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INDIA METEOROLOGICAL DEPARTMENT

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Very Severe Cyclonic Storm "THANE" over the Bay of Bengal (25-31 December, 2011) : A Report

1. Introduction:

A very severe cyclonic storm developed over the Bay of Bengal during last week of December. It crossed north Tamil Nadu and Puducherry coast between Puducherry and Cuddalore within 0630-0730 hrs IST of 30th December, 2011 with a wind speed of 120-140 kmph.

The system was continuously monitored and predicted since 24th December 2011. The Special Weather Outlook and Tropical cyclone Advisory were issued during 25-31 December, 2011 giving details of the very severe cyclonic storm 'THANE' and its forecasts, warnings and advisories to various national and international agencies. The bulletin was issued to control room, National Disaster Management (NDM), MHA, Govt. of India and other high officials at centre and concerned states and Union Territories, viz., Andaman & Nicobar Islands, Puducherry, Tamil Nadu, Andhra Pradesh.

The Area Cyclone Warning Centre, Chennai of IMD issued various user specific bulletins including fishermen warning, port warning, coastal weather bulletin, sea area bulletin, four stage warning for state and districts disaster management officials. The forecasts and warnings were also issued by Cyclone Warning Centre, Visakhapatnam, Meteorological Office Port Blair, Meteorological Centre, Thiruvananthapuram.

The genesis of depression over the southeast Bay of Bengal was predicted 36 hrs in advance, i.e. on 24th December 2011 morning. The first bulletin issued in the evening of 25th December with the formation of depression indicated the formation of cyclone and its movement towards Tamil Nadu coast. The average track forecast errors for 24, 48 and 72 hrs lead time are 77, 160 and 181 km against the long period average of 150, 250 and 350 km. The average intensity forecast errors for the same lead time period are 10, 16 & 21 knots respectively. The landfall point error (km) for 24, 48 and 72 hrs lead time are 20,160 & 140 respectively and landfall time error(hrs) for the same period of lead time is 1 hr, which are quite low. The timely and accurate warning helped the disaster managers to initiate appropriate action.

The details of life history, adverse weather, bulletins and warnings issued and their performance are described in following sections.

2. Life history:

A depression formed over southeast Bay of Bengal in the evening of 25th December, 2011 and lay centred about 1000 km southeast of Chennai. It gradually moved north-northwestwards and intensified into a deep depression in the early morning of 26th December, 2011 and into a cyclonic storm 'THANE' in the same midnight. It then moved west-northwestwards and intensified into a severe cyclonic storm in the afternoon and into a very severe cyclonic storm in the evening of 28th December, 2011. It then moved west-southwestwards and crossed north Tamil Nadu & Puducherry coast between Cuddalore and Puducherry within 0630 and 0730 hrs IST of 30th December, 2011 with a wind speed of 120-140 kmph.

After landfall, the system rapidly weakened into a severe cyclonic storm over north coastal Tamil Nadu at 0830 hrs IST of 30th and into a deep depression around noon and into a depression in the same evening over the north Interior Tamil Nadu. It weakened further and lay as a well marked low pressure area over north Kerala and neighbourhood in early morning of 31st December, 2011.

The best track and associated parameters are shown in Fig. 1 and Table 1, The typical satellite and radar imageries are shown in Fig. 2 and 3 respectively.

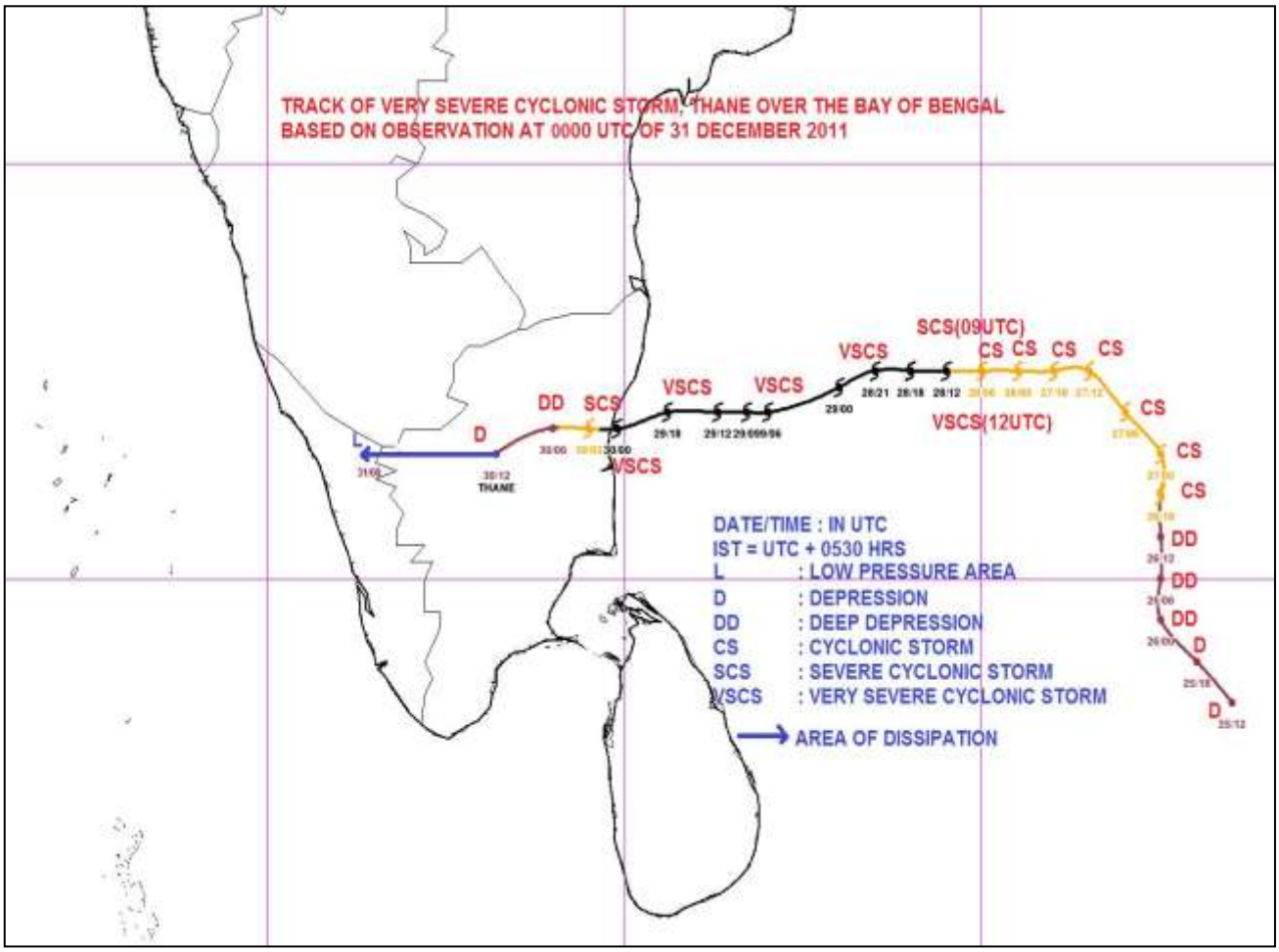

Fig.1. Track of very severe cyclonic storm, THANE over the Bay of Bengal

Table 1.Best track positions and other parameters of very severe Cyclonic storm THANE over the Bay of Bengal during 25-31 December, 2011.

Date	Time (UTC)	Centre lat. N/long. E	C.I NO.	Estimated Central Pressure (hPa)	Estimated Maximum Sustained Surface Wind(Kt)	Estimated Pressure drop at the Centre(hPa)	Grade
25.12.2011	1200	8.5/88.5	1.5	1000	25	3	D
	1800	9.0/88.0	1.5	1000	25	3	D
26.12.2011	0000	9.5/87.5	2.0	998	30	4	DD
	0600	10.0./87.5	2.0	998	30	4	DD
	1200	10.5/87.5	2.0	998	30	5	DD
	1800	11.0/87.5	2.5	996	35	7	CS
27.12.2011	0000	11.5/87.5	2.5	994	40	8	CS
	0600	12.0/87.0	2.5	994	40	8	CS
	1200	12.5/86.5	2.5	992	40	10	CS
	1800	12.5/86.0	3.0	990	45	12	CS
28.12.2011	0000	12.5/85.5	3.0	990	45	12	CS
	0600	12.5/85.0	3.0	988	45	14	CS
	0900	12.5/85.0	3.5	986	55	16	SCS
	1200	12.5/84.5	4.0	982	65	20	VSCS
	1500	12.5/84.0	4.0	980	65	22	VSCS
	1800	12.5/84.0	4.0	978	65	24	VSCS
	2100	12.5/83.5	4.0	976	65	26	VSCS
29.12.2011	0000	12.3/83.0	4.0	974	70	28	VSCS
	0600	12.0/82.0	4.5	972	75	30	VSCS
	0900	12.0/81.7	4.5	972	75	30	VSCS
	1200	12.0/81.3	4.5	972	75	30	VSCS
	1800	12.0/80.6	4.5	972	75	30	VSCS
30.12.2011	0000	11.8/79.9	4.5	972	75	30	VSCS
	0300	11.8/79.5	--	986	55	16	SCS
	0600	11.8/79.0	--	998	30	5	DD
	1200	11.8/78.2	--	1000	25	3	D
31.12.2011	0000	The system weakened into a well marked low pressure area over north Kerala and neighbourhood.					

D : Depression
DD : Deep Depression
CS : Cyclonic Storm
SCS : Severe Cyclonic Storm
VSCS : Very Severe Cyclonic Storm

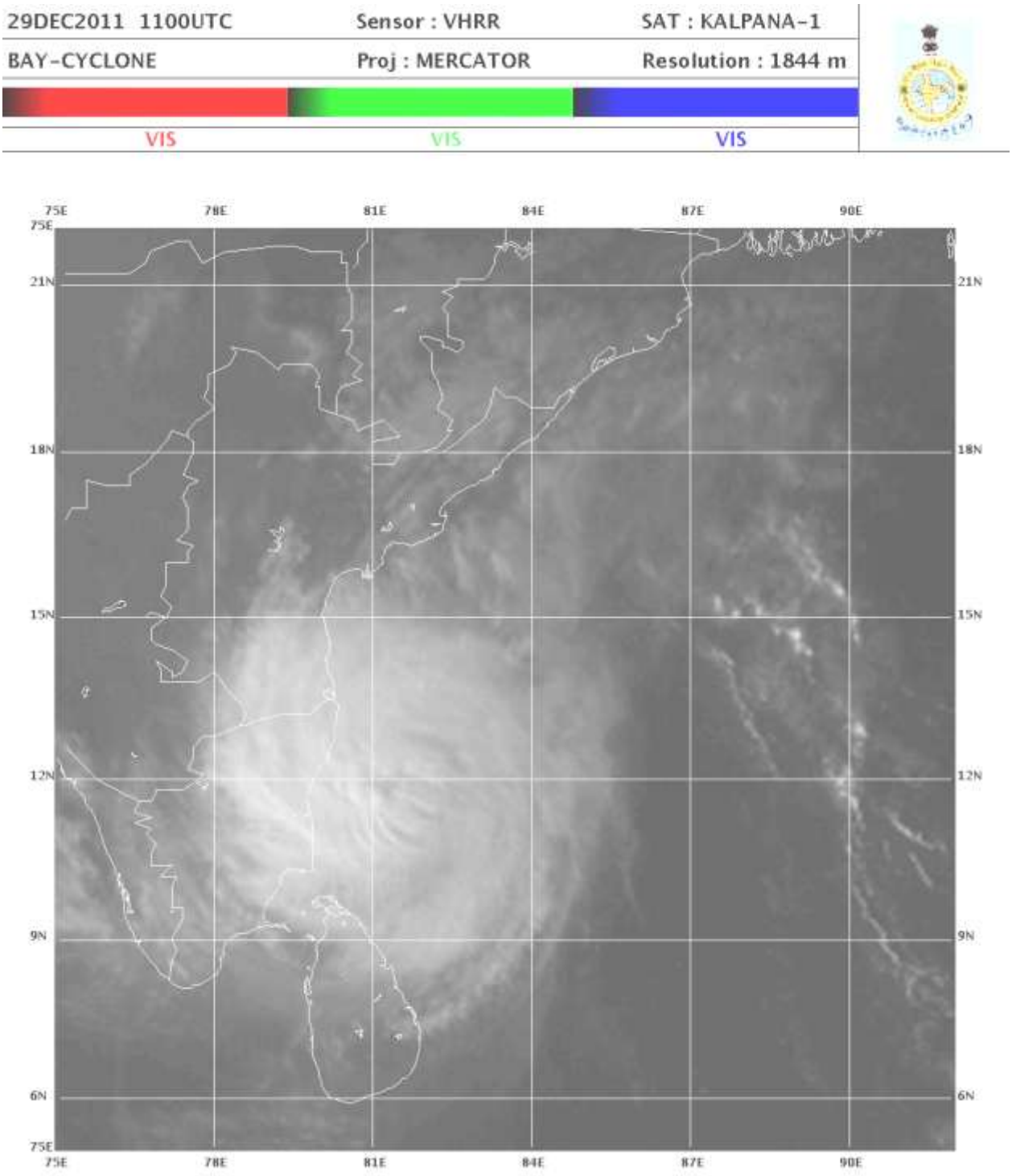

Fig.2. Typical satellite imagery of very severe cyclonic storm, THANE, showing EYE feature

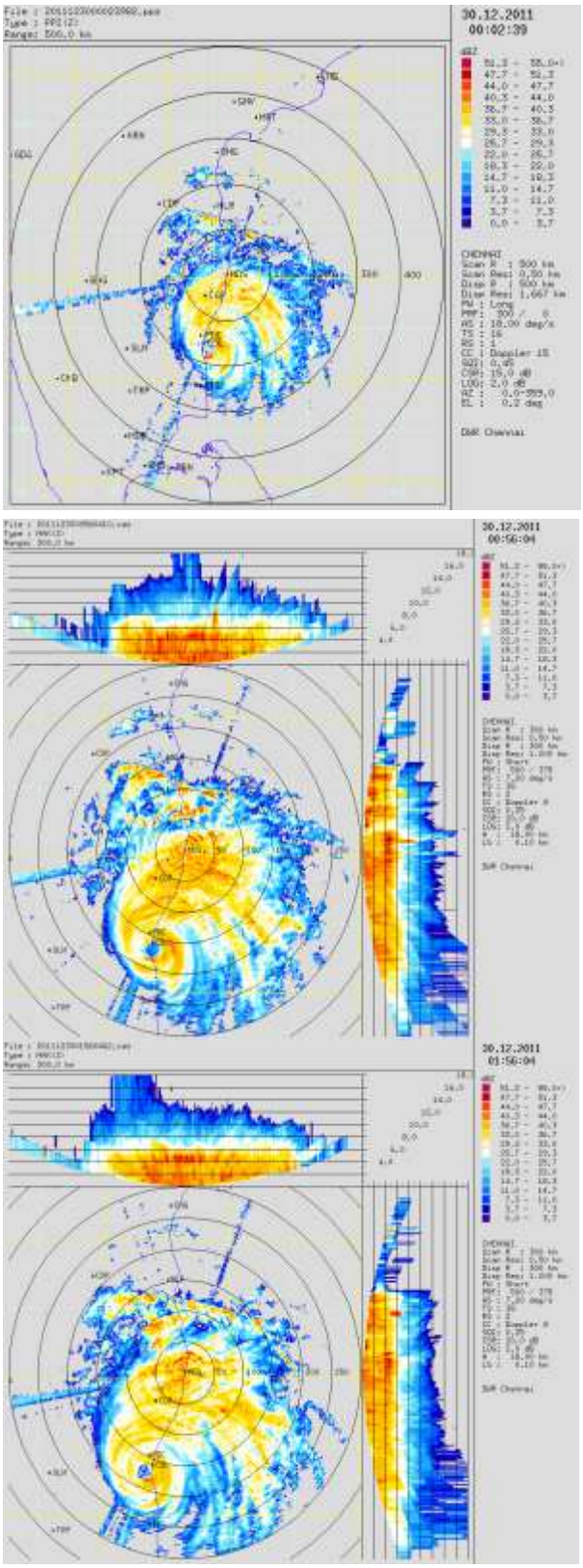

Fig.3. Doppler Weather Radar (DWR), Chennai imagery of very severe cyclonic storm, THANE at the time of landfall

3. Realised Weather

(a) Heavy Rainfall

Heavy to very heavy rainfall occurred at a few places over north Tamil Nadu and Puducherry on 30th and 31st December. Isolated heavy rainfall also occurred over south Tamil Nadu, south coastal Andhra Pradesh, Rayalaseema during this period and over Kerala on 31st December.

The following stations recorded past 24 hrs heavy rainfall (centimeters) at 0830 hrs IST of 30th and 31st December 2011.

30 December 2011

Puducherry : Puducherry airport 15,

Tamil Nadu : Kalpakkam and Kelambakkam (both Kanchipuram dt) 10 each, Cuddalore, Maduranthagam and Uthiramerur (both Kanchipuram dt) 9 each, Chengalpattu and Mahabalipuram (both Kanchipuram dt) 8 each and Chennai airport, Tiruvallur and Chidambaram (Cuddalore dt) 7 each.

Andhra Pradesh : Rapur (Nellore dt), Puttur (Chittoor dt) 7 each,

31 December 2011

Kerala : Haripad (Alapuzha dt) 22, Tiruvananthapuram 18, Nedumangad (Tiruvanathapuram dt) 16, Kayamkulam (Alapuzha dt) 15, Thiruvalla (Pattanamthitta dt) 14, Chengannur (Alapuzha dt) 12, Neyyatinkara (Tiruvananthapuram dt) 11, Mavelikara (Alapuzha dt) 10, Konni (Pattanamthitta dt), Kanjirapally (Kottayam dt), Kottayam, Alapuzha 9 each, Varkala (Tiruvananthapuram dt), Kozha (Kottayam dt) 7 each,

Puducherry : Puducherry airport 10

Tamil Nadu : Kallakurichi (Villupuram dt) 18, Gingee (Villupuram dt) 16 each, Sankarapuram (Villupuram dt), Mylaudy and Nagerkoil (both Kanyakumari dt) 14 each, Uthiramerur (Kanchipuram dt) and Kuzhithurai (Kanyakumari dt) 13 each, Virudhachalam (Cuddalore dt), Cheyyar (Tiruvannamalai dt) 12 each, Mancompu (Alapuzha dt), Tozhudur (Cuddalore dt), Tirukoilur (Villupuram dt), Polur, Vanthavasi and Sathanur Dam (all Tiruvannamalai dt) 11 each, Kanchipuram, Maduranthagam (Kanchipuram dt), Arani (Tiruvannamalai dt) 10 each, Chengalpattu (Kanchipuram dt), Chembarambakkam (Tiruvallur dt), Ulundurpet (Villupuram dt) and Tiruvannamalai 9 each, Punalur, Tiruvallur, Boothapandy (Kanyakumari dt), Kanyakumari, Chengam (Tiruvannamalai dt) and Sholingur (Vellore dt) 8 each and Chennai airport, Cheyyur, Kelambakkam and Sriperumpudhur (all Kanchipuram dt), Poonamalli, Ramakrishnarajupet and Tiruvalangadu (all Tiruvallur dt), Tiruttani, Sethiyathope (Cuddalore dt) and Tindivanam (Villupuram dt), Kumbakonam (Thanjavur dt), Arakonam

and Kaveripakkam (both Vellore dt), Vellore, Attur (Salem dt), Coonoor, Jayamkondam (Ariyalur dt) and Padallur (Perambalur dt) 7 each.

(b) Gale wind

Gale wind speed reaching 120-140 kmph prevailed along and off north Tamil Nadu and Puducherry coast. Puducherry reported maximum wind of 68 knots (125 kmph) and Cuddalore reported maximum wind of 76 knots (140 kmph) at the time of landfall.

(c) Storm surge

As per post-cyclone survey conducted by IMD, the storm surge of about 1 metre height inundated the low lying coastal areas of Cuddalore, Puducherry and Villuparam districts at the time of landfall of the cyclone, THANE.

4. Monitoring, prediction and warning services

(a) Monitoring and prediction

The system was monitored mainly by satellite during its genesis and further intensification stage. Of course the surface observations from buoys and ships supported monitoring. When the system came within the radar range, DWR, Chennai monitored it and hourly inputs were provided to cyclone forecasters since evening of 28th December 2011. It helped in accurate monitoring of location and better estimation of intensity and associated landfall processes including heavy rainfall location and intensity and gale wind speed. When the system came close to coast, it was monitored by coastal observations in addition to satellite and DWR, Chennai.

Apart from the synoptic guidance, the numerical weather prediction (NWP) and dynamical & statistical models helped in prediction of genesis, track and intensity of cyclone, THANE and associated adverse weather.

(b) Warning Bulletins issued by IMD

The system was continuously monitored and predicted since 24th December 2011. The Special Weather Outlook and Tropical cyclone Advisory were issued during 25-31 December, 2011 giving details of the very severe cyclonic storm 'THANE' and its forecasts, warnings and advisories to various national and international agencies. The bulletin was issued to control room, National Disaster Management (NDM), MHA, Govt. of India and other high officials at centre and concerned states and Union Territories, viz., Andaman & Nicobar Islands, Puducherry, Tamil Nadu, Andhra Pradesh. The statistics of the number of bulletins issued by IMD are given below. Initially, the warnings were issued for Adaman & Nicobar Islands, when the system was closer to it and then it was issued for Puducherry, Tamil Nadu, Andhra Pradesh and Kerala.

Bulletins for national disaster management agencies	: 37
Bulletin for WMO/ESCAP Panel counties	: 28
Tropical cyclone advisory for international civil aviation	: 15

The Area Cyclone Warning Centre (ACWC), Chennai of IMD issued various user specific bulletins including fishermen warning, port warning, coastal weather bulletin, sea area bulletin, four stage warning for state and districts disaster management officials. The forecasts and warnings were also issued by Cyclone Warning Centre, Visakhapatnam, Meteorological Office Port Blair, Meteorological Centre, Tiruvananthapuram.

(c) Forecast performance:

The forecasts and warnings issued by IMD have been verified and the same are described below.

(i) Genesis forecast

The genesis of depression over the southeast Bay of Bengal was predicted 36 hrs in advance, i.e. on 24th December 2011 morning.

(ii) Track and intensity forecast

The verification of intensity and track forecast issued by IMD is discussed in Table 2. The average track forecast errors (km) for 24, 48 and 72 hrs lead time are 77, 160 & 181 km against the long period average of 150, 250 and 350 km. The average intensity forecast errors (knots) for the same lead time period are 10, 16 & 21 knots respectively.

Table 2 Average Track & Intensity Forecast Error Very Severe Cyclonic Storm THANE

Lead Time(hrs)	Average Track forecast error (km)	Average Intensity error(kt)	No. of forecast verified
12	43	7	17
24	77	10	15
36	129	13	13
48	160	16	11
60	175	4	9
72	181	21	7

The landfall point error (km) for 24, 48 and 72 hrs lead time are 20,160 & 140 respectively and landfall time error(hrs) for the same period of lead time is 1 hr (Table 3)

Table 3. Verification for landfall forecast

Lead Time(hrs)	Landfall point error(Km) (Forecast point - actual point)			Landfall time error (hrs) (Forecast - actual time of landfall)		
	Forecast point	Actual Point	Error (km)	Forecast time(IST)	Actual time (IST)	Error (hrs)
12	12.0^0N/79.9^0E	11.8^0N/79.9^0E	20	30/0500	30/0700	-2
24	12.0^0N/79.9^0E	11.8^0N/79.9^0E	20	30/0600	30/0700	-1
36	12.5^0N/80.1^0E	11.8^0N/79.9^0E	80	30/0600	30/0700	-1
48	13.2^0N/80.2^0E	11.8^0N/79.9^0E	160	30/0600	30/0700	-1
60	13.1^0N/80.2^0E	11.8^0N/79.9^0E	150	30/0600	30/0700	-1
72	13.0^0N/80.2^0E	11.8^0N/79.9^0E	140	30/0600	30/0700	-1
84	13.0^0N/80.2^0E	11.8^0N/79.9^0E	140	30/0600	30/0700	-1

(iii) Gale wind warning for the coast

The verification of gale wind warning is presented in Table 4. The actual wind was 120-140 kmph against the forecast wind of 120-130 kmph gusting to 145 kmph 24 hrs in advance, 95-105 kmph gusting to 115 kmph 48 hrs in advance.

Table 4. Verification of gale wind warning

Lead Time(hrs)	Forecast gale wind (kmph)	Actual gale wind speed (kmph)
12	120-130 gusting 145	120-140
24	120-130 gusting 145	120-140
36	100-110 gusting 125	120-140
48	95-105 gusting 115	120-140
60	90-100 gusting 110	120-140
72	90-100 gusting 110	120-140
84	90-100 gusting 110	120-140

(iv) Storm surge warning

MD predicted storm surge of 1-1.5 metre height above the astronomical tide over Puducherry, Tiruvallur, Villupuram, Chennai and Kanchipuram districts of north Tamil Nadu at the time of landfall. As per post-cyclone survey conducted by IMD, the storm surge of about 1 metre height inundated the low lying coastal areas of Cuddalore, Puducherry and Villuparam districts at the time of landfall.

(v) Heavy rainfall warning

Table 5 shows verification of heavy rainfall warnings issued in association with very severe cyclonic storm ‘Thane’ during 25-31 December, 2011. The occurrence of heavy to very heavy rainfall over Andaman & Nicobar Islands, Tamil Nadu and Puducherry, south coastal Andhra Pradesh and Kerala could be very well predicted. However, the extremely heavy rainfall as predicted over north Tamil Nadu did not occur during this period.

Table 5. Verification of heavy rainfall warnings issued in association with very severe cyclonic storm 'Thane'

F/C Date	Sub-Division	F/C Valid for 24 hrs.	F/C Valid for 48 hrs.	Realized wx during 24 hrs.	Realized wx during 48 hrs.
25-12-2011 1730 hrs IST	Andaman & Nicobar Islands	ISOL H	ISOL H	ISOL H	ISOL H
26-12-2011 0830hrs IST	Andaman & Nicobar Islands	ISOL H	ISOL H	ISOL H	ISOL H
27-12-2011 0830hrs IST	Andaman & Nicobar Islands	ISOL H	-Nil	Nil	Nil
	North coast TN	ISOL H	Nil	Nil	Nil
	South coastal AP	ISOL H	Nil	Nil	Nil
28-12-2011 0830hrs IST	North coast TN & PDC	ISOL H	SCT H-VH ISOL Ex-H	Nil	SCT H-VH
	North Interior TN	ISOL H	SCT H-VH ISOL Ex-H	Nil	ISOL H-VH
	South coastal AP	ISOL H	ISOL H	Nil	ISOL H
	Rayalaseema	ISOL H-VH	SCT H-VH ISOL Ex-H	Nil	ISOL H
29-12-2011 0830hrs IST	North coast TN & PDC	SCT H-VH ISOL Ex-H	SCT H-VH ISOL Ex-H	SCT H-VH	SCT H-VH
	North Interior TN	SCT H-VH ISOL Ex-H	SCT H-VH ISOL Ex-H	SCT H-VH	SCT H-VH
	South TN	ISOL H	ISOL H	ISOL H	H-VH
	South coastal AP	ISOL H-VH	ISOL H-VH	ISOL H	ISOL H
	Rayalaseema	ISOL H-VH	ISOL H-VH	ISOL H	ISOL H
30-12-2011 0830hrs IST	North coast TN & PDC	SCT H-VH	-NIL	SCT H-VH	NIL
	North Interior TN	SCT H-VH	-NIL	SCT H-VH	NIL
	South TN	NIL	- NIL	ISOL H-VH	NIL
	South coastal AP	ISOL H-VH	NIL	ISOL H-VH	NIL
	Rayalaseema	ISOL H-VH	NIL	ISOL H-VH	NIL
	Noth Kerala	ISOL H-VH	NIL	ISOL H-VH	NIL
	South Karnataka	ISOL H-VH	NIL	ISOL H-VH	NIL

Legend:
H: Heavy 7-12 cm), VH: Very Heavy (13-24 cm), Ex H: Extremely Heavy (≥ 25 cm)
ISOL: Isolated (25% or less numbers stations reporting heavy rain)
SCT; Scattered (25-50% of stations reporting heavy rain)
PDC : Puducherry, TN : Tamil Nadu, AP : Andhra Pradesh