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THE EAST PAKISTAN CYCLONE OF NOVEMBER 1970*

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Abstract

The East Pakistan Cyclone of November 1970 was a natural calamity of great magnitude. In this paper, we describe the movement and the synoptic features of the storm. This has been done with the help of satellite cloud pictures; because conventional data from the vicinity of the storm were largely absent on crucial days. The unusually long northerly track of the storm during the first four days (7th to 10th) and the subsequent recurvature and accelerated movement on the last day are discussed. The high winds and large waves associated with the storm caused structural damages at Paradeep Port. A big storm surge swept across the off-shore islands, especially Bhola and Hatia in East Pakistan, which caused much loss of life in these areas. A few interesting aspects of the storm surge are discussed in this paper.

Introduction

The East Pakistan Cyclone of November1970 was a natural calamity of great magnitude. According to press reports the cyclone took a toll of one half to one million human lives. Great storm waves were generated by the cyclone which completely washed away 15 off-shore islands of East Pakistan, and many more islands were seriously affected. The cyclone had a few interesting features in its development and movement. These are discussed in the paper.

History of the Storm

The remnants of a tropical disturbance in the China Sea moved eastwards across the Malay Peninsula and lay as a low pressure area in south-east Bay of Bengal on the 5th of November. It moved slowly eastwards and concentrated into a depression by the 7th when it was centred about 800 km east-south-east of Madras. Thereafter, moving slowly in a north-north-westerly direction, the depression intensified further into a cyclonic storm with its centre about 700 km east-north-east off Madras on the 9th. It remained practically stationary on the 9th and 10th. Subsequently, it intensified into a cyclonic storm on the 11th morning and its movement suddenly accelerated. It crossed the East Pakistan coast late on the evening of 12th. But, later it weakened rapidly. The track of the storm is shown in Fig. 1.

The sudden acceleration and recurvature of the storm is in agreement with the synoptic considerations, because the storm entered a fast westerly air stream when it crossed the latitude of 15°N.

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Winds

The central region of the storm with hurricane winds did not cross any of the Indian Coastal stations. No reports have been received from the storm-ravaged East Pakistan coastal belt. Estimates of the strongest wind could be made from indirect evidence provided by the conventional data outside the central storm area,

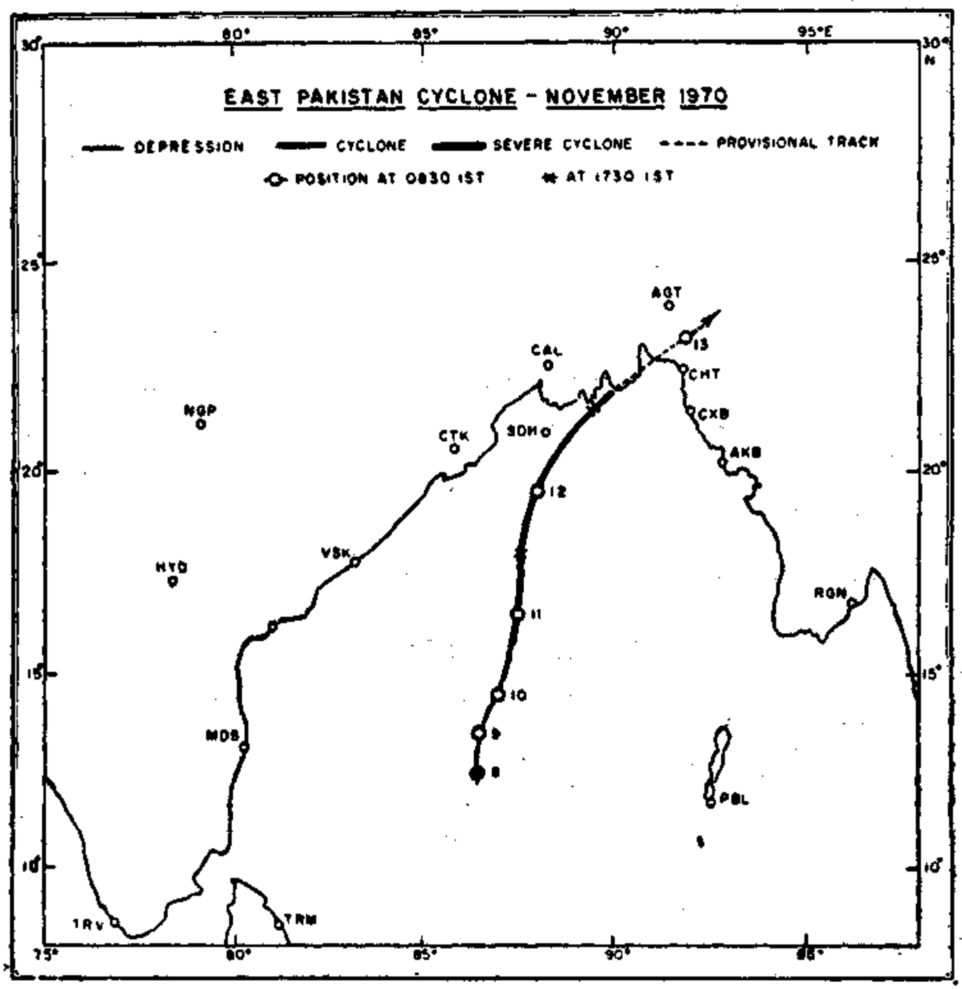

Fig. 1. The tracks of the East Pakistan Cyclone of Nov. 1970. The dates along the track indicate the morning (0300 GMT) position of the storm.

and from weather satellite pictures. Saugor Island, which was the nearest station to the storm track, recorded a wind speed of 94 km per hour. Calcutta, which was a little further away from the track, recorded a maximum wind of 81 km per hour. At Paradeep port, wind speeds of 90 km per hour were estimated. Paradeep port suffered structural damages on account of high winds and huge waves which entered the break-waters of the port. The ship ' Jagamitra ', which was lost in the storm, radioed that it was experiencing winds of hurricane force around 11 a.m. on the 12th. Its position was then near latitude 20.3°N long. 89.0°E. The barometric pressure then was 964 mbs. Apparently, the ship was very near the storm centre. On the 12th, the 0300 GMT observation of ESSA-8 satellite show that the storm was in the cyclone (×) stage with an eye clearly visible near 19.5°N and 88.5°E. The diameter of the overcast area was 5°. The estimated wind from the satellite picture works out to be a little over 90 knots.

Satellite Data

Plates I-IV show the sequence of satellite pictures of the Bay of Bengal on November 9 to 12 respectively. The appearance of an eye in the midst of a large overcast area is seen even on the 11th morning. On the 8th, the disturbance could be classified under stage ' C ' of an International classification of storms for satellite pictures. On the 9th, it could be classified under the cyclone stage (×) indicating rapid intensification. But, the eye was not visible on this day on the morning satellite (ESSA-8) picture. In the evening-ITOS-1-picture, the eye was dimly visible. It remained so on the 11th, but on the 12th morning (ESSA-8) picture, the storm appeared in the highest category of cyclones, with an enlarged canopy of overcast area of 5° in diameter.

Conventional meteorological data were practically absent in the vicinity of the storm. The satellite data provided an excellent means of detecting the storm and in following its movement and intensity from day to day. The storm illustrates, as in the case of many others, the usefulness of satellite observations which are now available to meteorologists. With the aid of satellite data, the forecasting offices of the Indian Meteorological Department could monitor the storms with a high degree of confidence, and issue adequate and timely warnings to the coastal areas which are threatened by the storm.

Isobaric Structure of the Storm and Rainfall

Fig. 2 a to d show the isobaric structure of the storm at 1200, 1500 and 1800 GMT of the 12th and at 0300 GMT of 13th respectively. The figures do not show the isobars in the central region of the storm. However, the reported barometric pressure of 964 mbs by the ship 'Jagamitra' probably indicates very nearly the pressure depth of the storm. During the formative changes of the cyclone (8th and 9th), heavy to very heavy falls were reported from the Bay Islands which lay within the storm field. Again, on the 12th and 13th, when the storm crossed the coast and weakened over land, widespread rain was reported in West Bengal and South Assam. Very heavy to torrential falls must have also occurred in the coastal areas of East Pakistan.

Storm Wave

The most distressing feature of this storm was a huge storm surge, which caused extensive damage and loss of life in East Pakistan. According to available reports from various sources, several hundred off-shore islands were affected in some way or the other and fifteen of them were completely washed away. Eighty per cent of the population of the badly affected islands was estimated to have perished. The storm surges were reported to have reached a height of 10 metres. Records show

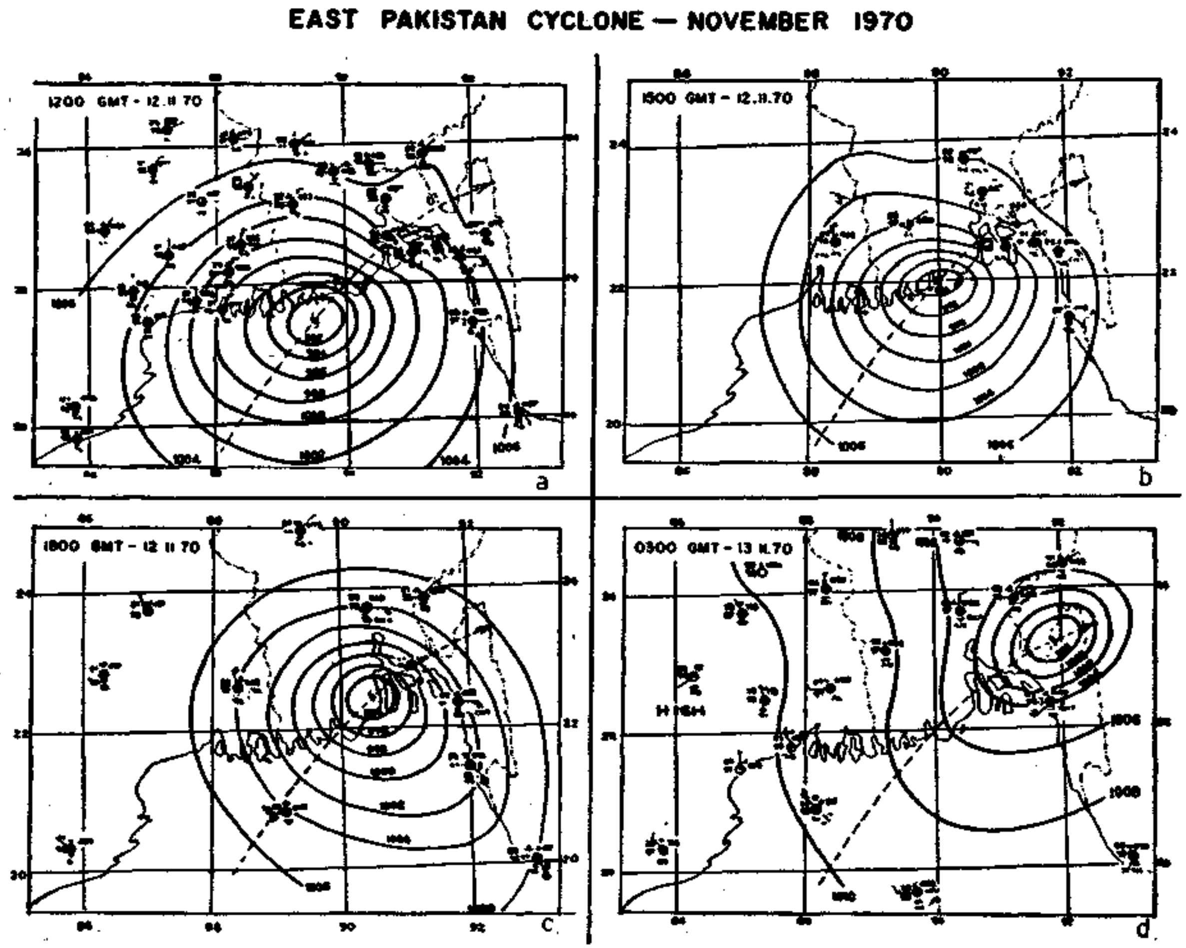

Fig. 2. The isobaric structure of the storm at (a) 1200 GMT (b) 1500 GMT (c) 1800 GMT of 12th Nov. and (d) 0300 GMT of 13th Nov. 1970.

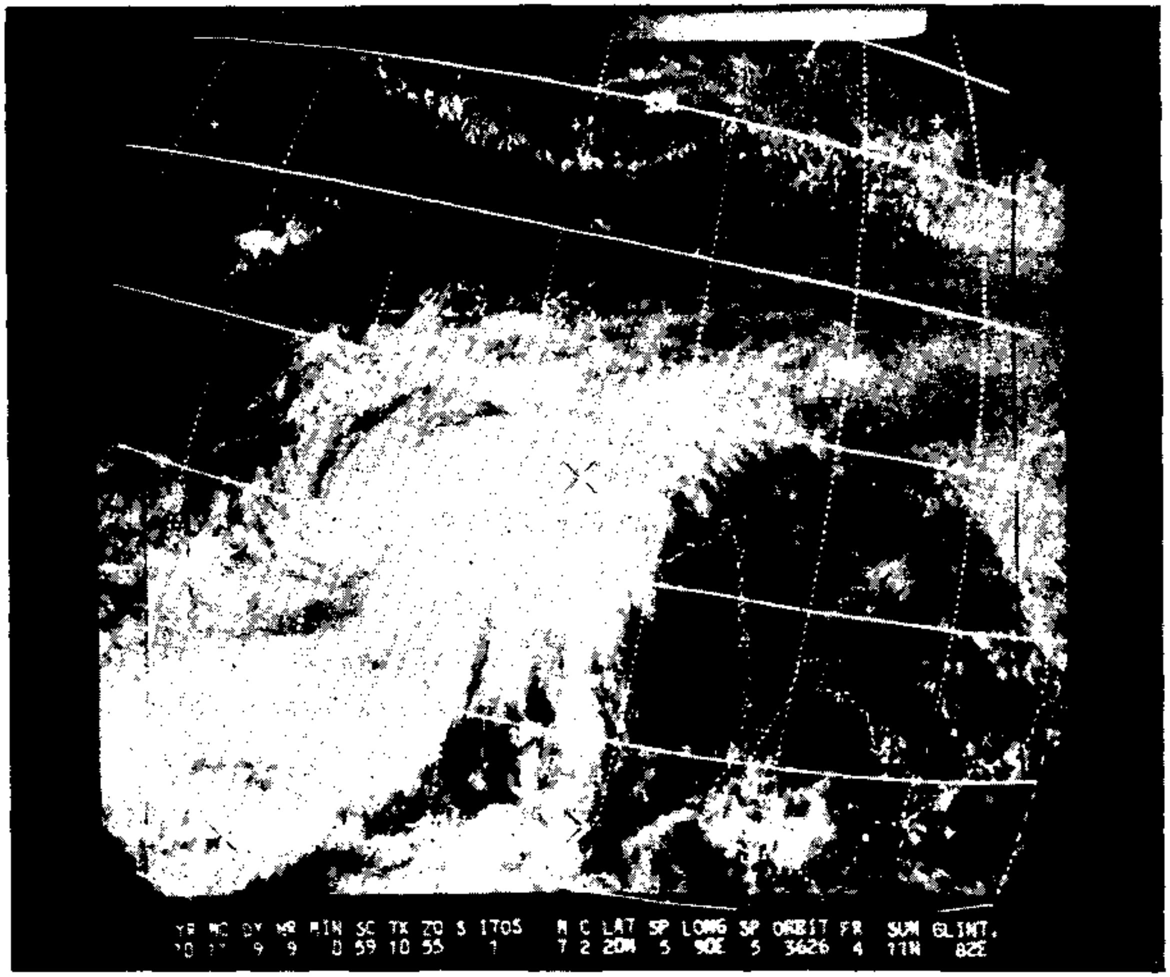

PLATE I. Satellite picture of the storm on 9th Nov. 1970.

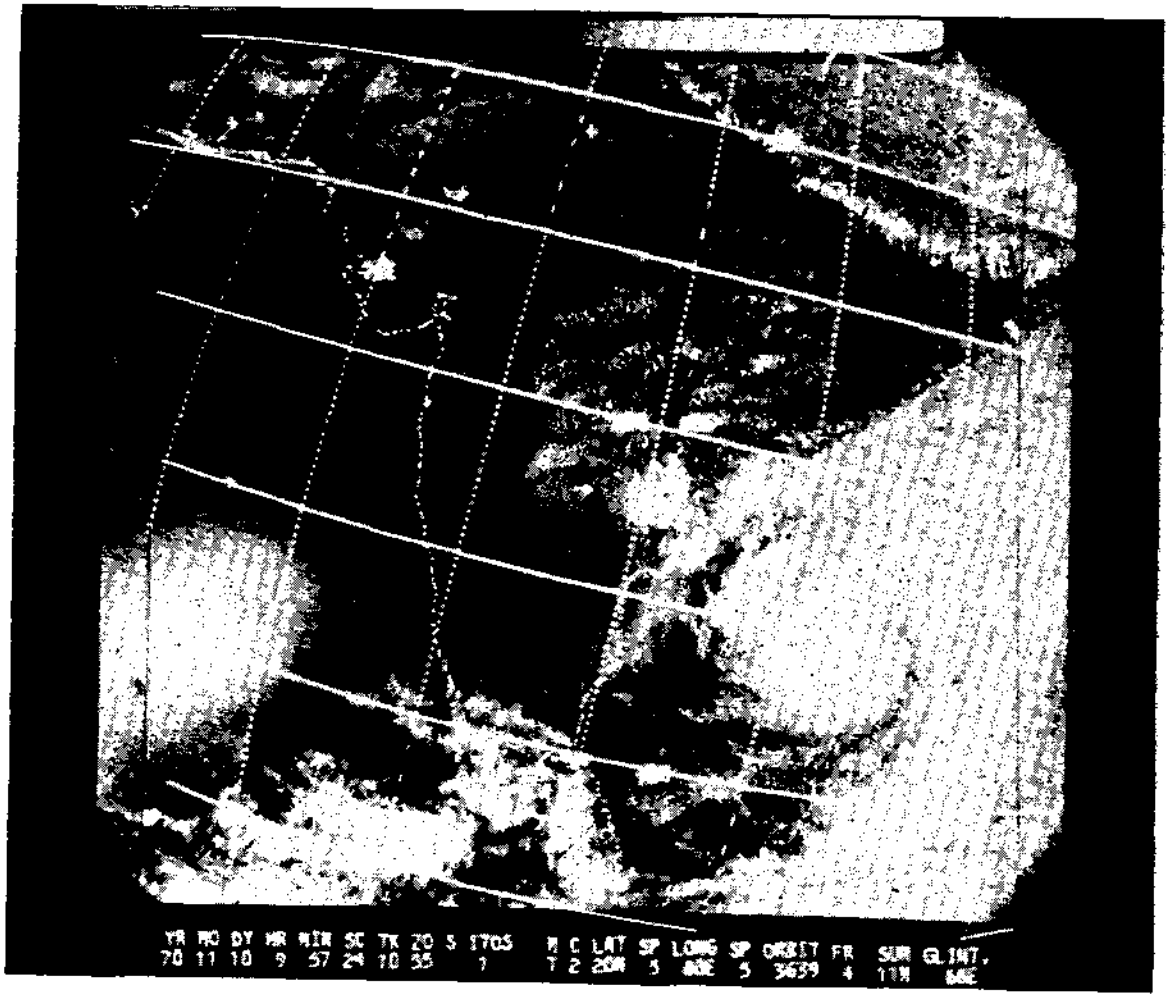

PLATE II. Satellite picture of the storm on 10th Nov. 1970.

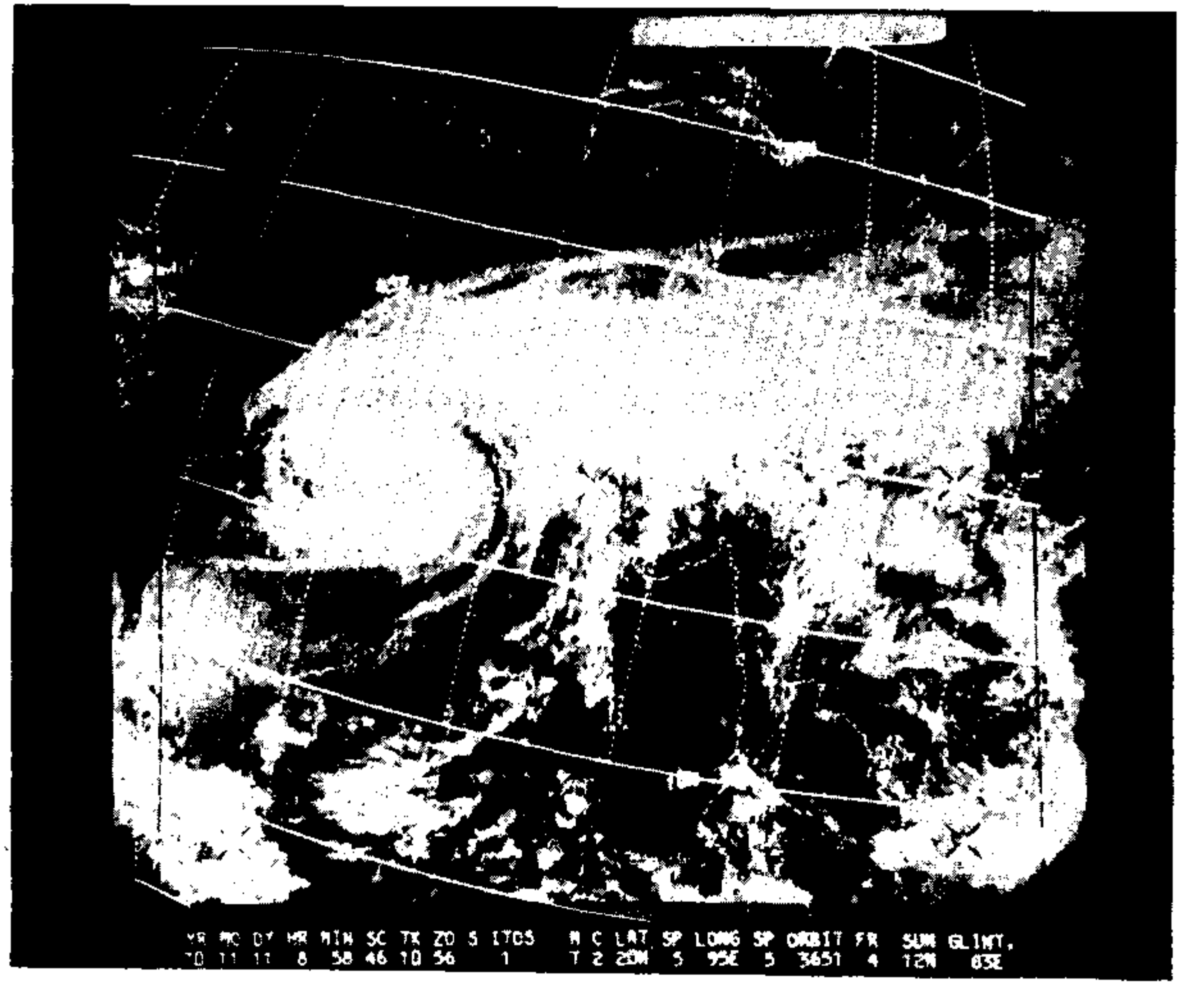

PLATE III. Satellite picture of the storm on 11th Nov. 1970.

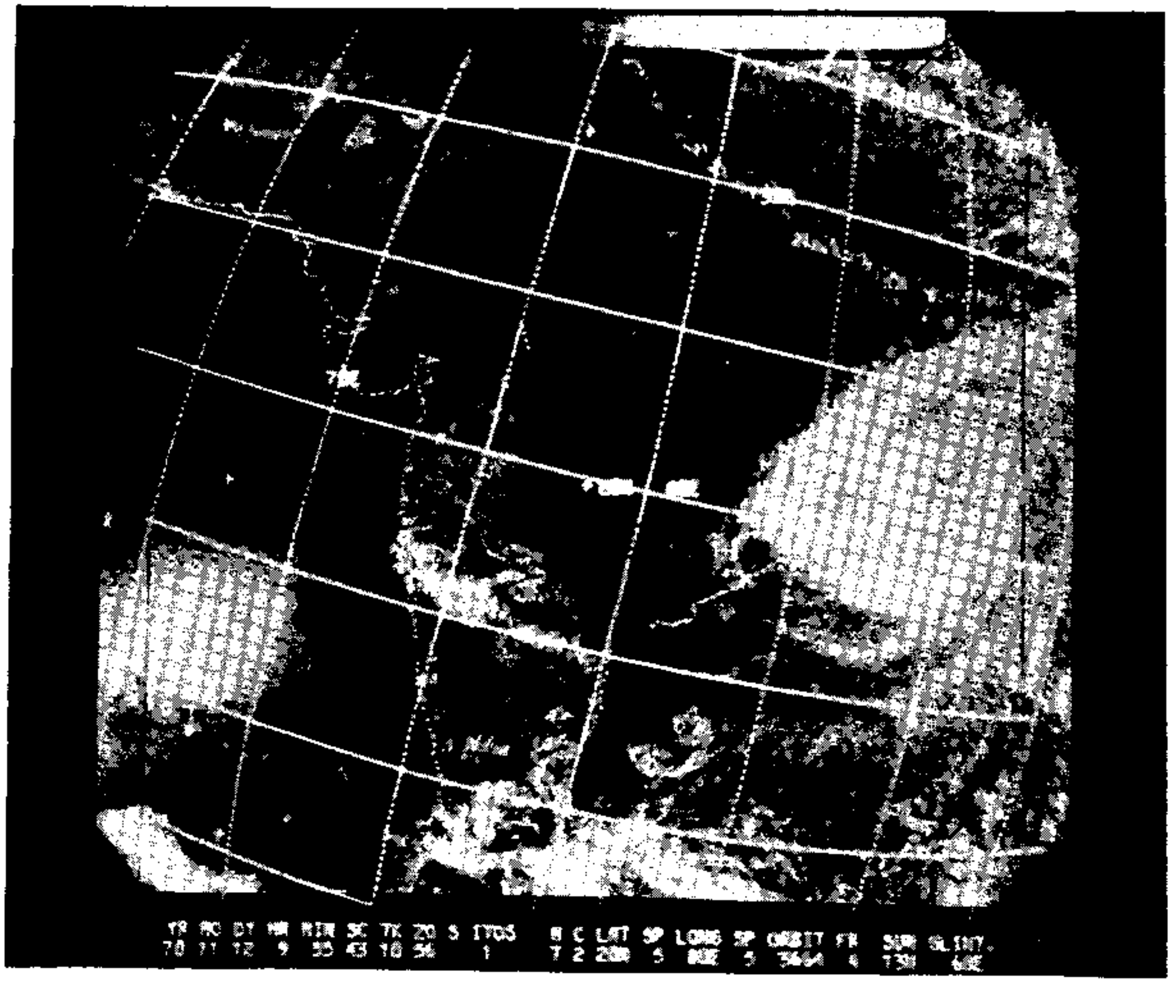

PLATE IV. Satellite picture of the storm on 12th Nov. 1970.

that the coastline surrounding the north Bay of Bengal is particularly susceptible to inundation by storm-waves. In the past, the Calcutta storms of 1737 and 1864, the Backergunge storm of 1876, the False Point cyclone of 1885, the Midnapore cyclone of 1942, have all been accompanied by major storm-surges causing loss of life and property. Even in this area, the coastline of East Pakistan is particularly vulnerable to storm-surges. During 1960's, five major storm-surges have caused much loss of life in this area, particularly on the off-shore islands of East Pakistan. This cyclone is the latest in a series of such natural disasters.

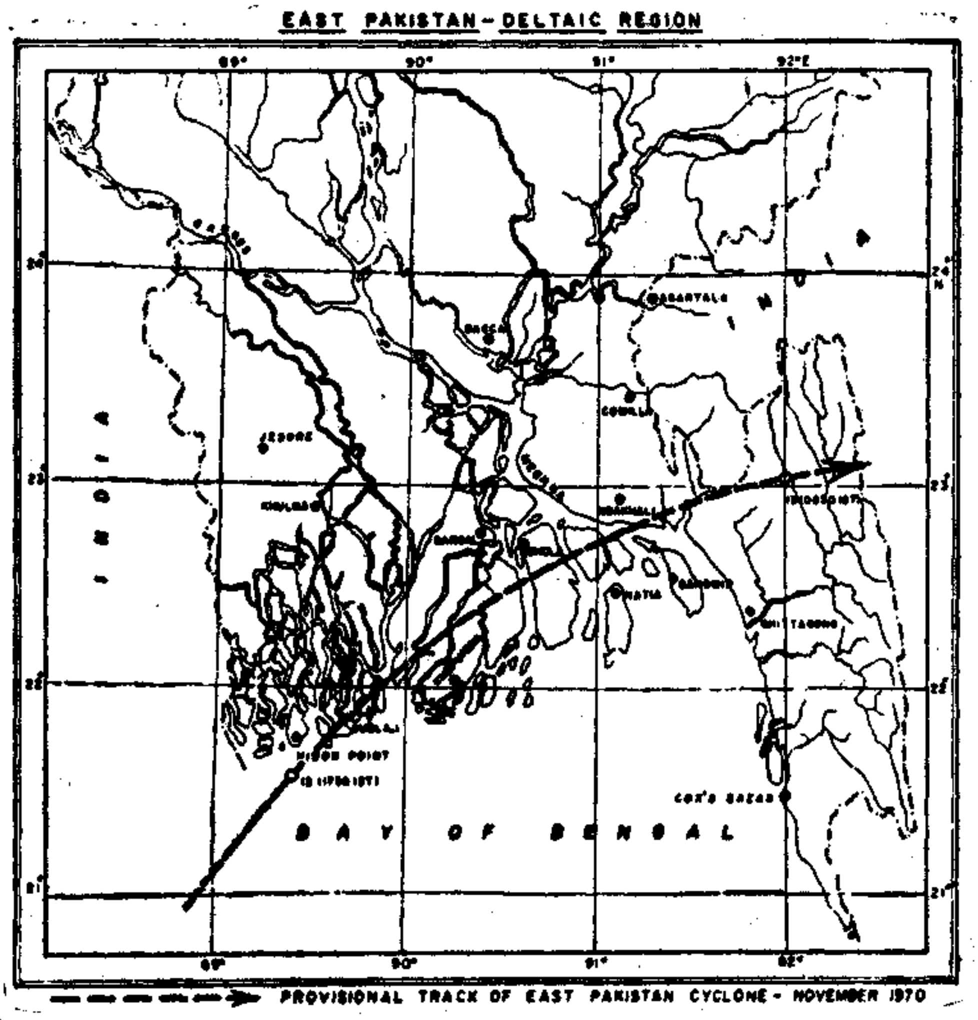

Fig. 3. The enlarged track of the storm on 12th and 13th Nov. 1970 and detailed picture of the off-shore islands.

The storm hit the East Pakistan coast towards the late evening of November 12th. Fig. 3 shows the track of the storm on 12th and 13th November 1970. The time of crossing coincides almost with the time of high astronomical tide. The height of the astronomical tide was large, because it was the period of spring tides. The interaction between the astronomical tide and the storm surge does not appear to have been worked out for a narrow estuary like the mouth of the Meghna in East Pakistan. Although it is recognised that, contrary to popular belief, a storm surge is often more effective at the time of low astronomical tide, in this particular situation we feel the surge generated by the storm must have considerably enhanced the effect of the astronomical tide.

As the storm advanced towards the coast, the whole of East Pakistan coastal belt, and its off-shore islands came under the grip of violent onshore (southerly) winds on the evening of the 12th. This must have piled up waters along the coast and could have caused huge waves in this region. The waves submerged several off-shore islands and caused immense loss of life, particularly on the islands of Hatia, Bhola and Manpura.

The prediction and warning about the occurrence of storm surges is a difficult problem which has not yet been completely solved. In an earlier study, Bhaskara Rao (1968) assumed a simplified steady-state model for storm surges and calculated the height of storm waves at different locations along the coastlines of India and neighbouring countries. His study shows the importance of the bottom topography of the sea-bed off the coastline.

A full solution for storm surge prediction must take into consideration the complete hydrodynamical equations, which govern the motion of the sea, as well as the meteorological effects of onshore winds, friction and bottom topography. We can, however, draw a few inferences which are of some interest. If ζ represents the height of the storm surge ; h, the depth of the sea-bed from the surface of the water and f, the Coriolis parameter, then

$$\zeta_t = gh \nabla^2 \zeta + f^2 \zeta$$

where we denote partial derivatives by suffixes.

If we consider a wave with phase speed c, and wave number k, that is, we put

$$\zeta \sim \exp ik(x-ct)$$

then

$$c^2 = gh - f^2/k^2$$

For a wave to be stationary, $(c = o)$, the wavelength (L) of the surge is 4800 km if the depth (h) is 100 fathoms. On the other hand, the wavelength (L) need only be 1200 km, if h is 10 fathoms.

We may thus qualitatively infer that when a storm is near the coast, the waves generated by a storm need have only a small wavelength in order to remain effectively stationary $(c = o)$.

A detailed study of this aspect will be presented in a later study.

Reference

Bhaskara Rao, N. S. 1968, Ph.D. Thesis, University of Calcutta.