Cyclone Hazard Proneness of Districts of India

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- Regional Specialised Meteorological Centre (RSMC), New Delhi, has prepared cyclone hazard proneness of districts of India based on frequency of total cyclones, total severe cyclones, actual/estimated maximum wind strength, Probable Maximum Storm Surge (PMSS) associated with the cyclones and Probable Maximum Precipitation (PMP) for all districts as presented in Fig. 1. The hazard maps prepared by committee constituted by NDMA in 2012 indicating total number of severe cyclones (maximum sustained wind speed (MSW) of 48 knots or more), total number of cyclones (MSW of 34 knots or more), actual/estimated MSW, probable maximum storm surge, daily probable maximum precipitation over coast are presented in Fig.2 (a-e). The cyclone parameters for various districts are presented in Table 3-5.

- Ninety-six districts including 72 districts touching the coast and 24 districts not touching the coast, but lying within 100 km from the coast have been classified based on their proneness. Out of 96 districts, 12 are very highly prone, 41 are highly prone, 30 are moderately prone, and the remaining 13 are less prone. Twelve very highly prone districts include South and North 24 Praganas, Medinipur, and Kolkata of West Bengal, Balasore, Bhadrak, Kendrapara, and Jagatsinghpur districts of Odisha, Nellore, Krishna, and east Godavari districts of Andhra Pradesh and Yanam of Puducherry. The remaining districts of Odisha and Andhra Pradesh, which touch the coast are highly prone districts. The north Tamil Nadu coastal districts are more prone than the south Tamil Nadu districts (south of about 10◦N latitude). Most of the coastal districts of Gujarat and north Konkan are also highly prone districts. The remaining districts in the west coast and south Tamil Nadu are either moderately prone or less prone districts.

- For details about the data, methodology and results the following publication may kindly be referred:

  Cyclone hazard prone districts of India, M. Mohapatra, 2015, Journal of Earth System Science, 124, No.3, pp. 515-526) and
  Classification of Cyclone Hazard Prone Districts of India, M. Mohapatra, G.S. Mandal, B.K. Bandyopadhyay, Ajit Tyagi, U.C. Mohanty, 2012, Nat Hazards, 63:1601–1620

- This classification is only based on hazard criteria. Vulnerability of the place has not been taken into consideration. Therefore, composite cyclone risk of a district, which is the product of hazard and vulnerability, needs to be assessed separately through detailed study. Such an initiative is being taken by NDMA through the World Bank assisted National Cyclone Risk Mitigation Project (NCRMP).

- The maximum sustained surface wind (MSW) indicated against a district in this report is the 3-min average wind speed normally recorded by IMD. Keeping in mind that it is the 3-second peak-gust wind speed that is usually adopted for design of buildings and structures (Lakshmanan et al. 2009, Structural Engineering Research Centre (SERC), Chennai), the MSW indicated against the districts (Mohapatra et al. 2012) need to be multiplied by an appropriate factor for design of all buildings and structures in general and for the design of the post-disaster service structures (such as cyclone shelters, hospitals, transmission lines and communication towers, schools, etc.), in particular.
- In this list of cyclone hazard prone districts of the country, some of the districts of northeast India appearing in the list prepared by BMTPC have not appeared. This is because those districts are away from the coast and no parts of these districts were affected by storm surge requiring large scale evacuation of population. Floods due to cyclones over these districts are also very rare. These districts are mostly affected by depressions. Also interior districts of coastal states were not considered though some of these may be affcted by storm wind and very high rainfall causing damage and destruction to life and properties.

- The analysis is based on the estimation of daily point PMP by IMD. The criteria adopted for categorization of PMP is arbitrary and subjective. However, IMD and Central Water Commission are developing a new PMP atlas based on longer and latest data. The PMP atlas needs to be prepared considering the actual extreme rainfall over the districts due to TCs only. There is scope for reanalysis of TC hazard proneness based on PMP of districts in association with TCs.

- The wind data in association with TC is based on the period of 1971–2010. It is mainly based on the wind estimated by Dvorak's technique (Dvorak 1984) and post-cyclone survey report along with the coastal observations available from IMD's observational network. There is further scope for improvement in estimation of TC wind hazard with upgradation of observational network with high wind speed recorder (HWSR), Doppler Weather Radar and validation of Dvorak's technique based on instrumented aircraft observation from the core and periphery of the TC.

- The study is based on the residual storm surge height in association with the TC crossing coast. It does not take into consideration the total water envelope due to astronomical tide, in-shore current, river discharge, and heavy rainfall distribution, etc. All these factors can influence the storm surge and hence resultant tidal wave. Therefore, there is further scope to estimate the storm surge hazard based on total water envelope and coastal inundation and hence to modify the hazard proneness of the coastal districts. Studies are in progess by various researchers including those from Indian National Centre for Ocean Information Services (INCOIS), Hyderabad and Centre for Atmospheric Sciences, Indian Institute of Technology (IIT), Delhi to develop the models for total water envelope and coastal inundation due to landfall of TC.

- The factors such as probable maximum wind strength, PMSS, and daily PMP are used to determine the degree of proneness based on the observed datasets. However, if speed and the size of the storm varies, then it is going to have an impact on all the aforementioned factors based on maximum duration of the wind strength/rainfall/storm surge and maximum area (size) to be impacted by the landfalling TC. Hence, the degree of proneness may vary in such conditions.

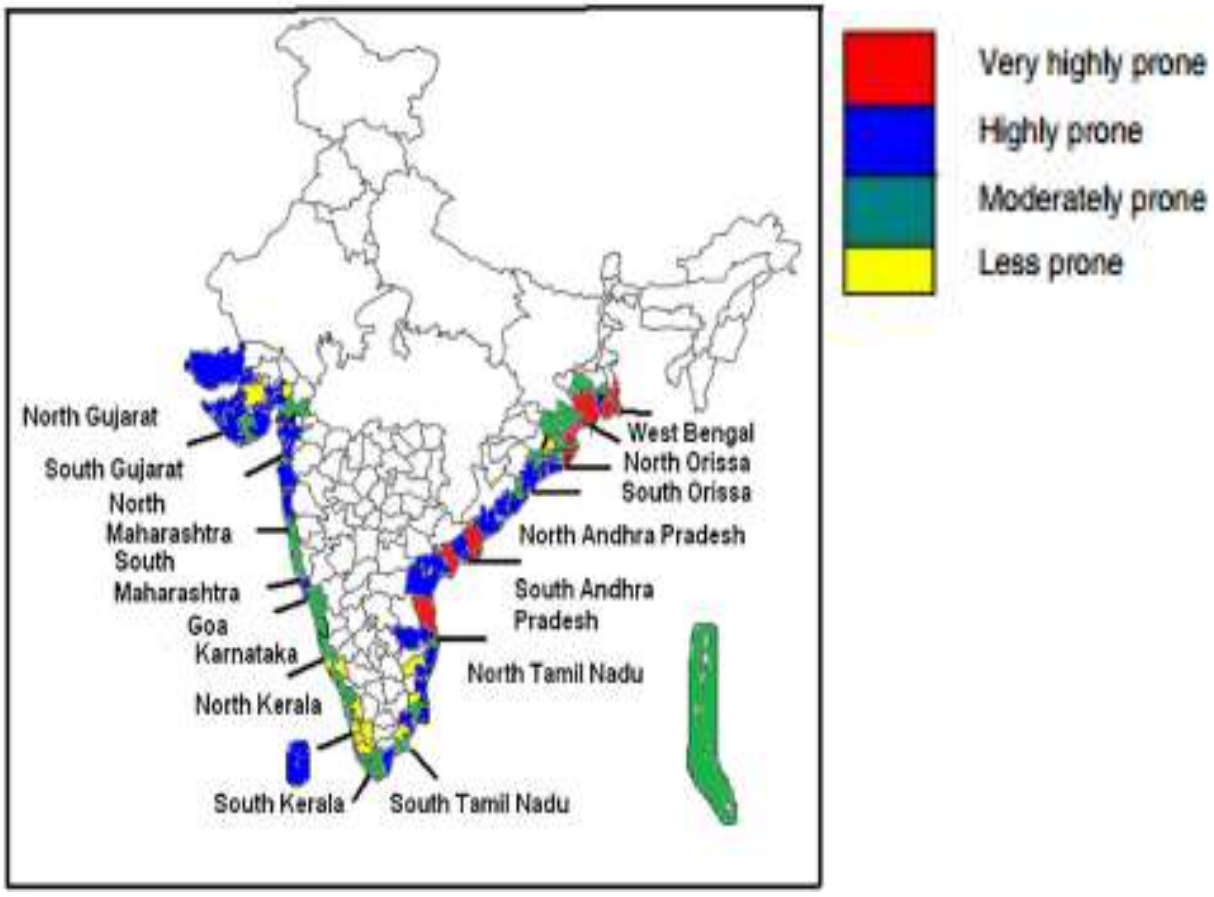

Fig.1: Cyclone hazard prone districts of India based on frequency of total cyclones, total severe cyclones, actual/estimated maximum wind strength, PMSS associated with the cyclones and PMP for all districts

Table 1: Cyclone hazard prone districts of India touching coast (72) based on frequency of total cyclones, severe cyclones; strength of actual/estimated wind, PMSS and PMP

State	Districts	Degree of Proneness
Andhra Pradesh (AP)	Nellore	P1
	East Godavari	P1
	Krishna	P1
Odisha	Balasore	P1
	Kendrapara	P1
	Jagatsinghpur	P1
	Bhadrak	P1
Puducherry	Yanam	P1
West Bengal	South 24-Pragana	P1
	Medinipur	P1
AP	Srikakulam	P2
	Guntur	P2
	Visakhapatnam	P2
	West Godavari	P2
	Prakasam	P2
	Vizianagaram	P2
Daman & Diu	Diu	P2
Gujarat	Junagadh	P2
	Kachchh	P2
Lakshadweep	Lakshadweep	P2
Odisha	Ganjam	P2
	Puri	P2
	Khordha	P2
Puducherry	Karaikal	P2
Tamil Nadu	Pudukkottai	P2
	Cuddalore	P2
	Kanchipuram	P2
	Tiruvarur	P2
	Nagappattinam	P2
	Chennai	P2
	Ramanathapuram	P2
	Toothukudi	P2
	Tirunelveli	P2
Andaman & Nicobar Islands (A&N Islands)	A & N Islands	P3
Daman & Diu	Daman	P3
Goa	North Goa	P3
	South Goa	P3
Gujarat	Ahmedabad	P3
	Bhavnagar	P3
	Amreli	P3
	Jamnagar	P3

Degree of Proneness	Meaning
P1	Very Highly Prone
P2	Highly Prone
P3	Moderately Prone
P4	Less Prone

	Anand	P3
	Navsari	P3
	Surat	P3
	Valsad	P3
	Bharuch	P3
	Porbandar	P3
	Rajkot	P3
	Vadodara	P3
Karnataka	Udupi	P3
	Uttar Kannada	P3
	Dakshin Kannada	P3
Kerala	Kozhikode	P3
	Malappuram	P3
	Thrissur	P3
	Kannur	P3
	Kollam	P3
	Alappuzha	P3
	Thiruvananthapuram	P3
Maharastra	Thane	P3
	Mumbai suburban	P3
	Ratnagiri	P3
	Raigarh	P3
	Sindhudurg	P3
Puducherry	Puducherry	P3
	Mahe	P3
Tamil Nadu	Viluppuram	P3
	Thanjavur	P3
	Tiruvallur	P3
	Kanyakumari	P3
Kerala	Kasargod	P4
	Ernakulam	P4
Total districts		72

Table 2: Cyclone hazard prone districts of India not touching (24) the coast based on frequency of total cyclones, severe cyclones; strength of actual/estimated wind, PMSS and PMP

State	Districts	Degree of Proneness
West Bengal	North 24 Pragana	P1
	Kolkata	P1
AP	Chittor	P2
West Bengal	Howrah	P2
Dadra & Nagar Haveli	Dadra & Nagar Haveli	P3
Odisha	Mayurbhanj	P3
	Cuttack	P3
	Nayagarh	P3
	Gajapati	P3
	Jajpur	P3
	Keonjhar	P3
West Bengal	Hoogly	P3
	Bardhaman	P3
Gujarat	Surendra Nagar	P4
	Kheda	P4
Kerala	Wayand	P4
	Palakkad	P4
	Kottayam	P4
	Idukki	P4
	Pathanamthita	P4
Odisha	Dhenkanal	P4
Tamil Nadu	Ariyalur	P4
	Tiruvannamalai	P4
	Sivaganga	P4
Total Districts		24

Table 3: Cyclone parameters for districts (touching coast) along east coast and Andaman and Nicobar (A and N) Islands

State	Districts	No. of severe Cyclones	Total No. of Cyclones	Wind Speed in knots	PMSS in metres	PMP in cm
West Bengal	South 24-Parganas	16	29	115	12	52
	Medinipur	10	22	115	13	56
Orissa	Balasore	5	28	75	11	60
	Kendrapara	6	17	140	8.5	60
	Bhadrak	4	17	65	9.5	60
	Jagatsinghpur	4	17	140	6.5	60
	Ganjam	5	11	100	4	48
	Puri	1	6	140	4	60
	Khordha	0	4	100	4	52
Andhra Pradesh	Nellore	8	18	110	4.5	60
	East Godavari	4	17	125	4.5	52
	Srikakulam	5	12	100	4	56
	Guntur	0	0	127	7.5	56
	Visakhapatnam	4	8	125	4	52
	Krishna	5	12	127	5.5	56
	West Godavari	3	6	127	5	52
	Prakasam	3	5	115	6	52
	Vizianagaram	1	3	94	4	52
Tamil Nadu	Pudukkottai	1	1	55	7	52
	Kanchipuram	8	13	55	3.5	68
	Cuddalore	4	6	90	3.5	68
	Tiruvarur	3	6	90	5.5	60
	Nagappattinam	3	10	90	4.5	68
	Chennai	0	0	95	3.5	52
	Viluppuram	3	3	77	3.5	68
	Ramanathapuram	1	2	55	12	48
	Thoothukudi	1	1	55	7	52
	Tirunelveli	3	3	55	7	48
	Thanjavur	1	2	90	5.5	48
	Tiruvallur	0	5	95	4	56
	Kanyakumari	0	0	45	3	40
Puducherry	Puducherry	3	3	77	3.5	68
	Karaikal	3	10	90	4.5	52
	Yanam	4	17	125	4.5	52
Andaman & Nicobar Islands	Andaman & Nicobar Islands	1	8	90	–	N/A
Total	35					

Table 4: Cyclone parameters for districts (touching coast) along west coast and Lakshadweep Islands

State	Districts	No. of severe Cyclones	Total No. of Cyclones	Wind Speed in knots	PMSS in metres	PMP in cm
Gujarat	Junagadh	4	9	90	3.5	84
	Kachchh	3	7	90	3.5	60
	Bhavnagar	3	5	90	4.5	56
	Jamnagar	1	2	90	3.5	72
	Porbandar	3	3	90	3.5	84
	Amreli	2	3	90	4	56
	Ahmedabad	1	1	90	4.5	60
	Anand	1	2	70	4.5	52
	Surat	0	0	45	4.5	88
	Navsari	0	1	70	4.5	88
	Valsad	0	0	45	5	104
	Bharuch	0	3	70	4.5	72
	Rajkot	2	4	90	3.5	72
	Vadodara	0	1	45	4.5	64
Daman & Diu	Daman	1	1	55	5	80
	Diu	4	9	90	3.5	80
Maharashtra	Thane	2	2	55	5	72
	Mumbai Suburban	1	1	55	5	95
	Ratnagiri	1	1	55	4	64
	Raigarh	0	1	55	5	72
	Sindhudurg	1	1	55	4	72
Goa	North Goa	0	0	55	4.5	64
	South Goa	0	0	55	4.5	64
Karnataka	Uttar Kannada	0	0	45	4.5	68
	Udupi	0	0	45	4.5	68
	Dakshin Kannada	0	0	45	4.5	92
Kerala	Kozhikode	1	1	45	4.5	60
	Malappuram	0	1	45	4.5	60
	Thrissur	0	1	45	4.5	52
	Kasargod	0	0	45	4	48
	Kannur	0	0	45	4	60
	Ernakulam	0	0	45	4	44
	Alappuzha	1	1	45	4	40
	Kollam	0	0	45	3.5	44
	Thiruvananthapuram	1	1	45	3	48
Lakshadweep	Lakshadweep	5	9	90	–	N/A
Puducherry	Mahe	1	1	55	4.5	60
Total No. of Stations	37					

Table 5: Cyclone parameters for districts of India not touching the coast, but within 100 km from the coast

State	Districts	No. of severe Cyclones	Total No. of Cyclones	Wind Speed in knots	PMSS in metres	PMP in cm
Dadra and Nagar Haveli	Dadra and Nagar Haveli	2	2	55	–	80
Gujarat	Surendra Nagar	2	2	55	0	56
	Kheda	0	0	45	0	52
Kerala	Wayanad	0	0	55	0	52
	Palakkad	0	1	55	0	52
	Kottayam	0	0	45	0	48
	Idukki	0	0	45	0	52
	Pathanamthitta	1	1	45	0	48
Tamil Nadu	Tiruvannamalai	0	2	55	0	40
	Ariyalur	0	4	45	0	52
	Sivaganga	0	3	55	0	40
AP	Chittoor	8	15	95	0	60
Orissa	Mayurbhanj	1	10	55	0	56
	Jajpur	0	2	65	0	60
	Keonjhar	0	5	45	0	52
	Dhenkanal	0	3	45	0	44
	Cuttack	1	4	140	0	52
	Nayagarh	1	7	65	0	52
	Gajapati	0	1	100	0	52
West Bengal	Hoogly	3	11	65	0	52
	Bardhaman	0	10	45	0	56
	Kolkata	12	23	115	0	52
	North 24 Parganas	11	23	115	0	52
	Howrah	12	23	115	0	50
Total No. of Stations	24					

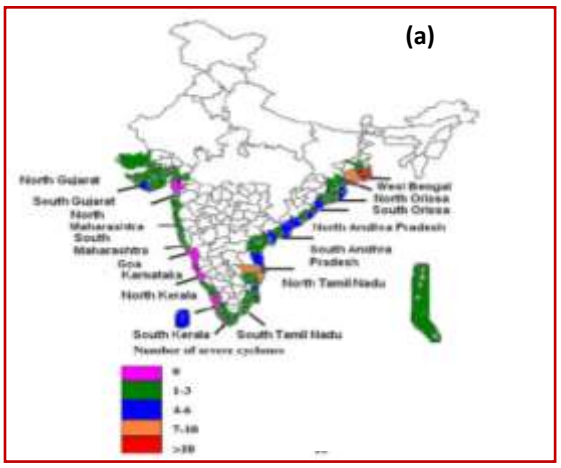

Fig. 2 (a): Number of Severe Cyclones (maximum sustained wind speed (MSW) of 48 knots or more) that affected coastal districts of India during 1891-2008

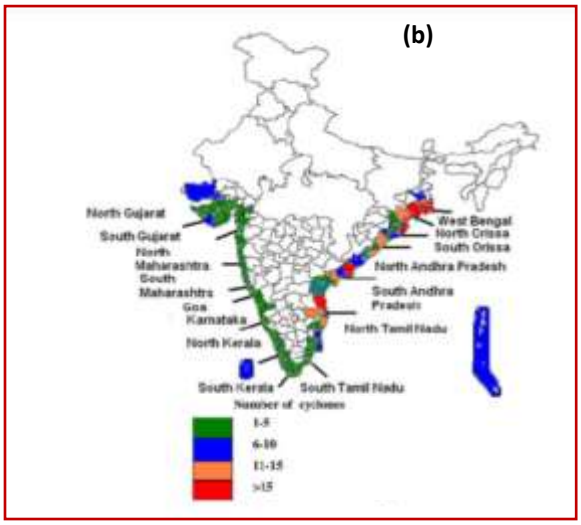

Fig. 2 (b): Number of Cyclones (MSW of 34 knots or more) that affected coastal districts of India during 1891-2008

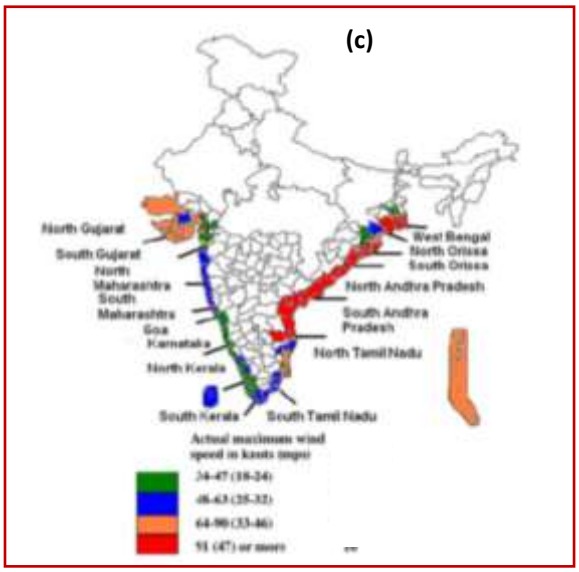

Fig.2 (c): Maximum / Estimated MSW (in mps) that affected coastal districts of India during 1891-2008

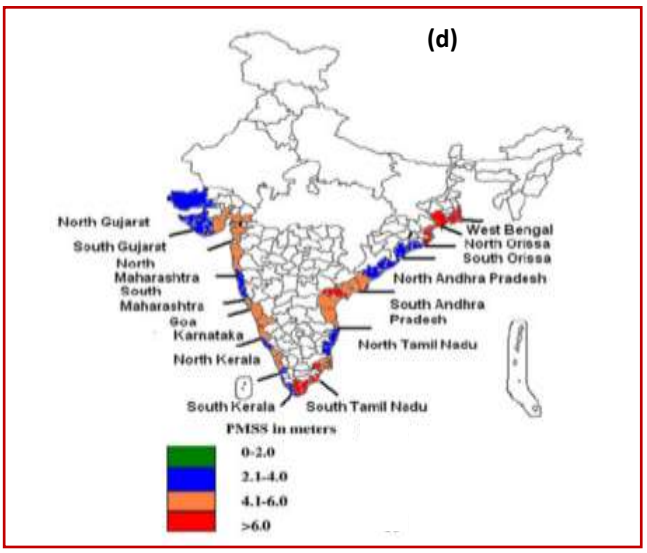

Fig.2 (d): Probable Maximum Storm Surge (in metres) that affected coastal districts of India during 1891-2008

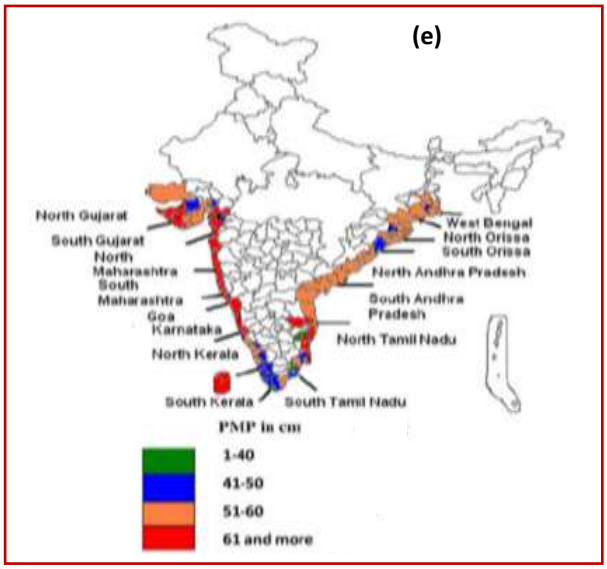

Fig.2 (e): Daily Probable Maximum Precipitation (in cm) that affected coastal districts of India during 1891-2008