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Historical Trend of Cyclone over the Bay of Bengal and People's Perception about Coping with Cyclone in Kakdwip Block of South 24 Parganas, West Bengal, India

Chandra Shekhar Sarkar[a], Aritra Chakraborty[b]

[a]Research Scholar, Department of Geography, Presidency University, Kolkata, India
[b]Assistant Professor, Department of Geography, Presidency University, Kolkata, India

Abstract

Climate change contributes to a rise in the magnitude and frequency of cyclones, which can negatively impact human society. People's awareness and preparedness are very crucial to reduced damage caused by cyclones. The present study delineated the cyclone trend over the Bay of Bengal (BoB) with special reference to the impact of major cyclones in West Bengal and explored the indigenous local traditional coping strategies to cyclone in Kakdwip block of South 24 Parganas District in West Bengal. A total of 110 respondents were selected through random sampling and data were collected using a primary survey. The result of the study highlights that the trend of yearly cyclone frequency over the Bay of Bengal from 1891 to 2019 has increased, but the severe cyclone frequency trend has slightly decreased. The most destructive cyclone on the eastern coast of India is Odisha super cyclone (1999). Cyclone AILA and AMPHAN both caused tremendous damage to West Bengal in the last three decades. The findings indicated that before the cyclone, the local people have taken various coping measures such as they repaired their house (33.6%), used of box for storing valuable assets (70.9%), temporarily migrated to a safe place (25.5%), took livestock to a safe place (30.9%), sold domestic animals (11.8%), stored dry food and water (76.4%) and saved money (78.2%). The result of the study also revealed that the local people have taken various coping strategies during cyclone like preventing strong support for outside door and windows (85.5%), switching off the electrical mains in the house (94.5%), reduced the consumption of meal (33.6%), listening radio for the weather update (81.1%) and passing the information to neighborhoods. Although, the Government has taken various measures to support the local people to cope with cyclones, more effective measures need to be followed to cope with cyclone in the block.

Keywords: Odisha super cyclone, AILA, AMPHAN, Bay of Bengal, severe cyclonic storm, coping strategies.

1. Introduction

Climate change contributes to a rise in the occurrence of extreme climatic disasters like heat waves, cold waves, thunderstorms, floods and cyclones. Climatic disasters are not only destroying the balance of the natural ecosystem but also negatively impact human life and significantly impede the progress towards sustainable development. The tropical cyclone is a major weather phenomenon over the Bay of Bengal (BoB) and almost 80% of cyclones of the North Indian Ocean form in the Bay of Bengal

(BoB). More than five tropical cyclones form every year in the Bay of Bengal (BoB), of which about two may reach the severe cyclonic stage. Most of the tropical cyclones of the BoB develop in the Pre-Monsoon (March-May) and Post-Monsoon time (October-December). There are three elements like high-speed wind, storm surge and massive rainfall associated with cyclones which cause immense human death and property loss, mainly in the coastal part of India and Bangladesh. According to Indian Meteorological Department's report, nearly 1213 cyclonic disturbances, 522 cyclones and 234 severe cyclones have been observed in the last 129 years over the Bay of Bengal. However, the devastating cyclones have increased in the last decade compared to past; cyclone AILA (2009), PHAILIN (2013), HUDHUD (2014), TITLI (2018), FANI (2018), BULBUL (2019) and AMPHAN (2020) are particularly significant in this regard. Lack of early warning, disaster management, coping strategies and preparedness would contribute to high vulnerability (Sahoo et al, 2016). People's knowledge about cope with disasters is a vital aspect to minimize damage. There are two types of disaster management include structural and non-structural measures; both are very useful management of cyclones. The structural measures contain the construction of cyclone shelters, roads, culverts, bridges, canals, river embankments, communication and power transmission systems etc. The non-structural measures are early warning, management of coastal regions, awareness programs and capacity building and disaster risk management.

The literature of the study is divided into two categories. The first group of literature relates to the cyclone over the Bay of Bengal and the second group of literature discusses people's knowledge about coping with cyclone. Many articles helped in understanding the concept, trend, impact and significance of tropical cyclone. O. P. Singh (Singh et al, 2000) attempted a study on changes in the tropical cyclone's frequency over the Arabian Sea and the Bay of Bengal from 1877 to 1999. S. Raghavan and S. Rajesh (Raghavan & Rajesh, 2003) made an important study on the trends of tropical cyclone effect in Andhra Pradesh. O. P. Singh (Singh, 2007) also conducted an important study on trends of severe cyclones over the Bay of Bengal. Shishir K. Dube (Dube, 2012) highlighted the storm surge forecast in the Bay of Bengal. C. V. Srinivas (Srinivas et al, 2013) made a study on predictions of cyclone over the Bay of Bengal applying ARW model. Sunando Bandyopadhyay (Bandyopadhyay et al, 2018) did an important study on cyclonic storm in Bangladesh, West Bengal and Odisha from 1877 to 2016. Manoranjan Mishra (Mishra et al, 2020) attempted to analyze the trend of cyclone activity in the Odisha coast in India. Satyajit Dhara and Ashis Kr. Paul (Dhara and Paul, 2016) attempted to analysis the impact of major cyclone in Kakdwip block of South 24 Parganas district. The significant study work on people's perception about coping with cyclone has been carried out by various scholars like Bishawjit Mallick (Mallick et al, 2009) investigated the activity and responses of people during cyclone Sidr at Baniasanta union of Bangladesh. Pramila Nandi and Dr. Malay Mukhopadhyay (Nandi and Mukhopadhyay, 2011) conducted a study on the perception of the people about Kalbaiskahi or Nor'wester in Santiniketan of West Bengal. Philip L. Chaney (Chaney et al, 2013) makes a comprehensive study on household understanding on factors that affect the adoption for tornadoes in DeKalb County of Alabama. Cindy Woods (Woods et al, 2014) examined the knowledge of people who lived through Cyclone Yasi using primary survey data. Zakia Sultana and Bishawjit Mallick (Sultana and Mallick, 2015) also conducted a study on adaptation plans after the cyclone in southwest coastal area Bangladesh based on a primary survey of 145 respondents. Joydeb Garai (Garai, 2016) attempted to examine the local coping strategies of cyclone in the southwestern coastal area of Bangladesh by using qualitative methods. A. D. Magee (Magee, 2016) discussed the tropical cyclone

opinions, effects and adaptation in the Southwest Pacific region based on a questionnaire survey of 130 participants from urban parts of Fiji, Vanuatu and Tonga. Anushka Sandanam (Sandanam et al, 2018) also conducted an in-depth study on perceptions of cyclone preparedness in the Wet Tropics region of Australia.

2. Objectives of the Study

- To study the previous historical trend of the cyclonic storm and severe cyclonic storms over the Bay of Bengal from 1891 to 2019.
- To identify the major cyclones in the eastern coastal states of India in the last thirty years.
- To analyse the impact of major cyclones in West Bengal from 1990 to 2020.
- To know the local people's perception about coping with cyclone in the Kakdwip block of South 24 Parganas district.

3. Materials and Methodology

3.1 Study area

Kakdwip block of the South 24 Parganas district is an important part of the lower Gangetic delta and is located at the banks of the Hooghly river. The latitudinal extension of the block is from 21º50'15" N to 22º12'28" N and the longitudinal extension is from 88º7'26''E to 88º29'28''E and the total area is about 252.7 square kilometres as per the 2011 census. There are 11 gram-panchayats, 39 mouzas and 39 villages in the block. The total population of the block is 281963, population density is 1116 and the total male and female population are 144120 and 137843 respectively. According to the 2011 census, there are 21.15% of people are the main workers, 14.55% of people are marginal workers and 64.30% of people are non-workers. There is 462.55 km length of the surface road, 18 ferry services, 8 bus routes in the block and the nearest railway station is Kakdwip, which is 95 km away from Kolkata.

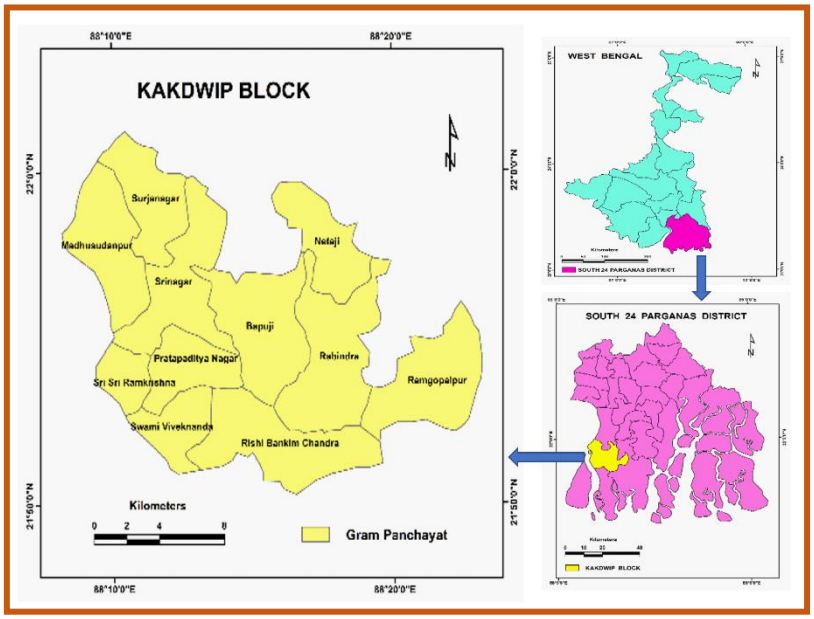

Figure 1: Location map

3.2 Data collection

3.2.1 Secondary data collection

The yearly severe cyclone frequency and Pre-Monsoon and Post-Monsoon severe cyclone frequency data of the previous 129 years for a period of 1891 to 2019 over the Bay of Bengal were collected from the Indian Metrological Department website (www.imd.gov.in). The major cyclone data of eastern coastal states in India were collected from the RSMC cyclone report (www.rsmcnewdelhi.imd.gov.in) and damage data of AMPHAN cyclone West Bengal was collected from the JRNA report on cyclone AMPHAN, 2020.

3.2.2 Primary data collection

A primary survey was conducted in the Kakdwip block of the South 24 Parganas district. In each gram panchayat, 10 respondents were selected randomly for the questionnaire survey, thereby the number of respondents for this study was 110. Mainly low-income people of the gram panchayats were selected for the study. Out of 110 respondents, there were 65 farmers, 30 fishermen, 10 small businessmen and 5 daily labourers. Consultation with local institutions personnel (BDO and panchayat's Pradhan) were also done.

3.3 Data analysis

Time series and trend analysis of cyclones were done by using Microsoft excel. Statistical analyses such as descriptive analysis was used in primary data analysis. Moreover, the thematic maps were prepared by using ArcMap version 10.3.

4. Result and Discussion

4.1 Historical trend of cyclone over the Bay of Bengal

A cyclone is a large-scale air mass and inward spiraling winds that rotate around a zone of low pressure. As cyclones form in the region between the tropic of Cancer and Capricorn, they are called tropical cyclones. One of the best examples of a tropical cyclone is the cyclone over the Bay of Bengal. Cyclonic disturbances are classified depending upon the wind speed. There are seven types of cyclonic disturbances; categories of the cyclonic storm are as follows-

Table 1: Categories of the tropical cyclone in the North Indian Ocean

Sl. No	Category	Wind speed
1	Low Pressure (L)	<17 knots (31 km per hour)
2	Depression (D)	17-27 knots (31-51 km per hour)
3	Deep Depression (DD)	28-33knots (52-61 km per hour)
4	Cyclonic Storm (CS)	34-47 knots (62-88 km per hour)
5	Severe Cyclonic Storm (SCS)	48-63 knots (89-118 km per hour)
6	Very Severe Cyclonic Storm (VSCS)	64-119 knots (119-221 km per hour)
7	Super Cyclonic Storm (SuCS)	>120 knots (> 222 km per hour)

Source: Indian Meteorological Department

In the last 129 years from 1891 to 2019, there are 1213 cyclonic disturbances, 522 cyclones and 234 severe cyclonic storms formed over the Bay of Bengal. The historical trend of cyclone over the Bay of Bengal from 1891 to 2019 has been discussed in three-part as year's trend of annual cyclone

frequency over the Bay of Bengal, annual severe cyclone frequency over the Bay of Bengal and five years frequency of Pre-Monsoon and Post-Monsoon severe cyclone over the Bay of Bengal.

4.1.1 Previous 129 years' trend of annual cyclone frequency (wind speed: 34-47 kt/hr.) over the Bay of Bengal (1891 to 2019)

Figure 2 shows the previous 129 years' annual frequency trend of the cyclonic storm (wind speed: 34-47 kt/hr.) over the Bay of Bengal. There is a total of 522 cyclones formed over the Bay of Bengal (BoB) in the period and an average of four cyclones in each year.

The highest number of cyclones formed in 1893 (9) followed by 1930 and 1967 (8). Yearly 7 cyclones have been found in the years 1896, 1916, 1925, 1926, 1928, 1933, 1941, 1966, 1968 and 1976. Yearly 6 cyclones have been identified in the years 1898, 1906, 1913, 1915, 1924, 1937, 1940, 1955, 1969

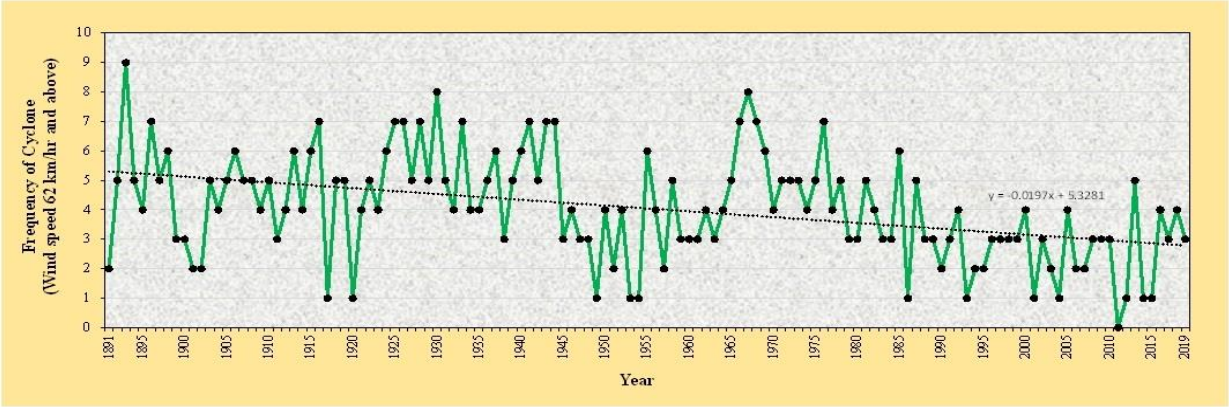

Figure 2: Annual cyclone frequency over Bay of Bengal from 1891 to 2019

and 1985. In addition, yearly 5 cyclones have been observed in the years of 1892, 1894, 1897, 1903, 1905, 1907, 1908, 1910, 1918, 1919, 1922, 1927, 1929, 1931, 1936, 1939, 1942, 1958, 1965, 1971, 1972, 1973, 1975, 1978, 1981, 1987 and 2013. Yearly 4 cyclones have been found in the years of 1995, 1904, 1909, 1912, 1914, 1921, 1923, 1932, 1934, 1935, 1946, 1950, 1952, 1956, 1962, 1964, 1970, 1974, 1977, 1982, 1992, 2000, 2005, 2016 and 2018. Besides, yearly 2 to 3 cyclones have been identified in the years of 1891, 1899, 1901, 1902, 1903, 1911, 1938, 1945, 1947, 1948, 1951, 1957, 1959, 1960, 1961, 1963, 1979, 1980, 1983, 1984, 1988, 1989, 1990, 1991, 1994, 1995, 1996, 1997, 1998, 1999, 2002, 2003, 2006, 2007, 2008, 2009, 2010 and 2019. The number of years in which only one cyclone has formed over the Bay of Bengal is 12; these are 1917, 1920, 1949, 1953, 1954, 1986, 193, 2001, 2004, 2012, 2014 and 2015. In 2011 alone there was not a single cyclone formed over the Bay of Bengal. Although, figure 2 represents the overall slight declining trend of annual cyclone frequency in the time period of 1891 to 2019 over the Bay of Bengal.

4.1.2 Previous 129 years' trend of annual severe cyclone frequency over the Bay of Bengal (1891 to 2019)

Figure 3 represents the annual frequency distribution and trend of the severe cyclonic storm for the period of 1891 to 2019. There is a total of 234 severe cyclones that occurred in this time period that means on average about two severe cyclones every year. In the year 1966, the maximum number of severe cyclones occurred (6) and followed by the year1922 (5) and 1976 (5). Yearly 4 severe cyclones

have been found in the years 1895, 1909, 1916, 1965, 1967, 1968, 1971, 1977,1982 and 2013 (Table 2). In addition, yearly 3 severe cyclones have been marked in the years of 1893, 1896, 1923, 1925, 1926, 1936, 1938, 1939, 1940, 1941, 1962, 1963, 1964, 1970, 1973, 1978, 1984, 1987, 1998, 2010 and 2018. Yearly two severe cyclonic storms have seen in the years of 1897, 1898, 1907, 1910, 1911, 1913, 1914, 1919, 1927, 1933, 1937, 1942, 1944, 1945, 1952, 1955, 1956, 1958, 1960, 1961, 1974, 1975, 1979, 1983, 1985, 1988, 1989, 1990, 1992, 994, 1995, 1996, 1997, 1999, 2000, 2003, 2017and 2019 (Table 2). Contrary, not a single severe cyclone has seen in the year 1894, 1899, 1903, 1904, 1905, 1915, 1920, 1924, 1928, 1929, 1934, 1946, 1950, 1954, 1957, 1980, 1986, 2001, 2005, 2011, 2012 and 2015. Although, figure 3 represents the overall slightly increasing trend of annual severe cyclone frequency in the period of 1891 to 2017 over the Bay of Bengal.

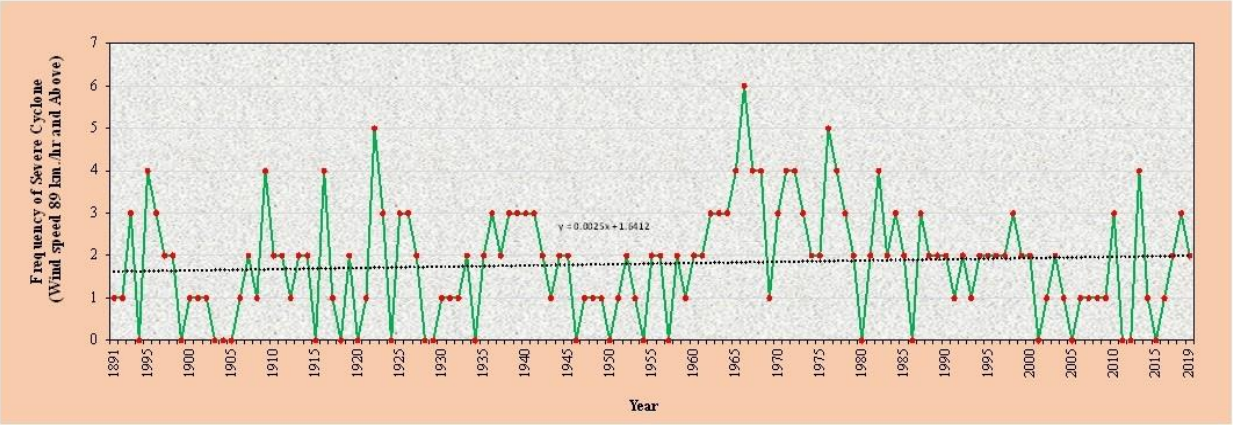

Figure 3: Yearly severe cyclone frequency over Bay of Bengal from 1891 to 2019

Table 2: Annual frequency of cyclone and severe cyclone over the Bay of Bengal from 1891 to 2019

Year	CS	SCS	Year	CS	SCS	Year	CS	SCS	Year	CS	SCS
1891	2	1	1924	6	0	1957	2	0	1990	2	2
1892	5	1	1925	7	3	1958	5	2	1991	3	1
1893	9	3	1926	7	3	1959	3	1	1992	4	2
1894	5	0	1927	5	2	1960	3	2	1993	1	1
1895	4	4	1928	7	0	1961	3	2	1994	2	2
1896	7	3	1929	5	0	1962	4	3	1995	2	2
1897	5	2	1930	8	1	1963	3	3	1996	3	2
1898	6	2	1931	5	1	1964	4	3	1997	3	2
1899	3	0	1932	4	1	1965	5	4	1998	3	3
1900	3	1	1933	7	2	1966	7	6	1999	3	2
1901	2	1	1934	4	0	1967	8	4	2000	4	2
1902	2	1	1935	4	2	1968	7	4	2001	1	0
1903	5	0	1936	5	3	1969	6	1	2002	3	1
1904	4	0	1937	6	2	1970	4	3	2003	2	2
1905	5	0	1938	3	3	1971	5	4	2004	1	1
1906	6	1	1939	5	3	1972	5	4	2005	4	0
1907	5	2	1940	6	3	1973	5	3	2006	2	1

1908	5	1	1941	7	3	1974	4	2	2007	2	1
1909	4	4	1942	5	2	1975	5	2	2008	3	1
1910	5	2	1943	7	1	1976	7	5	2009	3	1
1911	3	2	1944	7	2	1977	4	4	2010	3	3
1912	4	1	1945	3	2	1978	5	3	2011	0	0
1913	6	2	1946	4	0	1979	3	2	2012	1	0
1914	4	2	1947	3	1	1980	3	0	2013	5	4
1915	6	0	1948	3	1	1981	5	2	2014	1	1
1916	7	4	1949	1	1	1982	4	4	2015	1	0
1917	1	1	1950	4	0	1983	3	2	2016	4	1
1918	5	0	1951	2	1	1984	3	3	2017	3	2
1919	5	2	1952	4	2	1985	6	2	2018	4	3
1920	1	0	1953	1	1	1986	1	0	2019	3	2
1921	4	1	1954	1	0	1987	5	3			
1922	5	5	1955	6	2	1988	3	2	Total	522	234
1923	4	3	1956	4	2	1989	3	2			
Note: CS- Cyclonic Storm and SCS- Severe Cyclonic Storm.											

Source: www.imd.gov.in

4.1.3 Five years interval frequency distribution of Post-Monsoon and Pre-Monsoon severe cyclone over the Bay of Bengal from 1891to 2019

Most of the cyclones over the Bay of Bengal mainly form in the Pre-Monsson (March-May) and Post-Monsoon (October-December) time. According to the Indian Meteorological Department's report, there is a total of 59 Pre-Monsoon severe cyclones and 141 Post-Monsoon severe cyclones, formed over the Bay of Bengal in the last 129 years from 1891 to 2019.

Table 3 and figure 4 represents the five years interval of the severe cyclone frequency distribution of the Pre-Monsoon and Post-Monsoon season for a period of 1891 to 2019. In the case of the Post-Monsoon severe cyclone, the highest number of severe cyclones occurred in the years 1966-1970 (12) and the lowest number of severe cyclones occurred in the years between 1901-1905 (only 1). While the overall Post-Monsoon severe cyclone frequency distribution represents the increasing trend in the period of 1891 to 2019, the highest number of pre-monsoon severe cyclones occurred in the year between 1961-1965 (5) and the lowest number occurred in the year between 1901-1905 and 1911-1915 (only 1). The overall Pre-Monsoon severe cyclone frequency distribution represents a slightly increasing trend in the period of 1891 to 2019.

Table 3: Pre-Monsoon and Post-Monsoon severe cyclone frequency over the Bay of Bengal from 1901 to 2015

Year	No. of Pre-Monsoon severe cyclone	No. of Post-Monsoon severe cyclone	Year	No. of Pre-Monsoon severe cyclone	No. of Post-Monsoon severe cyclone

1891-1895	2	4	1956-1960	1	5
1896-1900	1	4	1961-1965	5	10
1901-1905	1	1	1966-1970	4	12
1906-1910	3	6	1971-1975	2	9
1911-1915	2	1	1976-1980	4	8
1916-1920	2	3	1981-1985	3	10
1921-1925	4	8	1986-1990	2	6
1926-1930	2	4	1991-1995	2	6
1931-1935	1	4	1996-2000	2	8
1936-1940	4	5	2001-2005	2	2
1941-1945	2	5	2006-2010	4	3
1946-1950	0	2	2011-2015	0	5
1951-1955	2	4	2016-2019	2	6
Total				59	141

Source: www.imd.gov.in

4.1.4

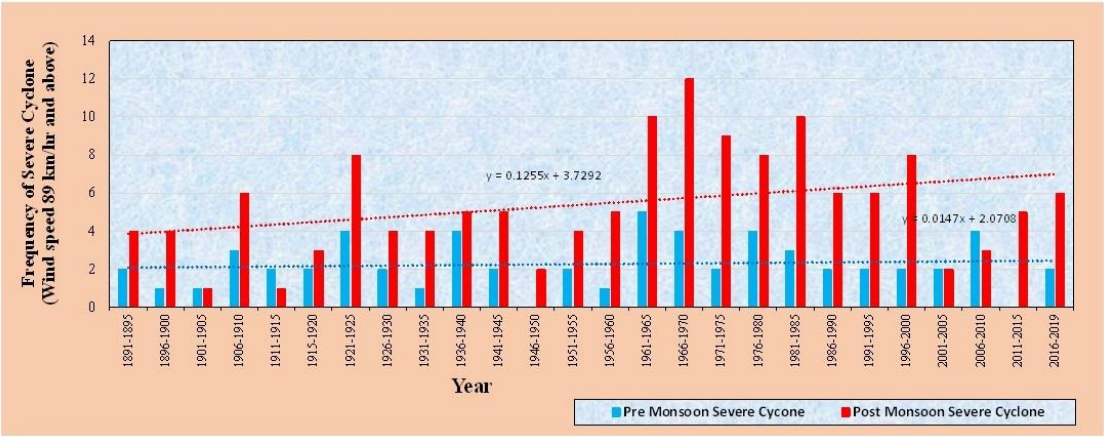

Figure 4: Five years frequency of severe cyclone over Bay of Bengal from 1891 to 2019

Frequency of cyclonic storm crossing in the eastern coastal states of India (West Bengal, Odisha, Andhra Pradesh and Tamil Nadu) from 1891 to 2019

The eastern coastal part of India is more cyclone-prone compare to the west coast. In the last 129 years from 1891 to 2019, 14 cyclonic storms and 16 severe cyclonic storms have crossed the western coastal part of India. On the other hand, 170 cyclonic storms and 114 severe cyclonic storms have crossed over the eastern coast of India. Table-4 and Figure 5 represent the frequency distribution of cyclonic storms and severe cyclonic storms in the four eastern states of India namely West Bengal, Odisha, Andhra Pradesh and Tamil Nadu. In the case of a cyclonic storm (wind speed: 34-47 knots), it was noticed that in the last 129 years, Odisha had faced the maximum number of cyclonic storms (74) followed by Andhra Pradesh (47). Tamil Nadu and West Bengal have faced 25 and 24 cyclonic storms respectively. Conversely, in the case of the severe cyclonic storm (wind speed: 48-63 kt/hr.), Tamil Nadu has faced the maximum number of cyclones (32) followed by Andhra Pradesh (31). West Bengal and Odisha have faced 25 and 24 severe cyclonic storms.

Table 4: Frequency of cyclonic and severe cyclonic storms crossing different coastal states of India from 1891 to 2019

Cyclone Category	West Bengal	Odisha	Andhra Pradesh	Tamil Nadu	Total
Cyclonic Storm (CS)	24	74	47	25	170
Severe Cyclonic Storm (SCS)	25	24	31	32	112

Source: Indian Meteorological Department and RSMC cyclone report 2018 and 2019

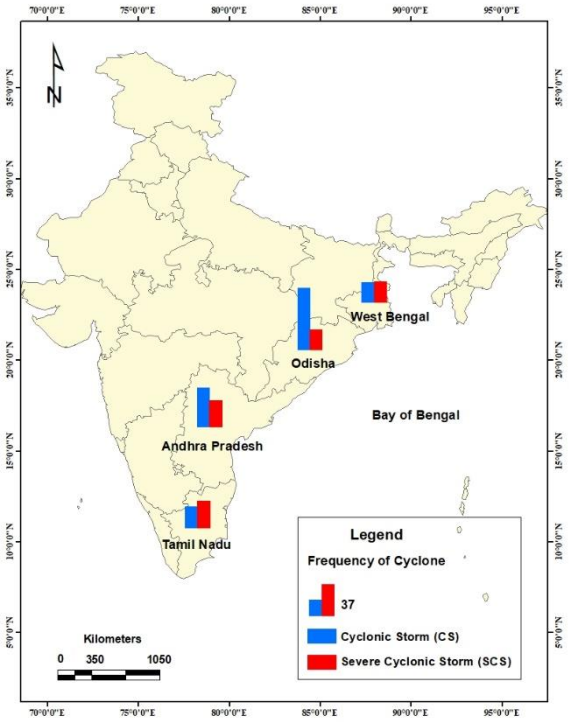

Figure 5: Frequency of cyclonic storm and severe cyclonic storm crossing coastal states of India (West Bengal, Odisha, Andhra Pradesh and Tamil Nadu) from 1891 to 2019

4.2 Major cyclones crossing in the eastern coastal states of India (West Bengal, Odisha, Andhra Pradesh and Tamil Nadu) from 1990 to 2020

The eastern coast of India mainly consists of four states like West Bengal, Odisha, Andhra Pradesh and Tamil Nadu. During the time period of 1990 to 2020, the eastern coastal state of India faced eleven Cyclonic Storm (CS), thirteen Severe Cyclonic Storm (SCS), fourteen Very Severe Cyclonic Storm (VSCS) and one Super Cyclonic Storm (SuCS). Table 5 gives a brief account of these climatic disasters with particular reference to the date of occurrence, cyclone name, category of the cyclone, landfall area, central pressure, maximum wind speed and damage etc. In the previous last three decades, the most devastating cyclone is the BOB 03 cyclone, which hit coastal Odisha near Puri on 29 October

1999 with a maximum speed of 140 kt/hr. 9887 people were died by the super cyclone. Besides, the other devastating cyclones were Machilipatnam Cyclone (1990), Karaikal Cyclone (1991), BOB 9302(1993), BOB 9403 (1994), BOB 9604 (1996), BOB 02 (1999), SIDR (2007), AILA (2009), PHAILIN (2013), HUDHUD (2014), TITLI (2018), FANI (2019) and AMPHAN (2020).

Table 5: Major cyclone in eastern coastal states of India from 1990 to 2020

Sl. No.	Date	Name of Cyclone	Cyclone Category	Landfall area	Central Pressure (mb)	Maximum wind speed in kt/hr	Damage (Total Human death)
1	09/05/1990	Machilipatnam Cyclone	VSCS	Andhra Pradesh coast	960	90	934
2	17/12/1990	Severe Cyclonic Storm	SCS	Odisha coast	-	55	-
3	15/11/191	Karaikal Cyclone	SC	Tamil Nadu coast	1000	45	300
4	04/12/1993	BOB 9302	SCS	Tamil Nadu coast	968	90	100
5	31/10/1994	BOB 9403	SCS	Tamil Nadu coast	-	55	304
6	09/11/1995	BOB 9502	VSCS	Andhra Pradesh coast	988	77	52
7	16/06/1996	BOB 9602	CS	Andhra Pradesh coast close to Visakhapatnam	992	45	165
8	06/11/1996	BOB 9604	SCS	Andhra Pradesh coast near Kakinada	990	55	978
9	06/12/1996	BOB 9605	CS	Tamil Nadu coast near to Chennai	994	45	--
10	27/09/1997	BOB 9702	VSCS	Bangladesh coast	934	55	32 (India)
11	15/11/1998	BOB 9802	VSCS	North Andhra Pradesh coast	982	65	16
12	22/11/1998	BOB 9803	SCS	West Bengal coast near to Sagar Island	998	55	-
13	17/10/1999	BOB 02	VSCS	Odisha coast near Gopalpur	968	90	198

14	29/10/1999	BOB 03	SuCS	Odisha Coast near Paradip	912	140	9887
15	29/11/2000	BOB 04	VSCS	Tamil Nadu coast near Cuddalore	976	77	12
16	27/12/2000	BOB 05	SCS	Tamil Nadu coast near Tuticorin	1002	55	5
17	16/10/2001	Cyclonic Storm	CS	Andhra Pradesh coast	998	35	0
18	12/11/2002	Severe Cyclonic Storm	SCS	West Bengal coast near to Sagar Island	990	55	20
19	15/12/2003	Severe Cyclonic Storm	SCS	Andhra Pradesh coast near Machilipatnam	992	55	81
20	19/09/2005	PYAAR	CS	Andhra Pradesh coast near Kalinagapatnam	988	35	1
21	30/10/2006	OGNI	CS	Andhra Pradesh coast	988	45	24
22	15/11/2007	SIDR	VSCS	West Bangladesh coast	944	115	1 (India) 3363 (Bangladesh)
23	27/11/2008	NISHA	CS	Tamil Nadu coast near north of Karaikal	996	45	100
24	25/05/2009	AILA	SCS	West Bengal coast close to Sagar Island	968	60	100 (WB, India) 175 (Bangladesh)
25	20/05/2010	LAILA	SCS	Andhra Pradesh Coast	986	55	6
26	30/12/2011	THANE	VSCS	Tamil Nadu coast close to south of Cuddalore	969	78	46

27	30/10/2012	NILAM	CS	north Tamil Nadu coast near Mahabalipuram, south of Chennai	987	45	61
28	12/10/2013	PHAILIN	VSCS	Odisha & adjoining north Andhra Pradesh coast near Gopalpur	940	115	22
29	12/11/2013	HELEN	SCS	Andhra Pradesh coast close to south of Machilipatnam	990	55	11
30	12/10/2014	HUDHUD	VSCS	Andhra Pradesh coast over Visakhapatnam	950	100	46
31	28/10/2016	KYANT	CS	Andhra Pradesh coast	988	40	-
32	02/12/2016	NADA	CS	Tamil Nadu coast	988	40	-
33	13/12/2016	VARDAH	VSCS	Tamil Nadu coast	984	65	-
34	20/09/2018	DAYE	SC	South Odisha and adjoining North Andhra Pradesh coasts	992	35	-
35	10/10/2018	TITLI	VSCS	South Odisha coasts	972	80	85
36	15/11/2018	GAJA	VSCS	Tamil Nadu Coast	976	70	46
37	13/12/2018	PHETHAI	SCS	Andhra Pradesh coast	997	45	-
38	03/05/2019	FANI	VSCS	Odisha coast close to Puri	952	100	64
39	09/11/2019	BULBUL	SCS	West Bengal Coast close to Sunderban Dhanchi forest	986	60	13 (WB)

40	20/05/2020	AMPHAN	VSCS	West Bengal and Bangladesh coasts	960	85-100	-
Note: CS- Cyclonic Storm, SCS- Severe Cyclonic Storm, VSCS- Very Severe Cyclonic Storm, SuSC- Super Cyclonic Storm.							

Source: RSMC cyclone report (1990-2020)

4.3. Major severe cyclone over West Bengal from 1990 to 2020

In the last three decades, West Bengal faced five major cyclones like BOB 9803 (1988), Severe Cyclonic Storm (2002), AILA (2009), BULBUL (2019) and AMPHAN (2020). Although, the most devastating cyclone among these cyclones in the state are AILA, BULBUL and AMPHAN.

4.3.1 AILA (May 23-26, 2009)

AILA formed as a depression on 23 May 2009, in the North Indian Ocean. It crossed the West Bengal coast near Sagar Island on May 25 with a wind speed of 60 kt./hr. and it was becoming a severe cyclonic storm. Mainly West Bengal and Bangladesh were damaged due to the severe cyclonic storm. As per the West Bengal Government report, 2.2 million people were affected, nearly 61,000 houses distorted, about 132,000 houses were partially affected and nearly 100 people were died in West Bengal due to AILA. It caused immense damage to rice and other crops. The high-speed winds destroyed all communication and transportation infrastructure and the 9600 square kilometers area of Sundarbans biosphere reserve area suffered extensive damage under the impact of cyclone AILA.

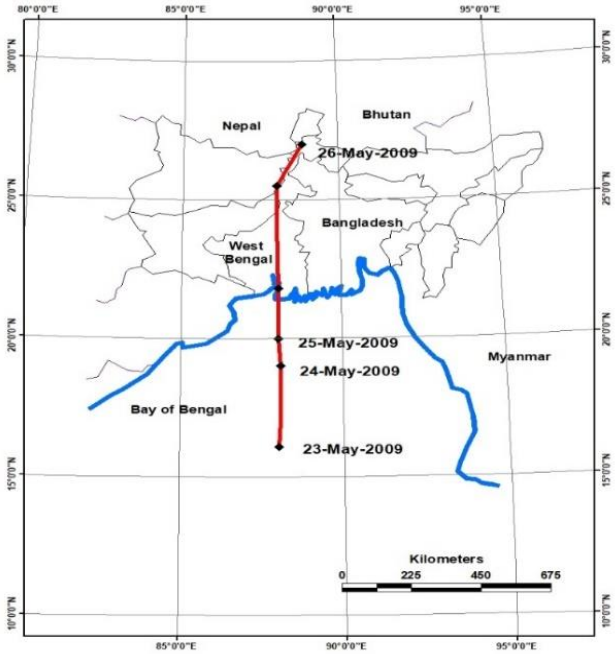

Figure 6: Observed track of AILA cyclone

4.3.2 BULBUL (November 05-11, 2019)

BULBUL originated from the remnant of severe tropical storm 'MATMO' (28th October - 2nd November) over the West Pacific Ocean that emerged into the North Andaman Sea. It developed as a tropical depression over the Andaman Sea on 4th November 2019. It crossed West Bengal Coast close to the Sunderban area on November 9 with a wind speed of 60 kt./hr. and became a severe cyclonic storm. It affected extensive destruction in the coastal district of East Midnapore, both 24 Parganas and adjoining districts of Gangetic West Bengal. More than 4,65,000 people were affected, nearly 60,000 houses were damaged and the number of casualties was 13 in the state due to BULBUL. It caused huge damage to the mangrove forest in the Sunderban Delta, the cultivation of flowers, vegetables, paddy crops and betel fields in the affected districts. The high-speed storm destroyed many electric poles in the coastal belt of Southern districts of West Bengal and 1050 mobile towers were also affected in the said area. The storm dissipated by November 11.

4.3.3 AMPHAN (May 16-21, 2020)

AMPHAN was the second Super Cyclonic Storm (SuCS) over the Bay of Bengal, after the Odisha Super Cyclone of 1999. It formed as a tropical depression over the South Andaman Sea on 16th May 2020. It crossed West Bengal and Bangladesh coasts as a Very Severe Cyclonic Storm (VSCS) on 20th May, with a maximum wind speed of 150-170 km/hr. and gusting to 185 km/hr. It caused very heavy rainfalls in East and West Medinipur, both 24 Parganas, Howrah and Hooghly, Kolkata and the adjoining area of West Bengal. It also caused a storm surge of about 4-6 meters over low laying coastal area of North and South 24 Parganas and about 3-5 meters over the coastal areas of the East Medinipur district of West Bengal during Landfall. Total 10 districts of Gangetic West Bengal and 384 blocks were affected by the AMPHAN cyclone. More than 13.5 million people were affected, nearly 28.6 lakh houses were damaged, around 5 lakh trees were uprooted, 86 people died and Around 21.22 lakh animals were lost in the state due to AMPHAN. The very high-speed winds destroyed all-electric poles, fishing boats, education-related infrastructure and ICDS centers in the severely affected districts. Around 17 lakh hectares of agricultural land (including paddy and vegetable) crops were totally damaged and 250556.17 hectares of betel vine, litchi and mango orchards were lost in the state due to the cyclone.

4.4 Socio-economic profile of the respondents

A total of 110 participants took part in the questionnaire survey across the Kakdwip block of the South 24 Parganas district. Table 6 summarizes the demographic profile of the survey respondents. Out of 110 respondents, 32% were female and 68% were male. 41% of the respondents were in the age group of 40-50. Nearly half of the respondents (44.5%) were illiterate, 23.6% had primary education, 13.6% had secondary education, only1.8% had higher secondary education. The majority of the respondents were engaged in primary activities. 59.1% and 27.3% of the respondents were cultivators and fishermen respectively. Almost two-thirds (60%) of the households' income were less than 5000 Rs. Survey results also reveal that 63.6% of the respondent's houses were katcha.

Table 6: Demographic profile of the survey respondents (N=110)

Household characteristics of respondents	Total no. of respondents	Percentage (%)
Gender		

Male	75	68
Female	35	32
Age (years)		
40-50	45	41.0
50-60	38	34.5
More than 60	27	24.5
Education Qualification		
No	49	44.5
Class IV	26	23.6
Class VIII	15	13.6
Class X	15	13.6
Class XII	2	1.8
B.A/ B.Sc.	3	2.7
Occupational structure		
Cultivation	65	59.1
Fishing	30	27.3
Small Business	10	9.1
Daily labor	5	4.5
Monthly family income		
Less than Rs. 5000	66	60
Rs. 5000 - 10000	29	26.4
More than 10000	15	13.6
House type		
Katcha	70	63.6
Semi-pucca	15	13.6
Pucca	25	22.7

Source: Primary survey

4.5 People's perception about recent trend of natural disasters

Cyclone is the main climatic disaster event in the Kakdwip block. Among 110 respondents 61.8% of participants said that the frequency of cyclone has increased. Although, 30% of the respondents mention that the frequency of cyclone has decreased compared to the previous thirty years and only 8.2% believe that there is no change in the frequency of cyclone in this block (Table 7). The majority of the respondents (74.5% and 78.2%) believed that the drought period and thunderstorm with lightning has increased compared to the past three decades. On the other hand, only 36.4% identified that hailstorm has decreased.

Table 7: People's perception of natural disasters (N=110)

Measure	People' response		
	Increase	Decrease	No change

	No. of respondents	No. in %	No. of respondents	No. in %	No. of respondents	No. in %
Frequency of cyclone	68	61.80	33	30.00	9	8.20
Drought period	82	74.50	16	14.50	12	10.90
Hailstorm	40	36.40	65	59.10	5	4.50
Thunderstorm and lightning	86	78.20	22	20.00	2	1.80

Source: Field survey

4.6 People's perception about cyclone

As the Kakdwip block is nearly 30-35 km away from the Bay of Bengal (BoB) coast, it is a cyclone-prone area. When the respondents were asked if they have ever experienced cyclones, all the responds said that they have faced cyclone many times. 78% of the total respondents stated that they get early information about cyclone, which help them to prepare to face cyclone. Although, 81.78% of the respondents noticed that they experienced various losses due to cyclone (Table 8).

Table 8: People perception about cyclone (N=110)

Questions	People' response			
	Yes		No	
	No. of respondents	No in %	No. of respondents	No in %
Have you ever faced the cyclone?	110	100	0	0
Did you get any warning before the cyclone?	86	78.2	24	21.8
Did your household experience any loss due to cyclone?	90	81.8	20	18.2

Source: Field survey

4.7 Sources of early warning of cyclone

The people (86) who said that they get early information about the cyclone, are further asked to describe the source of knowledge on an early warning. Television and radio were the main way to get news before a cyclone, followed by gram panchayat and police. 38.4% of the 86 respondents said that they get early information from television and radio, 31.4% of the respondents obtain their early warning from gram panchayat, 26.7% indicated that they get early information from police. The rest of the 2.3% and 1.2% of the respondents get an early warning from the neighborhood and NGOs respectively (Table 9).

Table 9: Respondents' (who are cyclone aware) source of knowledge

Source of early warning	Number of respondents	No. in percentage (%)

Gram Panchayat	27	31.4
Police	23	26.7
NGO	1	1.2
Tv and radio	33	38.4
Neighborhood	2	2.3
Total	86	100.0

Source: Field survey

4.8 People's perception of cyclone damage

The people (90) who said that they have suffered various losses due to cyclones are further asked to describe the type of loss. The respondents have faced various losses due to cyclone such as crop damage, house damage, physical injuries. The majority of the respondents (41.1%) said that they have faced crop damage due to cyclone; 38.9% of the respondents identified house damage loss. Only 16.6% of the respondents said they faced both crop and house damage loss. Remaining 3.3% mentioned physical injuries due to cyclone (Table 10).

Table 10: Respondents' (who have experienced losses due to cyclone) perception of cyclone damage

Type of loss due to cyclone	Number of respondents	No. in percentage (%)
Physical injuries	3	3.3
House damage	35	38.9
Crop damage	37	41.1
House damage & crop damage	15	16.6
Total	90	100.0

Source: Field survey

4.9 People's perception about coping up with cyclone

Local People of the Kakdwip block area are experiencing cyclones at different times. During the field survey, it came to know from the respondents that they were tremendously affected by cyclone Aila in the year 2009. The maximum katcha houses and crops of the land was completely destroyed in this region. But there is a growing awareness among local people about the cyclone and they are taking various measures to cope up with the cyclone.

4.9.1 Measures taken by local people before cyclone

In this stage, local people have taken some and preparedness strategies based on their previous experiences of the cyclone. Table 11 holds the information regarding measures that the local people of the study area often take before any cyclone. Though these traditional techniques are not completely safe regarding cyclone.

House repairing, using a box for storing valuable assets, temporary migration to a safe place, taking livestock to a safe place, selling domestic animals, storing dry food and water and saving money are some of the measures taken in this area by local people. According to the field survey, 33.6% of the

households repair their houses to prevent cyclones, 70.9% of the respondents use box for storing valuable assets like important documents, ornaments, clothes, batteries, medicines etc. An important policy to avoid the effects of a cyclone is temporary migration to a safe place; 25.5% of the respondents reported this measure. 30.9% of the household take their livestock/poultry to a safe place before a cyclone. A small proportion of the respondents (11.8%) sell their domestic livestock or poultry before the cyclone. The majority of the respondents (76.4%) store dry food and drinking water and 78.2% of the respondents save money before a cyclone.

Table 11: People response to measures taken before a cyclone

Sl. no.	Measures	People's response			
		Yes		No	
		Response frequency	Response in %	Response frequency	Response in %
1	House repairing to prevent cyclone	37	33.6	73	66.4
2	Using box for storing valuable assets	78	70.9	32	29.1
3	Temporary migrate to a safe place	28	25.5	82	74.5
4	Taking livestock/poultry to a safe place	34	30.9	76	69.1
5	Selling domestic animals	13	11.8	97	88.2
6	Storage of dry food and water	84	76.4	26	23.6
7	Saving money	86	78.2	24	21.8

Source: Field survey

4.9.2 Measures taken by local people during cyclone

Adaptation measures to a cyclone depend on local community people's socio-economic and cultural conditions and their location. People of the study area have taken some measures during cyclones. Table 12 presents some initiatives that the local peoples follow to protect themselves during cyclones.

The study revealed that about 75% of the households stay at home during the cyclone because they believe that their houses can prevent cyclones; 85.5% of the households provide strong suitable support at outside doors and windows to prevent the speed of storms during a cyclone. They are also aware of the use of electricity during a cyclone; 94.5% of the respondents said that they remain to switch off the electrical mains in their house. According to the survey, reducing food consumption during a cyclone is the least common option; only 20% of the respondents said this measure. The reason is that they learn from the earlier cyclones and do store dry food and water before the cyclone. More than 80% of the respondents said they listen to radio news during cyclones and inform other people. As a result, of taking above mentioned adaptation measures, the amount of damage caused by cyclone is gradually decreasing.

Table 12: People's response to preparation during cyclone

Sl. no.	Measures	People's response	
		Yes	No

		Response frequency	Response in %	Response frequency	Response in %
1	Stay home as home is securely build	82	74.5	28	25.5
2	Provide strong suitable support for outside door and windows	94	85.5	16	14.5
3	Remain switch off the electrical mains in the house	104	94.5	6	5.5
4	Reduce the consumption of food	37	33.6	73	66.4
5	Listening radio for weather warning	90	81.8	20	18.2
6	Passing the information to other	91	82.7	19	17.3

Source: Field survey

4.9.3 People's perception of government initiatives to cope with the cyclone

The Government has taken various initiatives to enhance the people's power to cope up with cyclones in the Kakdwip block of South 24 Parganas such as irrigation management, crop insurance, rainwater harvesting, transport development, health system improvement, construction of cyclone shelter and pucca houses, providing early warning, tree plantation and environmental awareness programs etc.

The result of the study (table 13) reveals that above 96% of the respondents are aware of the Government's involvement in riverbank erosion management, improvement of the education system and tree plantation program. More than 85% of the respondents are aware of the government initiative on health system development and construction of cyclone shelters. The majority of respondents (80%) also noticed that the government had taken the step to construct pucca houses for the poor.77.3% of the respondents mentioned that the Government provides early warming or alert before the cyclone. Irrigation management, crop insurance and environmental awareness programs are also important parts of government responsibility but local people don't have sufficient knowledge about the measures. Only 22.7%, 42.8% and 42.7% of the respondents are aware of the government initiatives on irrigation management, crop insurance and environmental awareness programs respectively.

Table 13: People's response to the Government initiatives to cope with cyclone

Sl. no.	Initiatives	People's response			
		Yes		No	
		Response frequency	Response in %	Response frequency	Response in %
1	Irrigation management	25	22.7	85	77.3
2	Crop insurance	46	42.8	64	57.2
3	River bank erosion management	108	98.2	2	1.8
4	Tree plantation program	107	97.3	3	2.7
5	Rainwater harvesting	98	89.9	11	10.1
6	Education system improvement	106	96.4	4	3.6
7	Health facilities	96	87.3	14	12.7

8	Construction of pucca houses for poor	80	72.7	30	27.3
9	Transportation system improvement	106	96.4	4	3.6
10	Construction of cyclone shelter	98	89.1	12	10.9
11	Provide early warning	85	77.3	25	22.7
12	Environmental awareness program	47	42.7	63	57.3

Source: Field survey

5. Conclusion

The study mainly emphasises on analysis of the historical trend of cyclone over the Bay of Bengal. It reveals the local people's perception about coping up with cyclone in Kakdwip block of South 24 Parganas. The results highlight that in the last 129 years, the trend of annual cyclone frequency has decreased, but the trend of annual severe cyclone frequency and Pre-Monsoon and Post-Monsoon severe cyclone frequency has increased, which indicates that the annual frequency of severe cyclones will increase in the near future. The coastal area of Odisha state in India has faced the maximum cyclones in the last 129 years. Tamil Nadu has faced the maximum number of severe cyclones. The most destructive cyclone in India is the Odisha cyclone (1999). AILA and AMPHAN cyclones both have caused tremendous damage in West Bengal in the last three decades. The findings of the study also revealed that the local people of Kakdwip block in South 24 Parganas have a clear idea of the change in climatic parameters like temperature, rainfall, cyclone, thunderstorm and lightning. The majority of the respondents perceived that cyclone frequency, drought period, thunderstorm and lightning have increased. The local people of the study area are aware of the cyclone; they have taken various adaptation measures to cope with the cyclone. The results highlight that local people have taken various coping measures even before the cyclone like house repairing, use of box for storing valuable assets and for saving money, storage of dry foods and drinking water, temporarily migrate to a safe place, selling domestic animals, taking livestock to safe place etc. Furthermore, local people also have taken some other coping strategies during cyclone as providing strong support at outside door and windows, switching off the electrical mains in house, reducing consumption of food, listening radio etc. However, the Government has taken various initiatives to enhance the local people's coping strategies with cyclones; more effective measures need to be followed to cope with cyclone in the block.

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