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The Seasonal Climatology of Tropical Disturbances and Its Associated Tracks over the Bay of Bengal During 1891-2020

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Abstract: The Bay of Bengal (BoB) is the import basin where tropical cyclone has been forming frequently compared to global perspective. The number and frequency of cyclone over the BoB varies year to year. The recent climatology of tropical cyclone and its track and landfall is very important to minimize casualties and damages. A statistical attempt has been made to know the seasonal number of cyclones over the BoB during 1891-2020 using BMD and IMD cyclone eAtlas data and the most devastating cyclones' tracks of 1991, 1994, 2007, 2008, 2009 and 2020 are also drawn over the BoB. From the analysis it is found that the total number of cyclones formed over the BoB are 35, 123, 97 and 28 during pre-monsoon, monsoon, post-monsoon and winter seasons respectively whereas 58, 33, 103 and 26 for severe cyclonic storms respectively. The cyclone of all intensity over the BoB follows initially Westward/Northwestwards tracks, some of them re-curved and follows north/northeastwards tracks. Sometimes looping track is also found over the Bay of Bengal. It is also found that some cyclones have completed their journey in the BoB without landfall. This variation of cyclone makes the BoB basin more vulnerable and more challenging for forecasting of tropical cyclones.

Keywords: Cyclonic Disturbances, BOB, E-atlas, Track, Cyclone (CS & SCS) etc

1. Introduction

A tropical cyclone is a disturbance and it is a rapidly rotating storm system characterized by a low-pressure center, a closed low-level atmospheric circulation, strong winds, and a spiral arrangement of thunderstorms that produce heavy rain or squalls. Atmosphere and ocean are replete with inertial waves and intra-seasonal oscillations, which play a very important role in transferring energy and momentum [12]. TC forms frequently over 5° to 30° latitude from the equator [2]. A TC may path 300-400 miles on average per day and may pass up to 3000-miles before its death [net & 11]. Precondition of Tropical Cyclone genesis are - (i) > 60% Humidity at lower level (ii) SST > 27°C (iii) Lower level vorticity (iv) Co-riolise force effect at > 5° lat. and wind speed at least 62-88 km/hr. A series of low-pressure systems form over Bay of Bengal and move to W, NW, N, and NE direction across India, Bangladesh & Myanmar more [1, 5, 7, 8]. Bangladesh is a playground of different natural disasters of meteorological region [6]. Complex funneling shape of Bangladesh coast have made the weather system complicated here [3, 4, 9]. The landfall of the TCs brings a lot of devastating impact on the coastal regions especially in the eastern coast of India because of its shallow bathymetry, funnel shaped architecture of coast line, low-lying delta areas associated with large number of river basins and highly dense population along the coast [10, 13, 14]. So, It is important to know the long term variation of their frequencies and trend [14]. Most of the TC being formed in the southern Bay near Andaman Island during the month of April and May of pre-monsoon season and October to November of Post-monsoon season [3]. Total Cyclonic Disturbance is decreasing but increasing its intensity. Dissipated of cyclone is less at

monsoon, pre-monsoon, & post-monsoon respectively. Among recently crossed cyclones of Bangladesh & adjoining area the intensity of SIDR was more than Super Cyclone Amphan. It is found at land crossing time.

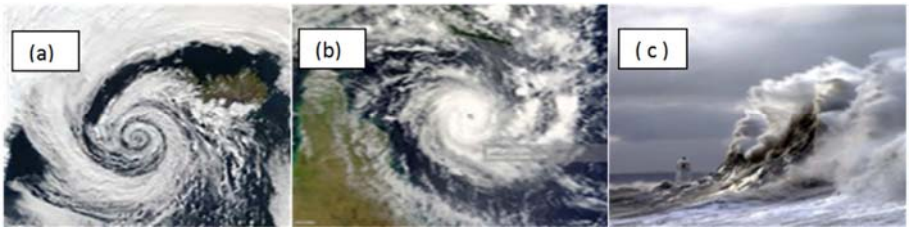

Figure 1. *(a-c): Cyclone images at sea region [15-17].*

2. Objectives

Due to Geographical location, BOB form frequently Cyclonic disturbance. Bangladesh is situated on the bank of head Bay and that's why the coastal people of Bangladesh suffered more. The objectives of this paper are:

(1) To observe the Tropical Disturbance (TD) over Bay Of Bengal (BOB) during 1891-2020
(2) To find out the intensity of Cyclone after its landfall.
(3) To observe the cyclone track over BOB
(4) To find out the seasonal variation of Tropical Disturbance

3. Data and Methodology

All of the data from 1891 to 2020 have been taken from BMD and RSMC in New Delhi. Cyclonic disturbance (CD), Depression (D), Cyclone (CS), Severe Cyclone (SCS) etc. events are counted. BMD has no earlier cyclone records. At this stage, few data from IMD have been included with BMD data for drawing graph & tracks Cyclones which recently (1990-2020) made landfall in Bangladesh Coast are counted for drawing track. For measuring intensity after landfall, there is no regular data in BMD, but a few data are available at achieves in RSMC. Available data of excel and ArcGIS has been used for analysis.

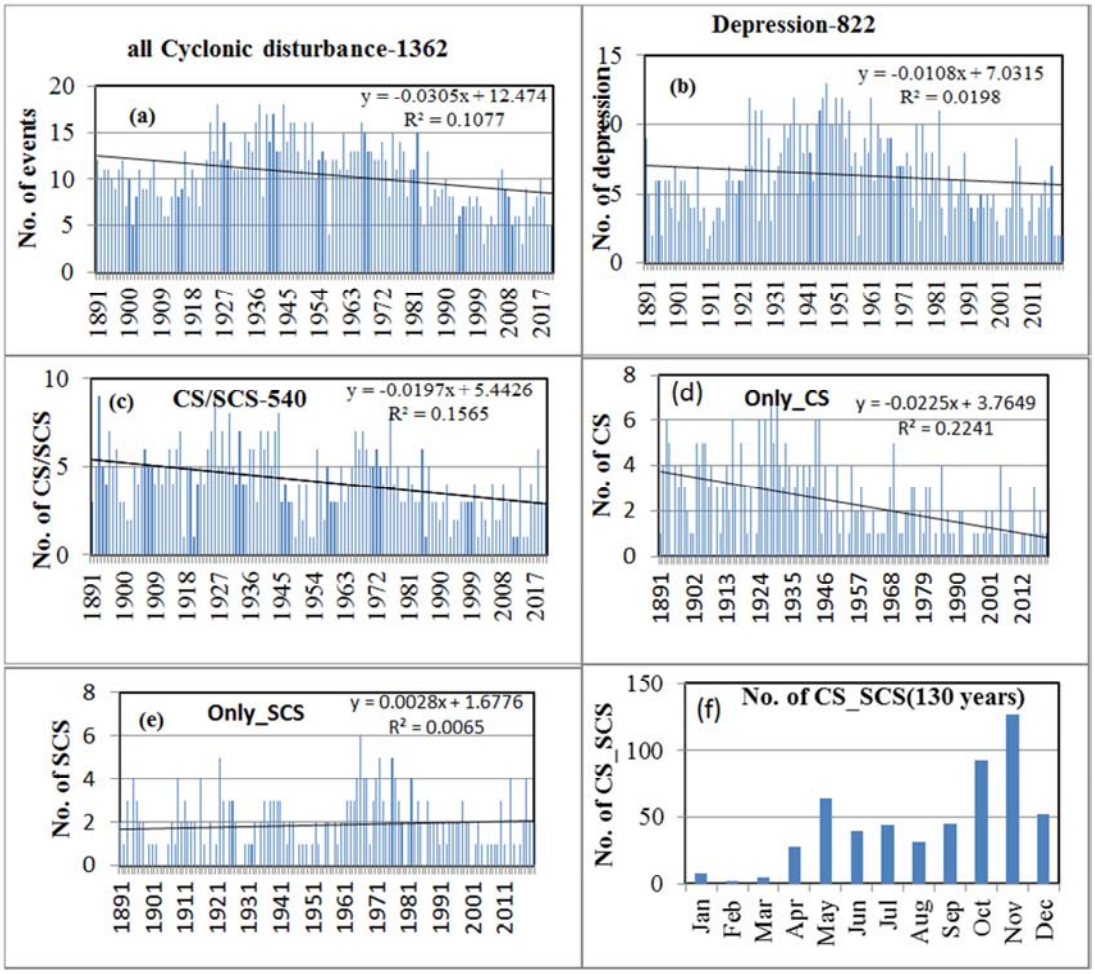

Figure 2. *(a-f): Trend analysis and Variationof Cyclonic Disturbance during 1891-2020.*

4. Result & Discussion

4.1. All Cyclonic Disturbance (CD) Variation and Trend Analysis of BOB During 1891-2020

Cyclonic disturbances variation during 1891-2020 are showed in figure 2 (a-f). Figure a shows total 1362 CD has occurred during 1891-2020 among them Depression (D) 822, Cyclone (CS-298)_Severe cyclone (SCS-242), and total CS & SCS are 540 which all are they showed decreasing trend. CS_SCS 1925-1945 and 1960-1980 was more and middle of diurnal year (1946-1956) was significantly less. After 1980 AD all of type Cyclone is decreased. At the last 30 years observing time, it shows slight increase due to last 5 years more cyclone. If we observed CS and SCS separately, CS found decreasing from 1946-1920 but SCS was more from 1956-1985 (30 years) and 2000--2010 SCS occurred less than previous years. When trend has been drawn, it is found CS is decreased but increased SCS slightly. When decoration of 130 years CS_SCS data according to month, November, October, May, September, June no of CS_SCS has found 127, 93, 64, 45, 44 respectively. On the opposite way, February, March, January, April, August are decreased formation respectively.

4.2. Seasonal Variation of Cyclonic Disturbances (CD) and Trend Analysis of BOB During 1891-2020

Seasonal variation of Cyclonic disturbances during 1891-2020 are showed in figure 3 (a-f). Figure –a, b and c represents the variation of monsoon season which indicates last 30 years CD has decreased. At Monsoon season total CS_SCS formation over BOB 161. Among 161, CS-128 and SCS -33 during 1891-2020. But last 30 years only 5 CS_SCS shows in Monsoon season which are June-1996, Sep-1997, Sep-PYARR-2005, July-KOMEN-2015, Sep-DAYE-2018. It also shows that the severity of Monsoon Cyclone is less. In winter trend shows cyclone during 1891-2020 is increase slightly but no. of CS & SCS are about same. Pre-monsoon and Post- monsoon trend are also about to same.

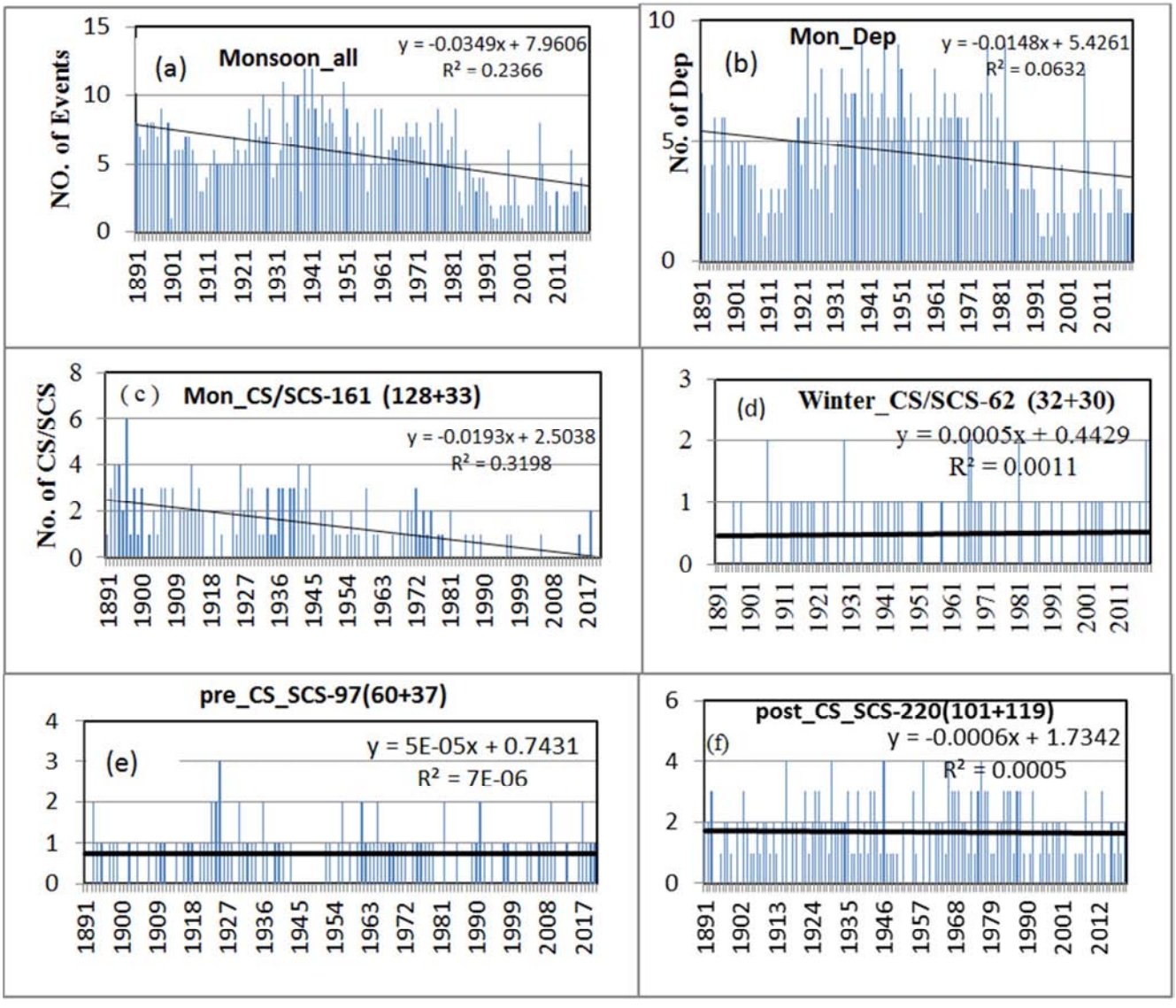

Figure 3. *(a-f): Seasonal Variation of CD and Trend Analysis of BOB during 1891-2020.*

4.3. Monthly and Seasonal CS and SCS in Numbers During 1891-2020 of BOB

Table 1. *Monthly CS and SCS in Numbers.*

Month	CS	SCS	Total
January	6	2	8
February	1	1	2
March	3	2	5
April	13	15	28
May	21	43	64
June	35	5	40
July	36	8	44
August	28	4	32
September	29	16	75
October	50	43	93
November	51	76	127
December	25	27	52
Total	298	242	540

Table 2. *Seasonal CS and SCS in Numbers.*

Season	CS	SCS	Total
Pre-monsoon	60	37	97
Monsoon	128	33	161
Post-monsoon	101	119	220
Winter	32	30	62
Total	321	219	540

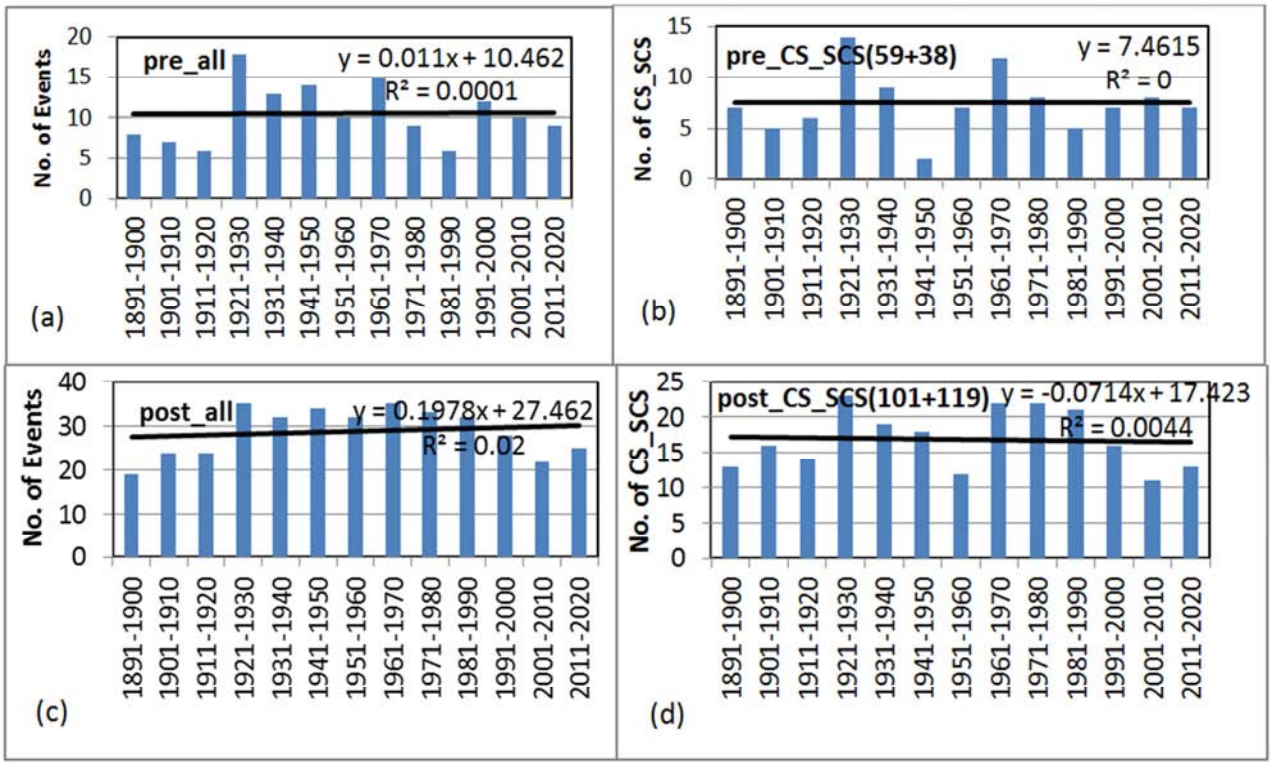

Figure 4. *(a-d): Decadal Year variation of CD during 1891-2020.*

From table 1 –It observe that highest number of severity in November month where total number of severe cyclones and cyclones are 76,51; October are 43,50 and May 43,21 respectively. It is has been seen that very less cyclone formed at BOB in February. Total Cs and SCS are 540 in the duration of 1891 to 2020 of BOB.

From table 2- It also get that highest number of CS are Monsoon season (128) but highest number of SCS are formed at post monsoon season. It also has been seen that the severity of post monsoon season is more that number of SCSis greater than number of CS. But in winter season CS (32) and SCS (130) about to same the duration of selected 30 years.

4.4. Decadal Year Variation of CD During 1891-2020

Decadal variation of Cyclonic disturbances during 1891-2020 are showed in figure 4 (a-d). During pre-monsoon season all of the disturbances trend are about to same even CS and SCS also shows same trend but during post monsoon all of the disturbances is increased but CS and SCS is decreased at the time of 1891 to 2020.

4.5. Total Formation vs. Dissipated over BOB (Not Land Basin CS) from 1891-2020

Seasonal variation of Cyclone and Severe Cyclone formation and dissipated over BOB (except land basin CS) during 1891-2020 are showed in figure 5 (a-b). From figure –"a", it is found that the more number of CS_SCS is formed at BOB during post monsoon season and Dissipated also in Post-monsoon season are more. The dissipated number of CS_SCS in monsoon are very less (2) but number of formation CS_SCS are not so less. Figure "b" shows that rate of CS_SCS is very high in winter season (39%), secondly in Post-monsoon (16%), 3rd ly pre-monsoon (11%). Rate of dissipated of CS_SCS shows also lowest in Monsoon season.

4.6. Number of Cyclonic Disturbance over BOB During and Monthly Rate of Landfall over Bangladesh and Adjoining Area During 1990-2020

Seasonal variation of Cyclonic disturbances during 1891-2020 are showed in figure 6 (a-b). Figure –"a" shows among all of the CD over BOB, Depression & Deep depression formation are more secondly CS, 3rd ly SCS, and SUCS respectively. (From Graph LD & LDD will be Cut off) for August SCS1 more, all Graph will be draw again).

4.7. Track of Recently Devastating 6 Cyclones of Bangladesh

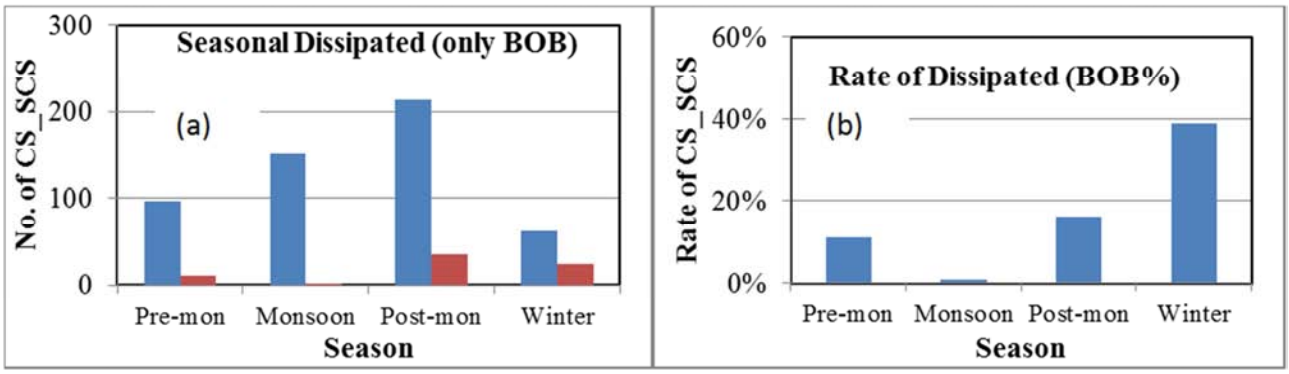

Figure 5. *(a-b): Total formation vs. dissipated over BOB during 1891-2020.*

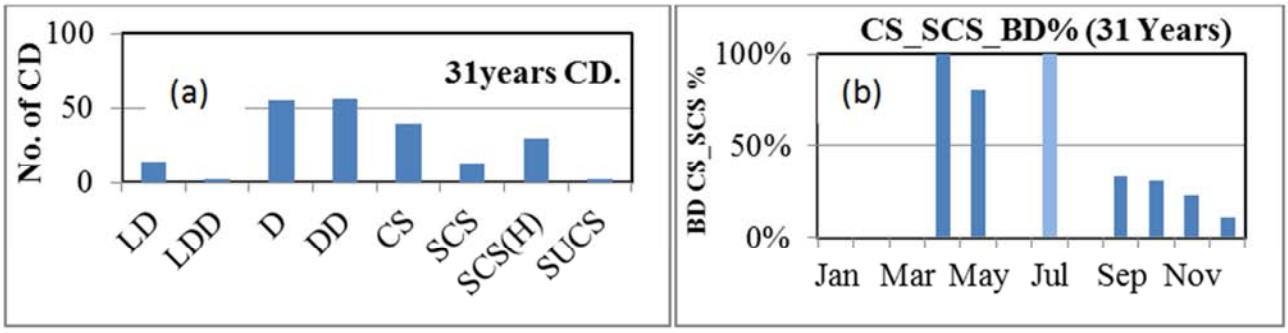

Figure 6. *(a-b): No. of CD and monthly rate of landfall over BD and adj. during 1990-2020.*

Table 3. *Very significant and recordable cyclones of Bangladesh.*

April /May	Oct/ Nov
May-1961	Nov-1876
May-1985	Nov-1966
May &Sep-1997	Nov &Oct-1970
May-2009	Nov-1974
May-2020	Nov-1986
April-1991 (29 Apr)	Nov-1988
April-1994 (29 Apr)	Nov-2007
	Oct-1960 (28 Oct)
	Sep-1919

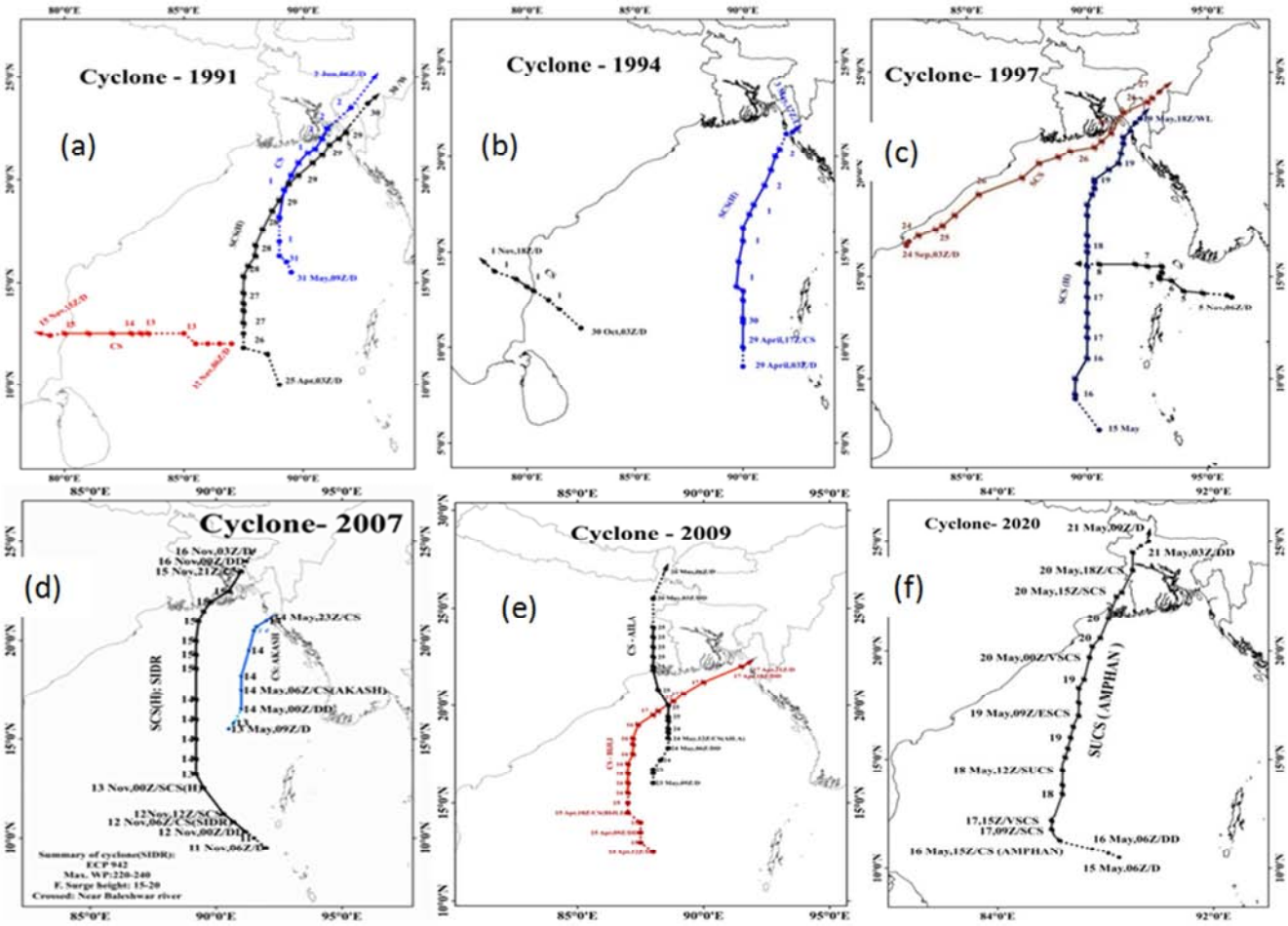

Figure 7. *(a-f): Track of Recently devastating 6 cyclones of Bangladesh.*

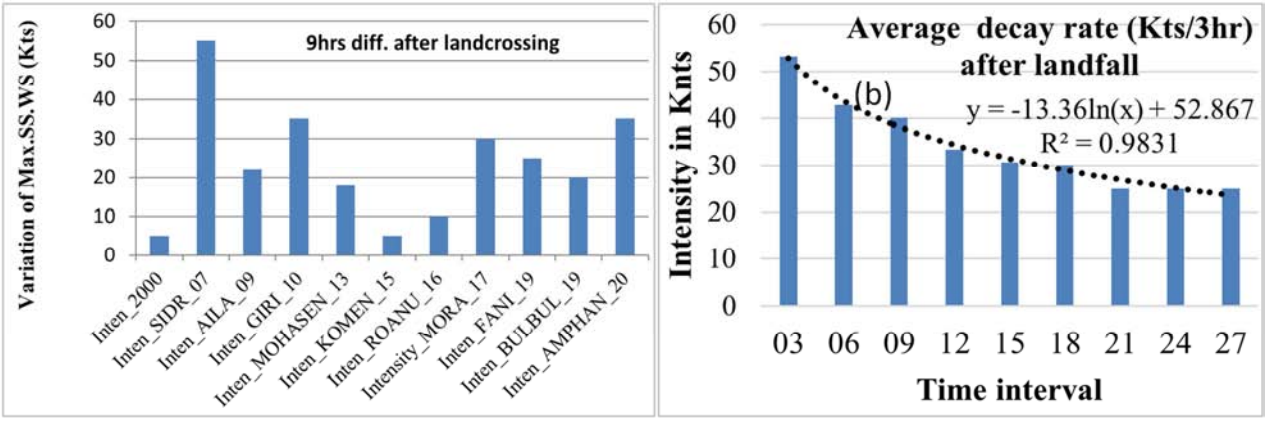

Figure 8. *(a-b): Decay feature of 11 cyclones after landfall of Bangladesh & adjoining area.*

Track of Recently devastating 6 cyclones of Bangladesh which are showed in fogure 7 (a-f). They are 29 April-1991, 29 April-1994, 15 May & 23 September-1997, 15 November-2007 (SIDR), 24 May-2009 (AILA), 21 May-2020 (Amphan-SUCS). Every cyclone has our casuality and loser of our wealth.

The data shows most of the recordable cyclone of Bangladesh landfall in Pre-monsoon season of May & late April and Post-monsoon season of November & late October.

4.8. Decay Feature of 11 Cyclones After Landfall of Bangladesh & Adjoining Area

Decay features are 11 cyclones after landfall of Bangladesh & adjoining area which are showed in figure 8 (a-b). Figure –"a" shows after 9 hrs difference windspeed decay of 11 cyclones. Among 11 cyclones SIDR speed decay was more (55 Kts/9hrs), secondly AMPHAN and GIRI (35 Kts/9hrs)), 3rd ly MORA, 4th ly decay speed FANI. But Lowest Wind speed lost after 9 hrs was

KOMEN and 2000 Cyclone (5 Kts/9hrs), 2nd ly lowest ROANU. Figure –"b" indicates average decay rate after landfall of 11 cyclonesof figure –"a" from their 2nd crossing time step (every 3 hrs average of all cyclones). Decay rate of Bangladesh and adjoining coast cyclone is about 13.4 Kts/3hrs.

4.9. Criticalloop Path, Track of CS_SCS, and Land Basin CS vs. SCS Surrounding of BOB During 1891-2020

Critical loop path of Cyclones and all of CS and SCS Tracks during 1891-2020 are showed in figure 9 (a-f). Cyclone Track of November in 1996 (figure "a" black color) shows very critical Path remaining at BOB. 6 December 2013 (figure "b"magenta) shows also different path. Figure "c"-2015 (KOMEN), figure "d" (September-1976) path also critical. At the same time different style loop path which made loop from BOB to others sea is different that are figure "e" (Nov-1977), If all the track of BOB have been drawn at a place, which will shows like figure –"f" (1891-2020).

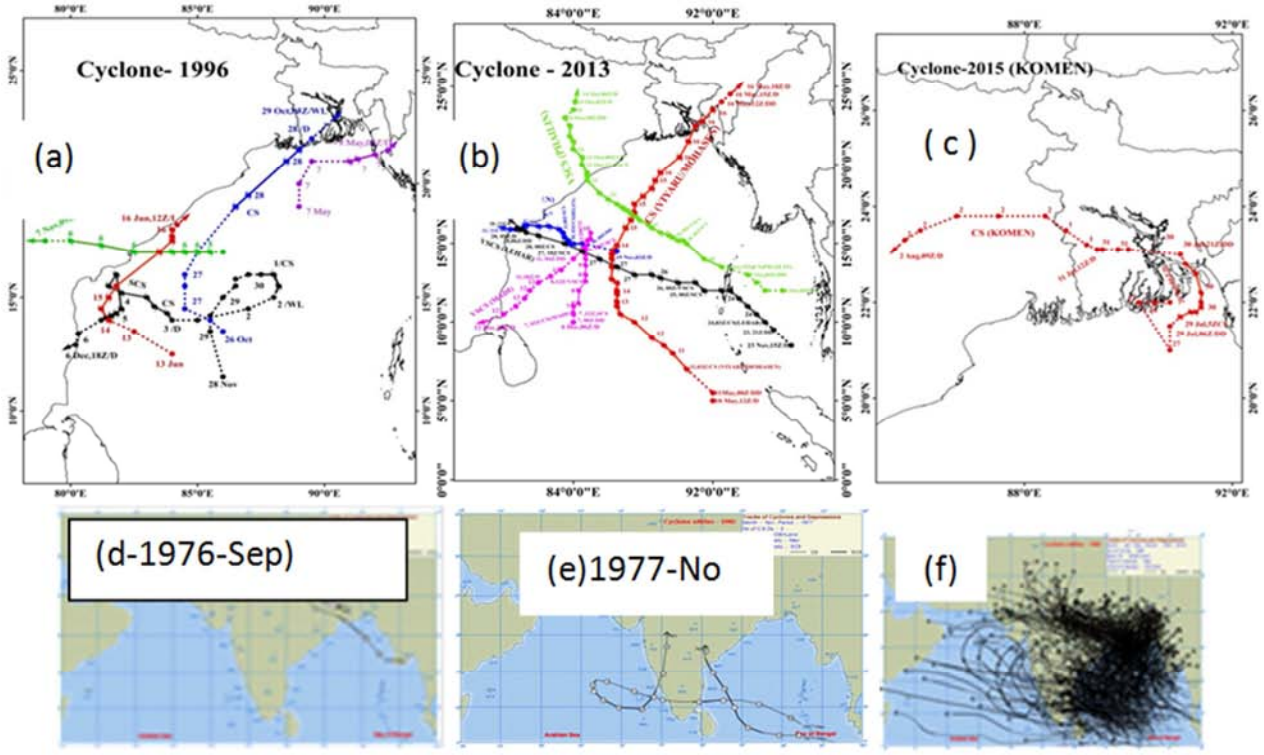

Figure 9. *(a-j): Critical loop path, Tracks, and CS_ SCS track during 1891-2020.*

4.10. Uncommon Movement Track (Without Loop) of BOB and Land Basin CS and SCS

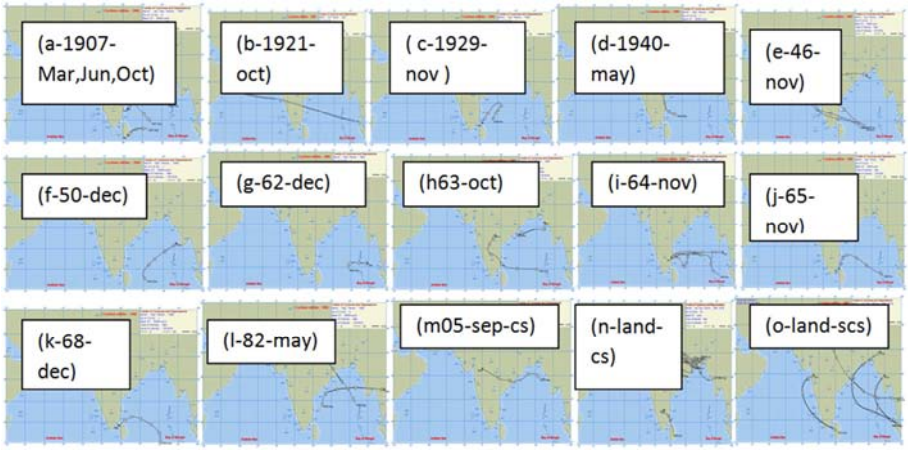

Figure 10. *(a-o): Track of uncommon movement of CS_SCS.*

Without looping cyclone there are also some uncommon movement track which showed in figure 10 (a-o). Among them a few cyclones movement are southward and a few are eastward. Southward movement are figure a (Mar, Jun, Oct-1907), figure c (Nov-1929), figure j (Nov-1965), figure k (Dec-1968), figure m (Sep-2005) and Eastward movement

are figure d (May-1940), figure e (Nov-1946), figure f (Dec-1950), figure g (Dec-1962), figure h (Oct-1963), figure I (Nov (1964), figure l (May-1982). Figure "n" and figure "o" are land basin cyclone of surrounding area of BOB. Figure "n" shows land basin CS (10) which are all only Cyclone and figure "o" show land basin SCS (4) but when it merge at sea, it carry moisture and be severe which land fall shows at another region.

5. Conclusion

The paper shows TD Trend, Separately CS & SCS trend, Critical loop path, Monsoon severity, land basin CS & SCS, Devastating cyclones whose are landfall of Bangladesh, after land fall their decay rate etc with respect BOB & surrounding area. Total Cyclonic disturbance (CD) like Depression (D), Cyclone (CS) is decreasing but the Severe Cyclone (SCS) are increasing slightly. During 1925-1945 and 1960-1980, CS & SCS were more but in 1946-1956 this was very less. During monsoon season of 1891-2020, the no. of CS & SCS over BOB was 161, among them 128 (CS), 33 (SCS). During pre-monsoon season most of the cyclone tracked N/NE wards, following landfall over Myanmar & Bangladesh coasts. During monsoon most of the cyclonic disturbances moved westwards and their tracks were long than other seasons. Sometime cyclone may show their critical track which direction detect is very difficult at previous time. Total no. of cyclonic disturbances is found to increase during 1891-1990, but it is found to decrease slightly afterwards. Dissipation rate of CDs over BOB is very less in monsoon season. The decay rate of recent CSs after landfall over Bangladesh coast is about 13.4 kts/3 hr.

Full Meaning

CD	Cyclonic Disturbances
CS	Only Cyclone
SCS	Only Severe Cyclone & above intensity
D	Depression
DD	Deep Depression
BOB	Bay of Bengal
Cyclone	Only Cyclone

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References

[1] Kh. Hafizur Rahman, Neeru Jaiswal1, C. M. Kishtawal, Md. Bazlur Rashid and S. M. Quamrul Hassan, Prediction of the Tropical Cyclogenesis over the Bay of Bengal using the OSCAT derived surface wind fields. The Atmosphere-ISSN 2311-486X, vol-5, no-1, July-2015, pp-1-8.

[2] Mohammad Abdur Rahman Khan, Dr. C. M. Kishtawal, Md. Rashaduzzaman, and Md. SanaulHoque Mondal, Development of Emperical Track Prediction for Landfalling Tropical Cyclones over Bangladesh and east Indian coast line. The Atmosphere-ISSN 2311-486X, vol-5, no-1, July-2015, pp-36-46.

[3] MehrunNessa and Suraiya Begum, Satellite Observation & Intensity Estimation of Tropical Cyclone Using D'Vorak Algorithm. The Atmosphere-ISSN 2311-486X, vol-5, no-1, July-2015, pp-130-134.

[4] Md. Abdur Rahman, P. C. Joshi and B. M. Rao. Tropical Cyclone Track Prediction Using INSAT-VHRR Data. DEW-DROP-ISSN 2414 6056, March-2016, Vol-2, No-1. Pp-53-59. (a Scientific Journal of Meteorology and Geo-Physics).

[5] M. A. K. Mallik, M. A. M. Chowdhury, Shamsuddin Ahmed, M. N. Ahsan, Md. A. E. Akhter, S. M. Q. Hassan, Md. Omar Faruk, A Study of the Trend, Track and Frequency of Monsoon Depression over the Bay of Bengal. DEW-DROP-ISSN 2414 6056, March-2016, Vol-2, No.-1, pp-31-36.

[6] Samarendra Karmaker, Dewan Abdul Quadir and Md. Abdul Mannan. Trends in maximum temperature and thunderstorms, their correlation and impacts on the livelihood of Bangladesh**.** The Atmosphere-ISSN 2311-486X, vol-5, no-1, July-2015, pp-113-129.

[7] Md. A. E. Akhter, Md. M Alam and M. A. K. Mallik, SIMULATION OF THE STRUCTURE AND TRUCK OF THE TROPICAL CYCLONE RASHMI USING NUMERICAL MODELS. DEW-DROP-ISSN 2414 6056, March-2016, Vol-2, No.-1, pp-60-74.

[8] P. V. S. Raju · Jayaraman Potty · U. C. Mohanty, Prediction of severe tropical cyclones over the Bay of Bengal during 2007–2010 using high-resolution mesoscale model, Received: 8 October 2010 / Accepted: 2 July 2011 / Published online: 17 August 2011 Springer Science+Business Media B. V. 2011, Nat Hazards (2012) 63: 1361–1374 DOI 10.1007/s11069-011-9918-1.

[9] Siddiki, UbaydurRahaman, Islam, Md. Nurul and Ansari, Mohammad Nayeem Aziz, Cyclonic track analysis using GIS over the Bay of Bengal, Int. Journal of Applied Sciences and Engineering Research, Vol. 1, Issue 5, 2012 www.ijaser.com © 2012 by the authors – Licensee IJASER-Under Creative Commons License 3.0 editorial@ijaser.com Research article, ISSN 2277–9442, DOI: 10.6088/ijaser.0020101070.

[10] Shyama Mohanty, Raghu Nadimpalli, Krishna K Osuri, Sujata Pattanayak, U C Mohanty and SouravSil, Role of Sea Surface Temperature in Modulating Life Cycle of Tropical Cyclones over Bay of Bengal, Tropical Cyclone Research and Review, Vol-8, No-2, pp 68-83.

[11] AbhijitMitra, JoystuDutta, AnkitaMitra and TarunThakur, AmphanSupercyclone: A death knell for Indian Sundarbans, eJournal of Applied Forest Ecology (eJAFE), Vol. 8, No. 1 (2020) 41-48 Available online at www.ejafe.com ISSN: 2347-4009, Research Gate, Article june-20,: https://www.researchgate.net/publication/342477802.

[12] Sridhar Balasubramanian and Vamsi K Chalamalla, Super Cyclone Amphan: A Dynamical Case Study, Research Gate, Preprint July 2020, arXiv: 2007.02982v1 [physics.ao-ph] 6 Jul 2020, https://www.researchgate.net/publication/342763311.

[13] Muhammad Al-Amin Hoque, Stuart Phinn, Chris Roelfsema, A systematic review of tropical cyclone disaster management research using remote sensing and spatial analysis, ELSEVIER, Ocean & Coastal Management 146 (2017) 109e120.

[14] SamarendraKarmaker, Trends In The Annual Frequency Of Cyclonic Disturbances And Storms In The Bay of Bengal, south asian association for regional cooperation (SAARC), proceedings of SAARC seminar on climate variability in the south Asian region and its impacts, 10-12 December 2002.

[15] https://www.shutterstock.com/image-photo/super-cyclonic-storm-amphan-currently-very-1734314534.

[16] https://www.gettyimages.com/photos/cyclone?phrase=cyclone&sort=mostpopular.

[17] https://weheartit.com/entry/278263605?context_page=6&context_set=81676047-lighthouse&context_type=collection.