. 66.4° E over the same region. It continued to move westwards and weakened into a **severe cyclonic storm** and lay centred at 0000 UTC of 16th June, near Lat. 20.7° N/Long. 65.5° E over the same region. It further moved nearly westwards and lay centred at 0300 UTC of 16th June, near Lat. 20.8° N and Long. 65.2° E over northeast and adjoining northwest & central Arabian Sea, about 470 kms westsouthwest of Porbandar (Gujarat), 440 km southwest of Dwarka (Gujarat) and 545 kms southwest of Bhuj (Gujarat). It moved north-northwestwards and lay centred at 1200 UTC of 16th June, near Lat. 21.1° N/Long. 65.0° E over the same region. It further moved east-northeastwards and weakened into a **cyclonic storm** and lay centred at 1500 UTC of 16th June, near Lat. 21.1° N/Long. 65.3° E over Northeast and adjoining northwest & Central Arabian Sea. It moved northeastwards and weakened into a **deep depression** and lay centred at 0300 UTC of 17th June, near Lat. 21.9° N/Long. 66.8° E over Northeast Arabian Sea and neighbourhood. It further moved east-northeastwards & weakened into a **depression** and lay centred at 0900 UTC of 17th June, near Lat. 22.2° N/Long. 67.4° E over the same region. It moved east-northeastwards and lay centred at 1200 UTC of 17th June, near Lat. 22.5° N/Long. 67.8° E over Northeast Arabian Sea & neighbourhood. It continue to move east-northeastwards and weakened into a well marked low pressure area over northeast Arabian Sea and adjoining Saurashtra & Kutch at 1800 UTC of 17th June.

2.3.2. *Other features observed*

The peak Maximum Sustained Surface Wind speed of the cyclone was 140-150 kmph (80 knots) gusting to

165 kmph during 0600 UTC of 12th June to 0000 UTC of 14th June over the eastcentral Arabian Sea. The lowest estimated central pressure was 970 hPa during the period. Though it intensified upto very severe cyclonic storm with wind speed of 80 knots (140-150 kmph), it weakened over sea while moving towards north Gujarat coast. It crossed north Gujarat coast as a well marked low pressure area.

2.3.3. Realized weather

The system caused light to moderate rainfall at many places with isolated heavy to very heavy rainfall over Saurashtra and Kutch on 13th & 14th June and over Gujarat region on 14th. It also caused light to moderate rainfall at many places with isolated heavy to very falls over Kerala, coastal Karnataka and Konkan & Goa during 10-14 June. As the cyclone skirted Gujarat coast, the core maximum wind due to the cyclone occurred over the Sea. However, squally to gale wind speed from 45 kmph to 90 kmph occurred along and off Gujarat coast during 12-14 June.

Chief amount of 24 hrs accumulated rainfall (≥ 7 cm) ending at 0300 UTC of date during the life cycle of the system is presented below:

10th June

Kerala & Mahe	: Piravam 14, Nedumangad 12, Cherthala & Alapuzha 11 each, Mancompu, Vaikom and Kodungallur 10 each, Kottayam, Kochi & Ernakulam South 9 each, Chalakkudi 8 and Peerumade, Kayamkulam, Chengannur & Aluva 7 each
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11th June

Kerala	: Vythiri 10, Thaliparamba 8 and Quilandi & Vadakara 7 each
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12th June

Coastal Karnataka	: Kumta 14 and Gokarna 11
Kerala	: Vadakara 10 and Enamakkal 9

13th June

Konkan & Goa	: Tala 9, Margao & Harnai 8 each and Shriwardhan & Murud 7 each
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Coastal Karnataka	: Udupi 17, Kota 13, Mulki, Manki, Gersoppa & Kollur 12 each, Mangaluru 11, Karkala 10, Kadra 9, Shirali & Kumta 8 each and Mudubidre, Manchikere & Honavar 7 each
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South Interior Karnataka	: Kottigehara 8
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14th June

Saurashtra & Kutch	: Talala 16, Sutrapada 15, Vanthali 9, Bhavnagar 8 and Mendarda, Mangrol & Malia 7 each
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Konkan & Goa	: Valpoi 10, Vaibhavwadi, Ponda, Kudal, Kankavli & Dodamarg 8 each and Margao 7
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Madhya Maharashtra	: Gaganbawada 13, Mahabaleshwar & Gargoti/Bhudargad 8 each and Velhe 7
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Coastal Karnataka	: Kollur 13, Siddapura 11, Kundapur, Ankola, Mani & Karwar 9 each, Kadra 8 and Shirali, Panambur, Bhatkal, Gokarna, Uppinangadi, Manki & Mudubidre 7 each
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South Interior Karnataka	: Virajpet & Kottigehara 7 each
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15th June

Gujarat Region	: Mangrol 9
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Saurashtra & Kutch	: Sutrapada 12, Talala 10, Veraval 9 and Kodinar 8
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2.4. Deep depression over northwest Bay of Bengal off north Odisha-West Bengal coast (6 - 9 August, 2019)

2.4.1. Under the influence of acyclonic circulation over Gangetic West Bengal and adjoining north Bay of Bengal & Bangladesh, a low pressure area formed over north Bay of Bengal and adjoining coastal areas of Bangladesh & West Bengal. Associated cyclonic circulation extended upto 7.6 km above m.s.l. tilting southwestwards with height on 5th August. It lay as a **well marked low pressure area** over the same region with the

associated cyclonic circulation extending upto 7.6 km above mean sea level tilting southwestwards with height on 6th morning. It concentrated into a **depression** and lay centred at 0300 UTC of 6th August, over northwest Bay of Bengal off north Odisha-West Bengal coasts near Lat. 20.5° N/Long. 88.0° E, above 160 km southeast of Balasore (Odisha) and about 130 km south-southeast of Digha (West Bengal) on 6th. It moved west-northwestwards and lay centred at 1200 UTC of 6th August, near Lat. 20.7° N/Long. 87.8° E, about 130 km southeast of Balasore (Odisha) and about 100 km south-southeast of Digha (West Bengal). It moved northwestwards and intensified into a **deep depression** over the same region and lay centred at 0000 UTC of 7th August, near Lat. 21.0° N/Long. 87.4° E, about 70 km southeast of Balasore (Odisha) and about 70 km south-southwest of Digha (West Bengal). It further moved northwestwards and lay centred over the same region at 0300 UTC of 7th August, near Lat. 21.1° N/Long. 87.4° E, about 65 km southeast of Balasore (Odisha) and about 60 km south-southwest of Digha (West Bengal) on 7th. It moved north-northwestwards and crossed north Odisha-West Bengal coast close to north of Balasore during 0800-0900 UTC of 7th August and lay over north coastal Odisha and adjoining Gangetic West Bengal near Lat. 21.7° N/Long. 87.3° E, close to Balasore (Odisha) and about 170 km southeast of Jamshedpur (Jharkhand). It moved west-northwestwards and lay centred at 1200 UTC of 7th August over north Odisha & neighbourhood near Lat. 21.9° N/Long. 86.5° E about 110 km south-southeast of Jamshedpur (Jharkhand) and 60 km northwest of Balasore (Odisha). It continued to move west-northwestwards and weakened into a depression and lay centred at 0000 UTC of 8th August, over northeast Chhattisgarh and neighbourhood near Lat. 22.8° N/Long. 84.0° E, about 90 km east-southeast of Ambikapur (Chhattisgarh) and 140 km west-southwest of Ranchi (Jharkhand). It further moved west-northwestwards and lay centred at 0300 UTC of 8th August, over north Chhattisgarh and neighbourhood, near Lat. 23.0° N/Long. 82.9° E about 40 km west-northwest of Ambikapur (Chhattisgarh), 250 km west of Ranchi (Jharkhand) and 190 km south-southeast of Siddhi (east Madhya Pradesh) on 8th. It continued to move west-northwestwards and lay centred at 1200 UTC of 8th August, over east Madhya Pradesh near Lat. 23.6° N/Long. 80.2° E about 80 km east-southeast of Damoh (east Madhya Pradesh), 150 km east-southeast of Sagar (East Madhya Pradesh) and 50 km northeast of Jabalpur (East Madhya Pradesh). It further moved west-northwestwards and lay centred at 0300 UTC of 9th August, over West Madhya Pradesh, near Lat. 23.8° N/Long. 77.3° E, about 60 km north of Bhopal (West Madhya Pradesh), 90 km southeast of Guna (West Madhya Pradesh) and 210 km southeast of Kota (East Rajasthan) on 9th. It continued to move west-

northwestwards and weakened into a well marked low pressure area over southeast Rajasthan & neighbourhood at 1200 UTC of 9th August.

2.4.2. Other features observed

The maximum observed wind speed of 14 kts at 0900 UTC of 7th when the system was crossing north Odisha-West Bengal coasts close to north of Balasore during 0800-0900 UTC. The lowest observed Pressure was 986.1 hPa at 1200 UTC of 7th.

2.4.3. Realized weather

Under the influence of this system, Heavy rain at a few places with very heavy rain at isolated places occurred over Odisha on 6th August. On 7 & 8, heavy to very heavy rain at a few places with extremely heavy rain at isolated places occurred over Odisha. Heavy to very heavy rain at a few places with extremely heavy rain at isolated places occurred over Chattisgarh on 8th. System also caused heavy rain at isolated places over West Bengal & Sikkim, Bihar and Jharkhand on 7 & 8 August.

Chief amount of 24 hrs accumulated rainfall (≥ 7 cm) ending at 0300 UTC of date during the life cycle of the system is presented below:

6th August

Odisha	: Krishnaprasad 13, Bramhagiri AWS 11, Thakurmunda 11, Puri 9, Karanjia 8 and Gopalpur 7
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7th August

Sub-Himalayan West Bengal	: Kalimpong 9, Mangan & Tadong 8 each and Sukiapokhri 7
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Odisha	: Lanjigarh 38, Kashipur 32, Katagarh 31, Phiringia ARG 29 and Kantamal 17
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Jharkhand	: Manatu 9 and Chandil & Latehar 7 each
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Gangetic West Bengal : Purihansa 7

Bihar	: Galgalia 7
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Chattisgarh	: Rajpur 17, Konta 14 and Bhairamgarh & Usoor 13 each
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8th August

Gangetic West Bengal : Purulia 13 and Diamond Harbour 11

Odisha : Laikera & Deogam 25 each, Binjharpur ARG 23, Kirmira ARG 22, Jajpur & Bolangir 21 each and Kuchinda 20

Jharkhand : Tenughat 9

East Madhya Pradesh : Malanjkhanda 14, Jabalpur AWS 11, Rehli 11 and Chindwara AWS 10

Chattisgarh : Deobhog 30, Lohandiguda 27, Mana AP 23 and Raipur, Pusaur & Jagdalpur 18 each

2.5. *Very severe cyclonic storm 'HIKAA' over the Arabian Sea (22 - 25 September, 2019)*

2.5.1. Under the influence of acyclonic circulation over eastcentral Arabian Sea and adjoining areas of Maharashtra, a low pressure area formed over eastcentral Arabian Sea off north Maharashtra coast. Associated cyclonic circulation extended upto 7.6 km above m.s.l. tilting southwards with height on 20th September. It lay over eastcentral and adjoining northeast Arabian Sea off north Maharashtra and south Gujarat coasts on 20th September evening and lay over northeast Arabian Sea off south Gujarat on 21st September. It became a **well marked low pressure area** over eastcentral and adjoining northeast Arabian Sea off south Gujarat coast at 0900 UTC of 21st September and lay over the same region at 1200 UTC. It concentrated into a **depression** over eastcentral and adjoining northeast Arabian Sea off Gujarat coast and lay centred at 0300 UTC of 22nd September, near Lat. 19.8° N/Long. 69.4° E, about 150 km southwest of Veraval (Gujarat) on 22nd September. It moved west-northwestwards and intensified into a **deep depression** and lay centred at 1200 UTC of 22nd September, over northeast and adjoining east central Arabian Sea near Lat. 20.4° N/Long. 68.2° E. It moved westwards and intensified into **cyclonic storm 'HIKAA'** and lay centred at 0000 UTC of 23rd September, over northeast and adjoining eastcentral Arabian Sea near Lat. 20.5° N/Long. 66.2° E. It continued to move westwards and lay centred at 0300 UTC of 23rd September, over the same region near Lat. 20.4° N/Long. 65.7° E. It further moved westwards and intensified into a severe cyclonic storm over northeast and adjoining northwest and central Arabian Sea and lay centered at

0900 UTC of 23rd September over the same region near Lat. 20.2° N/Long. 64.2° E. It continued to move westwards and lay centred at 1200 UTC of 23rd September, over northwest and adjoining northeast and central Arabian sea near Lat. 20.2° N/Long. 63.7° E. It continued moving westwards and intensified into a **very Severe Cyclonic Storm** over northwest and adjoining westcentral Arabian Sea and lay centred at 0000 UTC of 24th September, near Lat. 20.1° N/Long. 61.0° E, about 820 km west-southwest of Karachi (Pakistan), 220 km east-southeast of Masirah (Oman) and about 350 km east-northeast of Duqm (Oman). It further moved westwards and lay centred at 0300 UTC of 24th September, over northwest and adjoining westcentral Arabian Sea, near Lat. 20.1° N/Long. 60.3° E, about 160 km east-southeast of Masirah (Oman) and about 280 km east-northeast of Duqm (Oman). It continued to move west-southwestwards and lay centred at 1200 UTC of 24th September near Lat. 19.8° N/Long. 58.3° E over westcentral and adjoining northwest Arabian Sea, about 115 km south-southwest of Masirah (Oman) and about 70 km east-northeast of Duqm (Oman). It further moved west-southwestwards and crossed Oman coast near Lat. 19.7° N/Long. 57.7° E, close to north of Duqm during 1400-1500 UTC of 24th September, as a **very severe cyclonic storm**. It then moved westwards and weakened into a **severe cyclonic storm** and lay centred at 1500 UTC of 24th September over coastal Oman near Lat. 19.7° N/Long. 57.6° E, close Duqm. It continued to move westwards and weakened into a **cyclonic storm** over Oman and lay centred at 2100 UTC of 24th September near Lat. 19.6° N/Long. 56.6° E about 110 km west of Duqm and 50 km south-southeast of Haima. It moved westwards and weakened into a **deep depression** and lay centred at 0300 UTC of 25th September near Lat. 19.5° N/Long. 55.5° E about 220 km west of Duqm and 110 km west-southwest of Haima. It moved west-southwestwards and weakened into a **depression** and lay centred at 0600 UTC of 25th September over Oman, near Lat. 19.3° N/Long. 55.0° E. It further moved west-southwestwards and weakened into a well marked low pressure area over south Oman and adjoining Saudi Arabia at 0900 UTC of 25th September.

2.5.2. *Other features observed*

The peak maximum sustained surface wind speed of the cyclone was 130-140 kmph (75 knots) gusting to 155 kmph during 0600 UTC to 1200 UTC of 23rd September over the westcentral and adjoining northwest Arabian Sea. The lowest estimated central pressure was 978 hPa during the same period. Cyclone exhibited rapid weakening after landfall during 24th evening (1200 UTC) to 25th noon (0600 UTC) with wind speed decreasing from 75 kt to

25 kt. The system crossed Oman coast near Lat. 19.7° N and Long. 57.7° E close to Duqm between 1400 UTC and 1500 UTC of 24th September, with maximum sustained wind speed of 120-130 kmph gusting to 145 kmph.

2.5.3. Realized weather

Rainfall associated with VSCS HIKAA indicates occurrence of heavy to very heavy rainfall over east central Arabian Sea during 22-23 September, heavy rainfall over westcentral Arabian Sea on 24th and over Oman coast on 25th.

2.6. Depression over Gulf of Kutch and neighbourhood (29 September - 1 October, 2019)

2.6.1. Under the influence of a cyclonic circulation over Saurashtra & Kutch and adjoining areas of northeast Arabian Sea, a low pressure area has formed over northeast Arabian Sea and adjoining coastal areas of Saurashtra & Kutch. Associated cyclonic circulation extended upto 5.8 km above m.s.l. on 28th September. It lay as a **well marked low pressure area** over Gulf of Kutch and neighbourhood at 0000 UTC of 29th September and it persisted over the same region and the associated cyclonic circulation extended upto 7.6 km above m.s.l. It concentrated into a **depression** over the same region which lay centered at 1200 UTC of 29th September, near Lat. 23.1° N/Long. 70.2° E, close to Kandla (Gujarat). It moved northeastwards and lay centered at 0300 UTC of 30th September, near Lat. 23.4° N/Long. 70.7° E, about 120 km westnorthwest of Surendra Nagar (Gujarat). It moved eastwards and lay centred at 1200 UTC of 30th September, over northern parts of Gujarat region near Lat. 23.5° N/Long. 71.9° E, about 80 km northwest of Ahmadabad (Gujarat) and 80 km south-southwest of Deesa (Gujarat). It moved east-northeastwards and lay centred 0000 UTC of 1st October, over southeast Rajasthan & neighbourhood near Lat. 24.0° N/Long. 74.1° E, about 70 km south-southeast of Udaipur (East Rajasthan), 180 km east-northeast of Ahmedabad (Gujarat) and 220 km west-northwest of Indore (West Madhya Pradesh). It weakened into a well marked low pressure area over the same region and the associated cyclonic circulation extended upto 2.1 km above m.s.l. at 0300 UTC of 1st October.

2.6.2. Other features observed

The lowest observed Pressure of 1004.1 hPa at 1200 UTC of 30th September was recorded by Ahmedabad and maximum observed wind speed of 10 kts was recorded by Rajkot at 1200 UTC of 30th September, when the centre of system was very close to it.

2.6.3. Realized weather

Under the influence of depression, heavy rain at a few places with very heavy rain at isolated places occurred over Gujarat region on 29th September & 1st October and heavy to very heavy rain at isolated places over Saurashtra & Kutch on 29th September. Heavy to very heavy rain at few places with extremely heavy rain at isolated places occurred over Saurashtra & Kutch on 30th.

Chief amount of 24 hour cumulative rainfall (≥ 7 cm) ending at 0300 UTC is presented below:

29th September

Gujarat region	: Patan 14, Visnagar and Idar & Unjha 7 each
Saurashtra & Kutch	: Mundra & Visavadar 13 each and Talala 10

30th September

Gujarat region	: Harij 8 and Radhanpur 7
Saurashtra & Kutch	: Bhanvad 33, Jamjodhpur 22 and Kalyanpur and Jamkandorna 19 each

1st October

Gujarat region	: Satlasana 20, Bhabher 19, Bhiloda 18, Vijaynagar 17 and Himatanagar 16
Saurashtra & Kutch	: Thangadh 10, Dhrangadhra 9 and Wankaner 7

2.7. Super cyclonic storm 'KYARR' over the Arabian Sea (24 October - 2 November, 2019)

2.7.1. Under the influence of a cyclonic circulation over Maldives area & neighbourhood, a low pressure area formed over southeast Arabian Sea and adjoining Lakshadweep area on 17th October. Associated cyclonic circulation extended upto 5.8 km above m.s.l. It lay over southeast Arabian Sea and adjoining areas of Lakshadweep and eastcentral Arabian Sea on 18th. It lay over eastcentral and adjoining southeast Arabian Sea in the morning of 19th. It lay over eastcentral Arabian Sea with the associated cyclonic circulation extending upto 4.5 km above m.s.l. on 20th & 21st. It lay over central parts of Arabian Sea on 22nd. It became a **well marked low pressure area** on 23rd evening over the same region. It concentrated into a **depression** over eastcentral Arabian

Sea and lay centred at 0300 UTC of 24th October, near Lat. 15.4° N/Long. 70.4° E, about 360 km west-southwest of Ratnagiri (Maharashtra), 490 km southwest of Mumbai (Maharashtra) and 1750 km east-southeast of Salalah (Oman). It moved east-northeastwards and intensified in to a **deep depression** over eastcentral Arabian Sea and lay centered at 1730 hrs IST of the 24th October, near Lat. 15.5° N/Long. 70.8° E, about 310 km west-southwest of Ratnagiri (Maharashtra), 450 km southwest of Mumbai (Maharashtra) and 1790 km east-southeast of Salalah (Oman). It moved northwards and intensified into a **cyclonic storm 'KYARR'** and lay centered at 0000 UTC of the 25th October near Lat. 16.0° N/Long. 71.3° E, over eastcentral Arabian Sea. It further moved north-northeastwards and lay centered at 0300 UTC of 25th October near Lat. 16.0° N/Long. 71.6° E, over eastcentral Arabian Sea about 210 km west-southwest of Ratnagiri (Maharashtra), 370 km south southwest of Mumbai (Maharashtra). It moved north-northeastwards, intensified into a **severe cyclonic storm** and lay centered at 1200 UTC of 25th October near Lat. 16.3° N/Long. 71.7° E over eastcentral Arabian Sea about 190 km nearly to the west of Ratnagiri (Maharashtra), 330 km south-southwest of Mumbai (Maharashtra). It moved west-northwestwards and intensified into a **very severe cyclonic storm** and lay centered at 0000 UTC of the 26th October, near Lat. 16.5° N/Long 70.8° E over eastcentral Arabia Sea, about 270 km nearly to the west-southwest of Ratnagiri (Maharashtra), 360 km south-southwest of Mumbai (Maharashtra). It moved west-northwestwards and lay centered at 0300 UTC of 26th October, near Lat. 16.6° N/Long. 70.5° E over eastcentral Arabian Sea, about 300 km west-southwest of Ratnagiri (Maharashtra), 370 km south-southwest of Mumbai (Maharashtra). It further moved west-northwestwards and lay centered at 1200 UTC of the 26th October near Lat. 16.7° N/Long. 69.4° E over eastcentral Arabia Sea, about 420 km west-southwest of Ratnagiri (Maharashtra), 450 km west-southwest of Mumbai (Maharashtra). It further moved west-northwestwards and intensified into an **extremely severe cyclonic storm** and lay centered at 1800 UTC of the 26th October, near Lat. 16.7° N/Long. 69.1° E over eastcentral Arabia Sea, about 450 km west-southwest of Ratnagiri (Maharashtra), 480 km west-southwest of Mumbai (Maharashtra). It continued to move west-northwestwards and intensified into a **super cyclonic storm** and lay centered at 0300 UTC of the 27th October, near Lat. 17.1° N/Long. 67.8° E over eastcentral Arabian Sea, about 580 km west-southwest of Mumbai (Maharashtra). It further moved west-northwestwards & lay centered at 1200 UTC of 27th October, near Lat. 17.5° N/Long. 66.7° E over eastcentral Arabian Sea, about 670 km west-southwest of Mumbai (Maharashtra), 1340 km east-northeast of Salalah (Oman) and 890 km east-southeast of

Masirah (Oman). It continued to move west-northwestwards and lay centered at 0300 UTC of the 28th October, near Lat. 18.2° N/Long. 65.0° E over eastcentral Arabian Sea, 1160 km east-northeast of Salalah (Oman) and 690 km east-southeast of Masirah (Oman). It further moved west-northwestwards and lay centered at 1200 UTC of the 28th October, near Lat. 18.5° N/Long. 64.3° E over eastcentral and adjoining westcentral Arabian Sea, about 1110 kms east-northeast of Salalah (Oman) and 610 kms east-southeast of Masirah (Oman). It continued to move west-northwestwards and weakened into an **extremely severe cyclonic storm** over westcentral & adjoining eastcentral & north Arabian Sea and lay centered at 0300 UTC of 29th October, near Lat. 19.2° N/Long. 63.4° E, 1010 km east-northeast of Salalah (Oman) and 500 km east-southeast of Masirah (Oman). It moved north-northwestwards and lay centered at 1200 UTC of 29th October, near Lat.19.5° N/Long. 63.1° E 990 km east-northeast of Salalah (Oman) and 460 km east-southeast of Masirah (Oman). It moved westwards and weakened into a **very severe cyclonic storm** over westcentral and north Arabian Sea and lay centred at 0000 UTC of 30th October, near Lat. 19.6° N/Long. 62.3° E, about 930 km east-northeast of Salalah (Oman) and 370 km east-southeast of Masirah (Oman). It further moved westwards and lay centred near Lat. 19.6° N/Long. 62.1° E at 0300 UTC of 30th October, over westcentral and adjoining northwest Arabian Sea, about 910 km east-northeast of Salalah (Oman) and 350 km east-southeast of Masirah (Oman). It moved southwestwards and lay centred at 1200 UTC of 30th October, over the same region near Lat. 19.0° N/Long. 61.5° E about 830 km east-northeast of Salalah (Oman) and 330 km east-southeast of Masirah (Oman). It further moved southwestwards and weakened into a **severe cyclonic storm** and lay centred at 1500 UTC of 30th October, over westcentral & adjoining northwest Arabian Sea near Lat. 18.9° N/Long. 61.2° E, about 780 km east-northeast of Salalah (Oman) and 310 km east-southeast of Masirah (Oman). It continued to move southwestwards and weakened into a cyclonic storm and lay centred at 0300 UTC of 31st October, over westcentral Arabian Sea near Lat. 18.0° N/Long. 60.2° E, about 320 km south-southeast of Masirah (Oman). It moved south-southwestwards and lay centred at 1200 UTC of 31st October, over westcentral Arabian Sea near Lat. 17.4° N/Long. 59.9° E, about 380 km south-southeast of Masirah (Oman). It moved west-southwestwards and weakened into a **deep depression** and lay centred at 1500 UTC of 31st October, over westcentral Arabian Sea near Lat. 17.2° N/Long. 59.6° E, about 390 km south-southeast of Masirah (Oman). It moved southwestwards and weakened into a **depression** and lay centred at 0000 UTC of 1st November, overwestcentral Arabian Sea near Lat. 16.4° N/Long. 59.5° E, about 470 km south-southeast of Masirah (Oman). It moved southwestwards and lay centred at

0300 UTC of 1st November, over westcentral Arabian Sea near Lat. 16.3° N/Long. 59.0° E, about 480 km south-southeast of Masirah (Oman). It moved west-south westwards and lay centred at 1200 UTC of 1st November, over westcentral Arabian Sea near Lat. 15.4° N/ Long. 57.5° E, about 420 km east-southeast of Salalah (Oman) and 600 km south-southeast of Masirah (Oman). It moved west-southwestwards and lay centred at 0300 UTC of 2nd November, over west central Arabian Sea near Lat. 13.5° N/Long. 55.0° E, about 150 km east-northeast of Socotra Island and 460 km east-northeast of Bereeda (Somalia). It further moved west-southwestwards and lay centred at 1200 UTC of 2nd November, over westcentral and adjoining southwest Arabian Sea near Lat. 12.5° N/ Long. 53.0° E, around 100 km west of Socotra Island and 220 km east-northeast of Bereeda (Somalia). It further moved west-southwestwards and weakened into a **well marked low pressure** area at 1800 UTC of 2nd November, over westcentral and adjoining southwest Arabian Sea off north Somalia coast.

2.7.2. Other features observed

The peak Maximum Sustained Surface Wind speed of the cyclone was 235-245 kmph (130 kt) gusting to 260 kmph during 0900 UTC to 1800 UTC of 27th October over the eastcentral Arabian Sea. The lowest estimated central pressure was 922 hPa during 0900 UTC to 1800 UTC of 27th October.

2.7.3. Realized weather

The system caused heavy to very heavy rainfall at isolated places during 24-26 October over Maharashtra, Konkan and Marathwada.

Chief amounts of Rainfall ≥ 7 cm recorded during the past 24 hours ending at 0300 UTC of date are given below:

24th October

Konkan : Malvan & Vengurla
7 each

Marathwada : Badnapur 7

25th October

Konkan : Malvan 8 and Dodamarg,
Sawantwadi & Vengurla
7 each

Madhya Maharashtra : Pathardi & Akole 8 each

Marathwada : Manjlegaon & Manvat 9
each, Pathri & Ahmedpur
8 each and Georai 7

26th October

Konkan : Malvan 25, Devgad 18,
Vengurla 14, Kudal 11 and
Dodamarg, Sawantwadi &
Rajapur 7 each

Madhya Maharashtra : Chandgad 7

Marathwada : Selu 10 and Parbhani,
Palam & Purna 7 each

27th October

Konkan : Sawantwadi 18

Vidarbha : Korpana 7

28th October

Marathwada : Bhokar, Nanded &
Dharmabad 7 each

2.8. Extremely severe cyclonic storm 'MAHA' over the Arabian Sea (30 October - 7 November, 2019)

2.8.1. Under the influence of a trough of low at mean sea level over southwest Bay of Bengal off Sri Lanka coast a **low pressure area** formed over southwest Bay of Bengal off south Srilanka coast and associated cyclonic circulation extended upto mid-tropospheric levels on 28th October. It lay as a well marked low pressure area over Comorin area and adjoining Equatorial Indian Ocean at 0000 UTC of the 29th October. It lay over Lakshadweep-Maldives areas and adjoining Comorin area evening of 29th. It concentrated into a **depression** over Maldives-Comorin areas and lay centred at 0000 UTC of 30th October, near Lat. 6.5° N/Long. 76.2° E about 390 kms east-northeast of Male (Maldives) and 390 kms east-southeast of Minicoy (Lakshadweep). It moved northwestwards and lay over Maldives - Comorin & adjoining Lakshadweep area centered near Lat. 8.0° N/ Long. 75.0° E at 0300 UTC of 30th October, about 450 km north-northeast of Male (Maldives), 200 km east-southeast of Minicoy (Lakshadweep), 380 km southeast of Kavaratti (Lakshadweep) and 220 km west-southwest of Thiruvananthapuram (Kerala). It moved northwestwards and intensified into a **deep depression** over Lakshadweep and adjoining southeast Arabian Sea and Maldives area and lay centred at 0900 UTC of 30th October near Lat. 8.5° N/Long. 74.5° E about 490 km north-northeast of Male (Maldives), 150 km east-northeast of Minicoy (Lakshadweep) and 270 km west of Thiruvananthapuram (Kerala). It further moved northwestwards and intensified into **cyclonic storm 'MAHA'** and lay centred at 1200 UTC of 30th October over the same region near

Lat. 9.0° N/ Long. 74.1° E. It moved north-northwestwards and lay centered at 0000 UTC of 31st October near Lat. 11.0° N/Long. 73.0° E over Lakshadweep and adjoining southeast Arabian Sea, about 30 km east-southeast of Aminidivi (Lakshadweep), 300 km north of Minicoy (Lakshadweep), 60 km north-northeast of Kavaratti (Lakshadweep) and 300 km west-southwest of Kozhikode (Kerala). It continued to move north-northwestwards and lay centered at 0300 UTC of 31st October, near Lat. 11.5° N/ Long. 72.8° E over Lakshadweep and adjoining southeast Arabian Sea, about 40 km north-northeast of Aminidivi (Lakshadweep), 350 km north-northwest of Minicoy (Lakshadweep), 110 km north-northeast of Kavaratti (Lakshadweep) and 325 km west-northwest of Kozhikode (Kerala). It moved further north-northwestwards and intensified into a **severe cyclonic storm** and lay centered at 0600 UTC of 31st October, near Lat. 11.9° N /Long. 72.8° E over eastcentral Arabian Sea and adjoining Lakshadweep area about 90 km north-northeast of Aminidivi (Lakshadweep), 150 km north-northeast of Kavaratti (Lakshadweep), 25 km east-northeast of Chetlat (Lakshadweep) and 330 km west-northwest of Kozhikode (Kerala). It moved north-northwestwards and crossed Lakshadweep Islands and lay centered at 1200 UTC of 31st October, near Lat. 12.8° N/Long. 72.4° E over eastcentral Arabian Sea and adjoining Lakshadweep area about 80 km northeast of Cherbaniani Reef (Lakshadweep), 120 km north-northeast of Cheriapani Reef (Lakshadweep), 130 km northeast of Chetlat (Lakshadweep). It moved northwestwards and lay centered at 0300 UTC of 1st November, near Lat. 14.8° N/ Long. 71.0° E over eastcentral Arabian Sea about 450 km north-northwest of Aminidivi (Lakshadweep), 460 km north-northwest of Mangaluru (Karnataka) and 310 km south-southwest of Goa. It moved west-northwestwards and lay centered at 1200 UTC of 1st November, over eastcentral Arabian Sea near Lat. 15.6° N/Long. 69.5° E, about 590 km south-southwest of Veraval (Gujarat) and 460 km west of Goa. It moved further west-northwestwards and lay centered at 0300 UTC of 2nd November, over eastcentral Arabian Sea near Lat. 16.4° N/ Long. 68.3° E, about 540 km south-southwest of Veraval (Gujarat) and 550 km south-southwest of Diu. It moved northwestwards and lay centered at 1200 UTC of 2nd November, over eastcentral Arabian Sea near Lat. 17.0° N/ Long. 67.6° E, about 520 km south-southwest of Veraval (Gujarat) and 540 km south-southwest of Diu. It further moved west-northwestwards and lay centered at 0300 UTC of 3rd November, over eastcentral Arabian Sea near Lat. 17.6° N/Long. 66.4° E, about 550 km west-southwest of Veraval (Gujarat) and 580 km west-southwest of Diu. It moved westwards and intensified into a very severe cyclonic storm and lay centered at 0900 UTC of 3rd November, over eastcentral Arabian Sea near

Lat. 17.6° N/Long. 65.9° E, about 590 km west-southwest of Veraval (Gujarat), 630 km west-southwest of Diu and 590 km southwest of Porbandar. It moved further westwards and lay centered at 1200 UTC of 3rd November, over eastcentral Arabian Sea near Lat. 17.7° N/ Long. 65.7° E, about 600 km west-southwest of Veraval (Gujarat), 640 km west-southwest of Diu and 600 km southwest of Porbandar. It further moved west-northwestwards and intensified into an **extremely severe cyclonic storm** and lay centered at 0000 UTC of 4th November, over eastcentral and adjoining westcentral Arabian Sea near Lat. 18.1° N/Long. 64.8° E, about 660 km west-southwest of Veraval (Gujarat), 700 km west-southwest of Diu and 640 km west-southwest of Porbandar. It continued to move west-northwestwards and lay centered at 0300 UTC of 4th November, over eastcentral & adjoining westcentral Arabian Sea near Lat. 18.3° N/Long. 64.6° E, about 670 km west-southwest of Veraval (Gujarat), 710 km west-southwest of Diu and 650 km west-southwest of Porbandar. It moved north-northwestwards and lay centred at 1200 UTC of 4th November, over eastcentral and adjoining westcentral Arabian Sea near Lat. 18.9° N/Long. 64.1° E, about 690 km west-southwest of Veraval (Gujarat) and 650 km west-southwest of Porbandar. It moved northwards and weakened into a **very severe cyclonic storm** and lay centered at 0300 UTC of 5th November, over westcentral and adjoining eastcentral Arabian Sea near Lat. 19.7° N/ Long. 63.6° E, about 660 km west-southwest of Porbandar (Gujarat). It moved westwards and lay centered at 1200 UTC of 5th November, over eastcentral and adjoining westcentral Arabian Sea near Lat. 19.8° N/ Long. 64.1° E, about 610 km west-southwest of Porbandar (Gujarat). It moved eastwards and weakened into a **severe cyclonic storm** and lay centered at 0000 UTC of 6th November, over eastcentral and adjoining northeast Arabian Sea near Lat. 19.8° N/Long. 65.8° E, about 450 km west-southwest of Porbandar (Gujarat), 490 km west-southwest of Veraval (Gujarat) and 540 km west-southwest of Diu. It continued to move eastwards and lay centered at 0300 UTC of 6th November, over eastcentral and adjoining northeast Arabian Sea near Lat. 19.8° N/ Long. 66.3° E, about 400 km west-southwest of Porbandar (Gujarat), 440 km west-southwest of Veraval (Gujarat) and 490 km west-southwest of Diu. It further moved eastwards and weakened into a **cyclonic storm** and lay centered at 1200 UTC of 6th November, over eastcentral and adjoining northeast Arabian Sea near Lat. 19.7° N/ Long. 67.7° E, about 300 km southwest of Porbandar (Gujarat), 310 km west-southwest of Veraval (Gujarat) and 350 km west-southwest of Diu. It further moved eastwards and weakened into a **deep depression** and lay centered at 0000 UTC of 7th November, over eastcentral and adjoining northeast Arabian Sea near Lat. 19.8° N/ Long. 69.4° E, about 200 km south-southwest of

Porbandar (Gujarat), 150 km west-southwest of Veraval (Gujarat) and 180 km west-southwest of Diu. It continued to move nearly eastwards and lay centered at 0300 UTC of 7th November, over eastcentral and adjoining northeast Arabian Sea near Lat. 20.0° N/Long. 70.0° E, about 100 km south-southwest of Veraval (Gujarat) and 120 km west-southwest of Diu. It moved nearly eastwards and weakened into a **depression** and lay centered at 0600 UTC of 7th November, over same region near Lat. 20.0° N/Long. 70.4° E, about 100 km nearly to the south of Veraval (Gujarat) and 90 km nearly to the south of Diu. It further moved east-northeastwards, weakened into a well marked low pressure area over northeast Arabian Sea and adjoining south Gujarat coast at 1200 UTC of 7th November.

2.8.2. Other features observed

The peak Maximum Sustained Surface Wind speed of the cyclone was 175-185 kmph (100 knots) gusting to 205 kmph during 1200 UTC to 2100 UTC of 4th November over the westcentral and adjoining eastcentral Arabian Sea. The lowest estimated central pressure was 956 hPa during 1200 UTC to 2100 UTC of 4th November.

2.8.3. Realized weather

The Extremely Severe Cyclonic storm 'MAHA' didn't cause any significant rainfall over the states along the west coast of India throughout its life period. However, on 30th October, it caused heavy to very rainfall at most places with extremely heavy falls at few places over Maldives and heavy rainfall at most places over Comorin area. On 31st October, it caused heavy to very rainfall at few places over Maldives and heavy rainfall at few places over Comorin area. On 7th November, it caused heavy rainfall at isolated places over eastcentral Arabian Sea off south Gujarat coast. Lakshadweep Islands reported light to moderate rainfall with isolated heavy to very heavy and extremely heavy falls at isolated places on 30th & 31st October. As the system moved over to eastcentral Arabian Sea, coastal areas and windward side of the western ghats of Maharashtra also received fairly widespread to widespread rainfall with heavy to very heavy falls at isolated places on 2nd November.

Chief amount of rainfall exceeding 7 cm recorded during the past 24 hours ending at 0300 UTC of date are given below:

30th October

Lakshadweep : Minicoy 8

31st October

Kerala & Mahe : Alapuzha & Kayamkulam 10 each, Neyyattinkara 9, Mavelikara, Cherthala, Nedumangad, Mancompu, Kumarakam & Thiruvananthapuram 8 each and Kollam, Ernakulam South, Vaikom, Kochi & Chengannur 7 each

Lakshadweep : Amini 30 and Minicoy 12

1st November

Coastal Karnataka : Mani 8

Kerala & Mahe : Kannur, Taliparamba, Talassery, Kochi & Kumarakam 7 each

2nd November

Konkan : Alibag 9

Madhya Maharashtra : Nandgaon 15, Girnadam 12 and Chandwad 8

Marathwada : Sillod & Soegaon 7 each

3rd November

Marathwada : Dharur 10 and Soegaon 7

Gujarat Region : Khergam 8

Saurashtra & Kutch : Limbdi 7

2.9. Very severe cyclonic storm 'BULBUL' over the Bay of Bengal (5 - 11 November, 2019)

2.9.1. Under the influence of a cyclonic circulation over north Andaman Sea and adjoining Myanmar Coast, a Low Pressure Area formed over north Andaman Sea with associated cyclonic circulation extending upto 5.8 km above mean sea level, in the early morning of 4th November. It intensified into a **Well Marked Low Pressure Area** over the same region at 0900 UTC of 4th November. It persisted over the same region at 1200 UTC of 4th November. It moved west-north westwards and concentrated into a **depression** and lay centered at 0000 UTC of 5th November, over eastcentral and adjoining southeast Bay of Bengal and north Andaman Sea, near Lat. 13.1° N/Long. 91.5° E, about 150 km west-

northwest of Maya Bandar (Andaman Islands). It moved westwards and lay centered at 0300 UTC of 5th November, over eastcentral and adjoining southeast Bay of Bengal and north Andaman Sea, near Lat. 13.1° N/ Long. 91.0° E, about 200 km west-northwest of Maya Bandar (Andaman Islands). It moved west-northwestwards and lay centered at 1200 UTC of 5th November, over eastcentral and adjoining southeast Bay of Bengal and North Andaman Sea, near Lat. 13.2° N/Long. 90.1° E, about 300 km west-northwest of Maya Bandar (Andaman Islands). It further moved west-northwestwards and intensified into a **deep depression** and lay centred at 0000 UTC of 6th November, over eastcentral and adjoining southeast Bay of Bengal, near Lat. 13.4° N/Long. 89.3° E, about 390 km west-northwest of Maya Bandar (Andaman Islands). It moved westwards and lay centered at 0300 UTC of 6th November, over eastcentral & adjoining southeast Bay of Bengal, near Lat. 13.4° N/Long. 89.3° E, about 390 km west-northwest of Maya Bandar (Andaman Islands), 920 km south-southeast of Sagar Islands (West Bengal) and 960 km south-southwest of Khepupara (Bangladesh). It moved northwards and lay centered at 1200 UTC of 6th November, over eastcentral and adjoining southeast Bay of Bengal, near Lat. 13.5° N/ Long. 89.3° E, about 810 km south-southeast of Paradip (Odisha), 920 km south-southeast of Sagar Islands (West Bengal) and 950 km south-southwest of Khepupara (Bangladesh). It further moved northwards and intensified into **cyclonic storm 'BULBUL'** and lay centred at 1800 UTC of 6th November, over eastcentral and adjoining southeast Bay of Bengal, near Lat. 13.8° N/ Long. 89.3° E, about 770 km south-southeast of Paradip (Odisha), 850 km south-southeast of Sagar Islands (West Bengal) and 910 km south-southwest of Khepupara (Bangladesh). It continued to move northwards and lay centered at 0300 UTC of 7th November, over eastcentral Bay of Bengal, near Lat. 14.7° N/Long. 89.3° E, about 680 km south-southeast of Paradip (Odisha), 780 km south-southeast of Sagar Islands (West Bengal) and 810 km south-southwest of Khepupara (Bangladesh). It moved north-westwards and intensified into a **severe cyclonic storm** and lay centered at 1200 UTC of 7th November, over westcentral and adjoining eastcentral Bay of Bengal, near Lat. 15.9° N/Long. 88.0° E, about 510 km south-southeast of Paradip (Odisha), 640 km south of Sagar Islands (West Bengal) and 710 km south-southwest of Khepupara (Bangladesh). It moved north-northwestwards and intensified into a **very severe cyclonic storm** and lay centered at 0000 UTC of 8th November, over westcentral and adjoining eastcentral Bay of Bengal, near Lat. 16.9° N/ Long. 87.6° E, about 390 km south-southeast of Paradip (Odisha), 530 km south-southwest of Sagar Islands (West Bengal) and 630 km south-southwest of Khepupara (Bangladesh). It continued to move north-northwestwards and lay centered at 0300 UTC of 8th November, over

westcentral and adjoining eastcentral Bay of Bengal, near Lat. 17.2° N/Long. 87.6° E, about 350 km south-southeast of Paradip (Odisha), 490 km south-southwest of Sagar Islands (West Bengal) and 590 km south-southwest of Khepupara (Bangladesh). It moved northwards and lay centred at 1200 UTC of 8th November, over northwest & adjoining westcentral Bay of Bengal, near Lat. 18.5° N/ Long. 87.6° E, about 220 km south-southeast of Paradip (Odisha), 350 km south-southwest of Sagar Islands (West Bengal) and 470 km south-southwest of Khepupara (Bangladesh). It further moved nearly northwards and lay centred at 0300 UTC of 9th November, over northwest Bay of Bengal, near Lat. 20.4° N/Long. 87.6° E, about 95 km east-northeast of Paradip (Odisha), 140 km south-southwest of Sagar Islands (West Bengal), 100 km southeast of Chandbali, 140 km south-southwest of Balasore, 130 km south-southwest of Digha and 320 km southwest of Khepupara (Bangladesh). It moved north-northeastwards and lay centred at 1200 UTC of 9th November, over northwest Bay of Bengal, near Lat. 21.2° N/Long. 88.1° E, about 175 km east-northeast of Paradip (Odisha), 50 km south of Sagar Islands (West Bengal), 125 km east-southeast of Balasore, 75 km southeast of Digha, 150 km south-southeast of Kolkata and 235 km west-southwest of Khepupara (Bangladesh). It moved northeastwards and weakened into a **severe cyclonic storm** and crossed West Bengal Coast close to Sunderban Dhanchi forest during 1500 to 1800 UTC of 9th November. It moved east-northeastwards and further weakened into a **cyclonic storm** and lay centred at 0000 UTC of 10th November, over coastal Bangladesh and neighbourhood, near Lat. 22.2° N/Long. 89.5° E, about 160 km east-northeast of Sagar Islands (West Bengal), 75 km east-northeast of Sunderban National Park, 130 km east-southeast of Kolkata and 75 km west-northwest of Khepupara (Bangladesh). It further moved east - northeastwards and lay centred at 0300 UTC of 10th November over coastal Bangladesh & neighbourhood, near Lat. 22.2° N/Long. 89.7° E about 180 km east-northeast of Sagar Islands (West Bengal), 70 km east-northeast of Sunderban National Park, 140 km east-southeast of Kolkata and 60 km west-northwest of Khepupara (Bangladesh). It weakened into a **deep depression** at 0900 UTC of 10th November near Lat. 22.4° N/Long. 90.1° E about 50 km north-northeast of Khepupara (Bangladesh), about 220 km east-northeast of Sagar Islands (West Bengal), 140 km east-northeast of Sunderban National Park, 180 km east of Kolkata. It moved east-northeastwards and lay centered at 1200 UTC of 10th November over coastal Bangladesh and neighbourhood near Lat. 22.5° N/Long. 90.4° E, about 60 km north-northeast of Khepupara (Bangladesh), about 260 km east-northeast of Sagar Islands (west Bengal), 170 km east-northeast of Sunderban National Park, 210 km east of Kolkata. It further moved east-

northeastwards and weakened into a depression at 0000 UTC of 11th November, over southeast Bangladesh & adjoining south Tripura near Lat. 23.1° N/Long. 91.9° E, about 210 km north-northeast of Khepupara (Bangladesh) and 110 km southeast of Agartala (Tripura). It weakened into a low pressure area over southern parts of Tripura and neighbourhood on 11th morning.

2.9.2. Other features observed

The peak Maximum Sustained Surface Wind speed of the cyclone was 135-145 kmph (75 knots) gusting to 160 kmph during 0600 UTC of 8th November to 1200 UTC of 9th November over westcentral and adjoining northwest Bay of Bengal. The lowest estimated central pressure was 976 hPa during 1200 UTC of 8th November to 0000 UTC of 9th November. It weakened slightly prior to crossing (from 0300 UTC of 9th November onwards) the Sunderban Delta owing to increased vertical wind shear and Land interaction. The system crossed West Bengal coast close to Sunderban Dhanchi Forest near Lat. 21.55° N/Long. 88.5° E between 1500 UTC and 1800 UTC of 9th November, with maximum sustained wind speed of 110-120 kmph gusting to 135 kmph.

2.9.3. Realized weather

Rainfall associated with VSCS BUL BUL based on IMD-NCMRWF GPM merged gauge 24 hours cumulative rainfall ending at 0300 UTC indicates occurrence of heavy to very heavy rainfall over eastcentral Bay of Bengal on 5th November, heavy to very heavy & extremely heavy falls over eastcentral Bay of Bengal on 6th, over central and adjoining northwest Bay of Bengal on 7th and heavy to very heavy rainfall over northwest and adjoining westcentral Bay of Bengal off Odisha-West Bengal coast on 8th November. As the system reached further close to Odisha - West Bengal coast on 8-9, the following rainfall amounts were reported by meteorological observatories in Odisha and West Bengal during the past 24 hours ending at 0300 UTC of 9-10 November:

Chief amount of rainfall in cm (≥ 7 cm) recorded during the past 24 hours ending at 0300 UTC of date are given below:

9th November

Odisha : Paradip 16, Chandbali 15, Rajkanika 14, Tirtol & Balipatna 10 each and Bhadrak 7

West Bengal : Digha 7

10th November

Odisha : Bhograi 9

West Bengal : Dhapa 21, Canning 19, Joka 16, Cantai & Jora Bridge 13 each, Kakdwip 12, Ultadanga & Positional Astronomy Centre, IMD 11 each, Newmarket, Ballygunge, Patuli, Behala, Dumdum, Digha & Haldia 10 each, Alipore & Barrackpur 9 each, Mominpur & Palmer Bridge 8 each and Shibpur 7 (Other than Canning & Kakdwip, all other places are in Kolkata).

After crossing the coast & weakening, it caused isolated heavy rains over Tripura for a day

11th November

Tripura : Sabroom 8

2.10. Cyclonic storm "PAWAN" over the Arabian Sea (2 - 7 December, 2019)

2.10.1. A low pressure area lay over equatorial Indian Ocean and adjoining Southwest Arabian Sea on 30th November. It lay over southwest Arabian Sea and adjoining equatorial Indian Ocean with the associated cyclonic circulation extending upto 5.8 km above m.s.l. tilting southwestwards with height on 1st December. It lay as a **well marked low pressure area** in the morning of 2nd December. It persisted over the same region with the associated cyclonic circulation extended upto mid tropospheric levels on 2nd December. It concentrated into a **depression** over the same region and lay centered at 1200 UTC of 2nd December near Lat. 5.7° N/Long. 56.6° E about 820 km south-southeast of Socotra (Yemen), 120 km southeast of Bosaso (Somalia). It moved northwestwards and intensified into a **deep depression** over southwest Arabian Sea and adjoining Equatorial Indian Ocean and lay centred at 0000 UTC of 3rd December, near Lat. 6.5° N/Long. 56.5° E, about 740 km south-southeast of Socotra (Yemen) and 960 km southeast of Bosaso (Somalia). It moved north-northwestwards and lay centred at 0300 UTC of 3rd December, near Lat. 6.7° N/Long. 56.3° E over southwest Arabian Sea, about 710 km south-southeast of

Socotra (Yemen) and 930 km southeast of Bosaso (Somalia). It moved slightly eastwards and lay centred at 1200 UTC of 3rd December, near Lat. 7.2° N/ Long. 56.5° E over southwest Arabian Sea, about 670 km south-southeast of Socotra (Yemen) and 920 km east-southeast of Bosaso (Somalia). It moved northwards and lay centred at 0300 UTC of 4th December, near Lat. 7.4° N/Long. 56.6° E over southwest Arabian Sea, about 650 km south-southeast of Socotra (Yemen) and 920 km east-southeast of Bosaso (Somalia). It remained practically stationary and lay centered at 1200 UTC of 4th December, near Lat. 7.4° N/Long. 56.6° E over southwest Arabian Sea about 650 km south-southeast of Socotra (Yemen) and 920 km east-southeast of Bosaso (Somalia). It moved north-northwestwards and intensified into **cyclonic storm 'PAWAN'** and lay centred at 0000 UTC of 5th December, near Lat. 9.2° N/Long. 56.4° E over southwest Arabian Sea, about 470 km south-southeast of Socotra (Yemen) and 820 km east-southeast of Bosaso (Somalia). It continued to move north-northwestwards and lay centred at 0300 UTC of 5th December, near Lat. 9.2° N/Long. 56.4° E over southwest Arabian Sea, about 470 km south-southeast of Socotra (Yemen) and 820 km east-southeast of Bosaso (Somalia). It moved nearly west-northwestwards and lay centred at 1200 UTC of 5th December, near Lat. 9.6° N/ Long. 55.1° E over Southwest Arabian Sea, about 360 km south-southeast of Socotra (Yemen) and 670 km east-southeast of Bosaso (Somalia). It moved west-southwestwards and lay centred at 0300 UTC of the 6th December, near Lat. 8.1° N/Long. 53.0° E over southwest Arabian Sea, about 510 km south-southwest of Socotra (Yemen) and 540 km southeast of Bosaso (Somalia). It moved westwards and lay centred at 1200 UTC of 6th December, near Lat. 7.9° N/ Long. 52.3° E over southwest Arabian Sea, about 550 km south-southwest of Socotra (Yemen) and 510 km southeast of Bosaso (Somalia). It continued to move nearly westwards and crossed Somalia coast near Lat. 7.4° N/Long. 49.6° E during 0200-0300 UTC of 7th December as a Cyclonic Storm with wind speed of 60-70 kmph gusting to 80 kmph and weakened into a **deep depression** and lay centred at 0300 UTC of 7th December, near Lat. 7.4° N/Long. 49.5° E. It moved westwards and weakened into a **depression** and lay centred at 0900 UTC of 7th December, over north Somalia and neighbourhood near Lat. 7.3° N/Long. 48.3° E. It further moved nearly westwards and weakened into a well marked low pressure area and lay centred at 1200 UTC of 7th December, over north Somalia & adjoining Ethiopia.

2.10.2. Other features observed

The peak maximum sustained surface wind speed (MSW) of the cyclone was 70-80 kmph (40 knots) gusting

to 90 kmph during 1200 to 1500 UTC of 5th December over the southwest Arabian Sea. The lowest estimated central pressure was 998 hPa during the same period. It crossed Somalia coast near Lat. 7.4° N/Long. 49.6° E during 0200 to 0300 UTC of 7th December 2019 as a CS with maximum sustained wind speed (MSW) of 60-70 kmph gusting to 80 kmph.

2.10.3. Realized weather

The system developed over southwest Arabian Sea which caused heavy to very rainfall southwest Arabian Sea area during 3-4 December. However, rainfall gradually decreased from 4th onwards. On 7th, it caused heavy to very heavy rainfall at few places over coastal parts of northeast Somalia. On 8th, it caused moderate to heavy rainfall at isolated places over interior parts of northeast Somalia. It did not cause any adverse weather over any of the coastal states along west coast of India.

2.11. Deep Depression over eastcentral Arabian Sea (3 - 5 December, 2019)

2.11.1. A low pressure area formed over southeast Arabian Sea and adjoining Lakshadweep areawith associated cyclonic circulation extending upto 5.8 km above m.s.l. on 1st December. It lay over Lakshadweep area and adjoining southeast Arabian Sea morning of 2nd December. It lay as a **well marked low pressure area** over southeast Arabian Sea and adjoining areas of eastcentral Arabian Sea and Lakshadweep area on 3rd December, with associated cyclonic circulation extended upto 5.8 km above m.s.l. It lay over eastcentral Arabian Sea and adjoining areas of southeast Arabian Sea & Lakshadweep area in the evening of 3rd December. It concentrated into a **depression** and lay centred at 1800 UTC of 3rd December over eastcentral Arabian Sea and adjoining areas of southeast Arabian Sea & Lakshadweep area near Lat. 12.7° N/Long. 71.0° E. It moved northwestwards and intensified into a **deep depression** and lay centred at 0000 UTC of 4th December, over eastcentral Arabian Sea near Lat. 14.0° N/ Long. 70.0° E, about 640 km south-southwest of Mumbai (Maharashtra) and 440 km west-southwest of Panjim (Goa). It moved north-northwestwards and lay centred at 0300 UTC of 4th December, over eastcentral Arabian Sea, near Lat. 14.7° N/Long. 69.5° E, about 600 km south-southwest of Mumbai (Maharashtra) and 470 km west-southwest of Panjim (Goa). It moved westwards and lay centered at 1200 UTC of 4th December, over same region near Lat. 14.9° N/Long. 68.4° E about 660 km south-southwest of Mumbai (Maharashtra) and 580 km west of Panjim (Goa). It moved slowly northwestwards and weakened into a **depression** and lay centred at 0530 hours IST of the 5th December, over eastcentral

Arabian Sea, near Lat. 15.1° N/Long. 67.9° E, about 690 km west-southwest of Mumbai (Maharashtra) and 630 km west of Panjim (Goa). It further moved west-northwestwards and lay centred at 0830 hours IST of the 5th December, over eastcentral Arabian Sea, near Lat. 15.2° N/Long. 67.5° E, about 710 km west-southwest of Mumbai (Maharashtra) and 680 km west of Panjim (Goa). It moved west-northwestwards and weakened into a **well marked low pressure area** and lay over eastcentral Arabian Sea & neighbourhood at 1730 hours IST of the 5th December.

2.11.2. *Other features observed*

The lowest estimated central pressure (ECP) had been 1000 hPa and estimated maximum sustained surface wind speed was 30 kts gusting to 40 kts.

2.11.3. *Realized weather*

The system caused heavy to very heavy rainfall had been reported at isolated places over Lakshadweep area on 3rd.

Chief amount of 24 hrs rainfall (≥ 5 cm) ending at 0300 UTC of date during the life cycle of the system is presented below:

3rd December

Lakshadweep : Amini 20 and Agati 17

2.12. *Deep depression over southwest Arabian Sea (8 - 10 December, 2019)*

2.12.1. Under the influence of a trough in easterlies over Maldives area and adjoining equatorial Indian Ocean with embedded cyclonic circulation extended upto 3.6 km above m.s.l., a low pressure area formed over southeast Arabian Sea and adjoining equatorial Indian Ocean with associated cyclonic circulation extending upto mid-tropospheric levels on 7th December. It lay as a **well marked low pressure area** over southeast and adjoining southwest Arabian Sea at 0000 UTC of 8th December. It

lay over southwest and adjoining southeast Arabian Sea at 0300 UTC of the 8th December. Associated cyclonic circulation extended upto 5.8 km above m.s.l. It concentrated into a **depression** over southwest Arabian Sea and lay centred at 0900 UTC of 8th December near Lat. 9.4° N/Long. 62.2° E, about 970 km east-southeast of Socotra Island (Yemen) and 1540 km west-southwest of Kochi. It moved west-northwestwards and lay centred at 1200 UTC of 8th December, near Lat. 9.5° N/Long. 61.6° E, about 910 km east-southeast of Socotra Island (Yemen). It further moved west-northwestwards and lay centered at 1800 UTC of 8th December, near Lat. 10.0° N/Long. 61.0° E, about 830 km east-southeast of Socotra Island (Yemen). It continued to move west-northwestwards and intensified into a **deep depression** over southwest Arabian Sea and lay centered at 0000 UTC of 9th December, near Lat. 10.3° N/Long. 60.0° E, about 710 km east-southeast of Socotra Island (Yemen). It moved northwestwards and lay centred at 0300 UTC of 9th December, over southwest Arabian Sea near Lat. 10.6° N/Long. 60.0° E, about 700 km east-southeast of Socotra Island (Yemen). It moved west-northwestwards and weakened into a **depression** and lay centered at 1200 UTC of 9th December, over southwest Arabian Sea near Lat. 10.6° N/Long. 58.5° E. It moved westwards and lay centred at 0300 UTC of 10th December, over southwest Arabian Sea near Lat. 10.6° N/Long. 55.2° E, about 270 km southeast of Socotra Island (Yemen). It further moved westwards and weakened into a **well marked low pressure area** at 0600 UTC of 10th December, over southwest Arabian Sea.

2.12.2. *Other features observed*

The lowest observed pressure was reported 1009 hPa and maximum wind speed was reported 13 kts reported by ship OUYU2 (Lat. 9.6° N/Long. 70.3° E).

2.12.3. *Realized weather*

This system caused rainfall at a few places over Lakshadweep area on 8th and very light rain at isolated places over Lakshadweep area on 10th.