FINAL REPORT

of the

MEETING OF EXPERTS

on

TROPICAL CYCLONES

IN THE BAY OF BENGAL AND THE ARABIAN SEA

21-27 OCTOBER 1970, DACCA, PAKISTAN
1. OPENING OF THE MEETING

1.1 The Meeting of Experts on Tropical Cyclones in the Bay of Bengal and the Arabian Sea was held in Dacca from 21-27 October 1970 at the invitation of the Government of Pakistan. It was organised jointly by WMO and ECAFE in collaboration with the host Government. The Meeting was attended by representatives of Burma, India, Pakistan and Thailand and observers from Switzerland and the International Telecommunications Union (ITU). A list of participants is shown in Annex 'A' of this report.

1.2 Air Vice-Marshal A. Qadir, Joint Secretary, Ministry of Defence of Pakistan, welcomed the participants to the meeting. He pointed out that the problem of tropical cyclones is a global one which cannot be solved by efforts of individual countries and that collaboration and concerted action on the part of all nations interested in mitigating the losses and suffering caused by tropical cyclones, is required. He expressed the hope that modern scientific and technological developments could be applied to tropical cyclone research and that the recommendations of the meeting would lead to the establishment of the required research facilities in the region. He offered the fullest co-operation of his Ministry and wished the Meeting a successful session.

1.3 The representative of the Secretary-General of WMO, Mr. D.H. Nijhoff indicated that his Organization attaches great importance to this Meeting and its outcome as it represents an attempt to apply meteorological science and services to reducing the devastation and loss of life caused by tropical cyclones. He indicated that the area around the Bay of Bengal has a heavier annual loss of life from tropical storms than any other area in the world but that many problems will have to be solved before an effective warning system to minimise the losses can be built up. The various components of the system including observations, telecommunications, flood warning services, disaster prevention, etc. would have to be considered properly. He indicated that WMO would be ready to help in every way possible on the basis of priorities to be set by the Meeting.

1.4 The representative of ECAFE read a message from UNYUN, Executive Secretary of the United Nations Economic Commission for Asia and the Far East. He stated that as with other formidable problems of the region, the cyclone problem could not be solved by a single country alone; it must be tackled through regional co-operation which is the essential ingredient common to a number of successful ECAFE regional projects and
is the binding force which holds the participating countries together. Noting the increased participation in the Meeting as compared to the 1966 meeting, he expressed the hope that the same spirit of co-operation would prevail in this particular project and gave the assurance that ECAFE would continue to extend its unstinted co-operation to WMO and assist to the fullest possible extent any action programme or activities that the Meeting might agree to undertake co-operatively. He also expressed the hope that the representatives of the developed countries present would extend all possible assistance to this worthy cause.

1.5 His Excellency, Vice-Admiral S.M. Ahsan, the Governor of East Pakistan began his inaugural address by referring to the tragic effects past cyclones had caused in East Pakistan and, to a lesser extent, in West Pakistan. They were relatively frequent occurrences and the Government of Pakistan was fully conscious of the need for measures to mitigate their disastrous effects. A development programme to improve the cyclone forecasting and warning service had been initiated. He reviewed briefly the improvements made so far.

1.6 In spite of the enthusiasm of the Government, he continued, the desired results could not be achieved without the collaboration of developed countries endowed with better resources and knowledge. It was not simply a question of mitigating damage, there was also a need for concerted efforts to undertake research. The Governor appealed for assistance in the establishment of a modern scientific research centre in the area to carry out extensive research. He assured the Meeting that the Government of Pakistan would be glad to support a move to establish such a centre in East Pakistan and would give it all possible financial support.

1.7 The Governor concluded his address by wishing the Meeting success and expressing the hope that it would reach valuable conclusions.

2. ELECTION OF CHAIRMAN

2.1 The Meeting unanimously elected Mr. M. Samiullah (Pakistan) as its Chairman and U Hla (Burma) as its Vice-Chairman.
3. ADOPTION OF THE AGENDA

3.1 The provisional agenda for the Meeting was adopted without amendment. It is given in Annex 'B' to the report.

4. DISCUSSION OF THE ECONOMIC EFFECTS OF TROPICAL CYCLONE DAMAGE AND THE CONTRIBUTION OF THESE STORMS TO WATER RESOURCES

4.1 The Meeting recognised the importance of the availability of data on the annual cost of cyclone damage to different sectors of the national economy and the total effect on economic development. Information of this nature was considered essential in order to be able to secure the necessary Government support for a more effective system for the reduction of damage from tropical storms.

4.2 It was agreed that information on cyclone damage for a common base period, say 1960 - 1969, for each country would enable the average annual cyclone damage for the region to be determined which would be a very useful figure for assessing the importance and priority on cyclone damage mitigation in relation to other regional projects. It was also agreed that the beneficial effects, if any, of cyclones such as their contribution to water resources should be also considered in determining the net economic effects of tropical cyclones in the region.

4.3 It was reported that in the period 1960 to 1966, no major cyclones affected Burma and that associated damage was negligible. However, three major storms struck the country from 1967 to 1968. The cyclone of May 1967 caused damage of about US $1 million; that of October 1967 resulted in damage of US $14 million in crops and US $4 million in property. In May 1968, a major cyclone caused damage assessed at US $14 million. Therefore, for the period 1960 - 1969, the total damage caused by cyclones was estimated at US $33 million or an annual average of US $3.3 million.

4.4 In India, damage caused by cyclones for the period 1960 - 1969 was estimated at US $100 million or an annual average of US $10 million. The cyclones affect the coastal areas of Andhra Pradesh, Orissa, Tamil Nadu and West Bengal and occur generally in the pre-monsoon period from April to May and the post-monsoon period from October to December.
Pakistan had collected detailed estimates of damages due to cyclonic storms/floods on an annual basis during the period 1960 - 1969. The total losses during this period excluding 1967 for which no figures were available amounted to an equivalent of about US $ 800 million which represented 2.52 percent of the Gross Regional Product of East Pakistan. Although it was agreed that the damage when expressed as a percentage of the Gross Regional Product would be more representative in portraying the effects of cyclones on an areal basis, there was a need for presenting results under a uniform yardstick which for this purpose was the Gross National Product.

It was reported that cyclones originating from the Bay of Bengal did not affect Thailand very much and that, so far, no information had been compiled or was available concerning damage caused by cyclones to the country.

In discussing the damage caused by cyclones to the region, a note of caution was sounded concerning figures which may be quoted from press reports which were often unverified. In this connection, the attention of the Meeting was called to the decision of the twenty-second session of the WMO Executive Committee stressing the need for WMO Members to make systematic assessments whenever possible, including information on the cost to different sectors of the economy such as agriculture, industry, transport, etc. The WMO Executive Committee, noting that such studies had been carried out for some areas of the world, requested the WMO Secretary-General to collect from Members concerned copies of official surveys on the cost of tropical storm damage and, upon request, to make this information available to interested Members.

In the light of this decision, the Meeting urged those countries in the Bay of Bengal and the Arabian Sea area to arrange for systematic assessments to be made of the damage caused by all cyclones affecting their territory and to send reports thereon to the WMO and ECAFE Secretariats.

As no data on the breakdown by economic sectors of cyclone damage was provided by the countries attending the Meeting, the methods used in estimating cyclone damage were discussed. The Meeting was informed that the first meeting on cyclones held in Dacca in 1966 had discussed this problem and had recommended that the methods used by the Government of
Japan be adopted, but so far the countries had not submitted any reports to either ECAFE or WMO. It reiterated the need to make use of this method.

4.10 The Meeting also considered the beneficial effects of cyclones particularly on the water resources of the countries affected. In Burma it was reported that there was not much contribution to the water resources of the country, although in some cases it might have given increases in crops yields. In India, no data on this subject was available and it was felt that studies on this matter were required. It was considered, however, that cyclones only make an effective contribution in areas of low total annual rainfall and high variability.

4.11 In East Pakistan, studies showed that the total rainfall volume generated by cyclones from 1960 to 1969 was about 70.29 million acre-feet and the runoff volume was 31.90 million acre-feet or an average discharge of 5,300,000 cfs. However, this runoff was wasted into the sea and was of no beneficial use to East Pakistan. In certain cases, during dry periods, cyclonic rainfall helps in the healthy growth of crops by providing much needed soil moisture.

4.12 The consensus of the Meeting, however, was that it was difficult to express quantitatively any beneficial effects of cyclones as no studies had been made on this subject.
5. Review of the meteorological, telecommunication and hydrological facilities needed for the reduction of cyclone damage

5.1 Meteorological facilities - Global Observing System (GOS)

5.1.1 The Meeting of Experts studied in considerable detail the different components of the observing system in the countries affected by tropical cyclones in the Bay of Bengal and the Arabian Sea. It expressed the view that this system, together with the appropriate telecommunications links to complement it, formed the essential foundation for any cyclone warning system designed to save human lives and to reduce damage. It, therefore, considered that the establishment of an improved observing system with all the necessary facilities would constitute a valuable first step towards the above objectives.

5.1.2 In making its review of the components forming part of the observing system, the Meeting noted that the requirements had already been laid down in many respects and were shown in the regional basic synoptic network adopted by the fifth sessions of Regional Association II (Asia) and of V (South West Pacific) and in the World Weather Watch plan. However, it felt that there is a need to define more specifically those facilities which are of particular importance for cyclone warning purposes, including those additional to the World Weather Watch plan, and also to advise countries on the most suitable method of obtaining aid for their implementation when national resources are insufficient. The views of the Meeting and its recommendations on this item are recorded below under each component.
Surface and upper-air land stations

5.1.3 The Meeting noted the information provided by participants and the WMO Secretariat on the present state of implementation of the surface and upper-air land stations in the area 0°-25°N and 60°-105°E. As regards surface observations, it was felt that the only serious deficiencies are at the hours of 15, 18 and 21 GMT; however, most countries had already announced plans to implement these observations over the next two or three years. In accordance with the decision of V-RA II, the Meeting stressed the need for priority to be given to implementing the 18 GMT observations. It also felt that in tropical cyclone situations there would be a need for additional special observations and that provision for those should be given priority.

5.1.4 In considering the network of upper-air observations, the Meeting also took into account the recent decisions of C3M-V and V-RA II that when two observations cannot be made daily, preference should be given to the 00 GMT observations. The Meeting noted that this decision was already being followed in most of the countries concerned, although there were some serious deficiencies at both 00 and 12 GMT. Attention was directed in particular to those stations close to coastal areas in which the 00 GMT observation is not yet made and to which priority should be given in implementation plans. In this context reference was also made to the list of stations to be given high priority adopted by V-RA II. As a consequence, the Meeting urged that early plans be made for the implementation of the 00 GMT observation at a number of stations either from national resources or, where necessary, by seeking assistance for this purpose. When a full radiosonde/radiowind observation programme is not possible, the Meeting stressed the desirability of making at least upper wind observations.
5.1.5 The decisions of the Meeting with regard to priorities in the implementation of surface and upper-air land stations are summarised in paragraph 5.1.20 below.

APT Stations

5.1.6 The value of satellite observations as a means of detecting and tracking tropical cyclones was emphasized by the Meeting. In reviewing the list of APT stations already in operation or planned in the area of interest, it was noted that only two Members would be without a station by the end of 1970. The Meeting was also informed of the plans of some countries for the installation of additional APT stations.

5.1.7 The Meeting recommended that APT stations should be installed in Rangoon (Burma) and Colombo (Ceylon) as soon as possible in accordance with the requirement of the WMO plan for at least one station in each Member country. Although the VAP requests submitted for these stations had been approved for circulation, it was noted that no offers of the equipment had yet been made. It was, therefore, decided to include these stations in the priority list drawn up by the Meeting in order to invite the attention of prospective donors to the urgency of providing these facilities. The need for APT stations to be equipped to receive infra-red night-time cloud images as well as daytime cloud photographs was also highlighted. Attention was also invited to the advantages of locating APT stations close to cyclone warning centres.
Storm-warning radar stations

5.1.8 The existing and planned network of storm-warning radar stations was examined closely in view of the effectiveness of radar for cyclone warning purposes. The Meeting recognized that the countries concerned had fully shown their awareness of the importance of radar stations by devoting considerable effort to the establishment of such stations and by planning further installations of this type. It considered that the plans already made would provide an excellent coverage of a large part of the area affected by tropical cyclones. Nevertheless, the Meeting felt that there was a need for a small number of additional radar stations to complete the coverage, notably in the east of the Bay of Bengal. It accordingly included these stations in the priority list, expressing the hope that a complete coverage of the area by 10 cm radars would be achieved as quickly as possible. The importance for cyclone warning purposes of using radar equipped with an iso-echo contouring device was also stressed.

Fixed ocean stations

5.1.9 The Meeting of Experts recognized that the very high capital and running costs of fixed ocean stations made it unlikely that they could be considered as part of the observing system. Experience in different parts of the world in recent years had demonstrated clearly that Members were not able, either individually or collectively, to bear the costs associated with the operation of fixed ocean stations. At the same time the need for an improvement in the amount of data received from ocean areas was pressing, and vital to an efficient storm-warning service.
5.1.10 It was accordingly decided to concentrate on obtaining the data required by other methods such as the use of island stations, mobile ships, research and fishing vessels, together with the new techniques under development such as vertical soundings from satellites.

**Mobile ships**

5.1.11 The continuing need to take full advantage of mobile ships as a potential source of observations was agreed by the Meeting. It recalled that Fifth Congress had called for a substantial increase in the use of mobile ships but that efforts to recruit these additional ships had been only partially successful to date.

5.1.12 Although it was widely recognized that ships avoid storm areas, thereby limiting their usefulness for storm warning purposes, the Meeting felt that further strenuous efforts should be made in each of the countries affected by cyclones in the Bay of Bengal and the Arabian Sea to recruit more mobile ships to make both surface and upper-air observations. It was felt that one step that could be taken to this end would be for each country to ensure that its Port Meteorological Officers took full advantage of their opportunities in this respect, and especially in recruiting auxiliary ships to support the selected and supplementary ship programme. Adequate arrangements for the collection of ship reports through coastal radio stations linked to National Meteorological Centres should also be ensured. In this context, the Meeting considered that it might be necessary for countries to designate new coastal radio stations in some areas and to speed up the arrangements for the collection of the reports and their onward transmission to the National Meteorological Centres.
5.1.13 Finally, the Meeting expressed the view that the introduction of radiosonde observations on board ships crossing the Bay of Bengal and the Arabian Sea would provide an important improvement in the upper-air network in the tropical cyclone area. It recommended that each country should further investigate the possibilities of initiating such programmes on ships plying these waters as a matter of priority. Moreover, it indicated that VAP assistance for ground equipment and a limited supply of expendables might be requested if national resources were not available for this purpose.

**Automatic weather stations**

5.1.14 The increased recognition given to automatic weather stations in recent years as a means of augmenting the network of Manned stations was considered by the Meeting of Experts to be of direct interest in the context of a programme to improve the observing system. Their possible use, especially in sea areas affected by tropical cyclones, was closely examined by the Meeting.

5.1.15 The experience of Members in using automatic stations led the Meeting to record its view that the prime need in the area concerned was for a simple but robust automatic station capable of withstanding cyclone conditions. It further considered that such a station should measure only a few elements, perhaps only pressure, wind speed and direction, in order to make it as inexpensive as possible. Although the Meeting was conscious of the many problems associated with the operation of automatic stations in ocean areas, it felt that there were shallow waters in both the Bay of Bengal and the Arabian Sea in which automatic stations could be moored. It, therefore, recommended that such stations should be installed at least three locations in the head of the Bay of Bengal. The use of drifting stations should also be considered.
5.1.16 In recommending the use of automatic stations, the Meeting was of the opinion that it would be necessary to carry out trials under cyclone conditions in order to determine the type of platform and instrumentation best suited to the conditions they would meet. It suggested that this was a field in which collaboration between the countries affected would be of particular value. The possibility of joint servicing arrangements between the countries operating the stations should also be investigated.

Aircraft reports

5.1.17 The current arrangements for the collection and distribution of aircraft reports in the area of interest were reviewed by the Meeting. The need to make maximum use of all available reports, including post-flight reports, was stressed. The Meeting also felt that there was scope for improvements in the exchange of aircraft reports.

5.1.18 The Meeting learned with great interest of the steps being taken by some countries in the area to introduce meteorological reconnaissance flights. It considered that these flights were especially valuable for maximum wind and storm surge forecasting and urged that they be introduced as soon as possible and the results made speedily available to all interested Member countries for both operational and research purposes. The Meeting noted the need for accurate navigational aids such as Doppler radar for wind determination and other types of equipment for aerial reconnaissance. It considered aid might be sought from external sources for this purpose.

Microseisms

5.1.19 Although the Meeting did not feel that there was any special requirement for microseismic observations for operational purposes, it expressed the view that research into their use for cyclone warning purposes could usefully be pursued by individual countries.

Conclusions

5.1.20 At the end of its review of the observing system, the Meeting drew up a list of those facilities which it felt were most urgently needed and to which the Members responsible should give priority. These facilities are listed below:
Global Observing System (GOS)

**Land stations**

**Surface**
18 GMT observations where not already made.
Special observations in tropical cyclone situations.

**Upper-air**
- 43368 Car Nicobar - 00 GMT radiowind
- 48062 Akyab - 00 GMT radiosonde and radiowind
- 48108 Tavoy - 00 GMT radiowind
- 48109 Coco Island - 00 GMT radiowind
- 48112 Victoria Point - 00 GMT radiosonde and radiowind

96011 Bandaatjeh
Blangbintang - 00 GMT radiowind

**APT Stations**
- Rangoon (Burma)
- Colombo (Ceylon)

**Storm-warning Radar Stations**
- Akyab (Burma)
- Rangoon (Burma)
- Trincomalee (Ceylon)
- Port Blair (India)

**Mobile Ship Programme**

Upper-air observations

**Meteorological reconnaissance flights**

5.1.21 The Meeting requested the Secretary-General of WMO to explore the feasibility of assisting countries wherever possible in the implementation of the facilities set out above.
5.2 Telecommunication facilities - Global Telecommunication System (GTS)

5.2.1 The Meeting based its study of the telecommunication system required for cyclone warning purposes on the plans adopted by Region II (Asia) and Region V (South-West Pacific) to meet the requirements of the World Weather Watch. It stressed that the full implementation of those parts of the plans of direct concern to the countries affected by tropical cyclones was of fundamental importance to the design of an improved warning system. It then examined the information provided by the WMO Secretariat on the regional and national telecommunication networks, their present status of implementation and the known plans for the further implementation of the GTS over the next few years.

Regional telecommunication networks

5.2.2 Although a number of important regional circuits have not yet been established, the Meeting noted that there are well-established plans for the implementation of many of them over the next one to two years. These plans were based mainly on the use of national resources although in several cases aid has also been sought through the WMO Voluntary Assistance Programme (VAP). It was also pointed out that no offers have yet been made for some of the links for which VAP projects have been approved for circulation. The early implementation of these links could not, therefore, be guaranteed. The Meeting accordingly decided to invite the attention of prospective donors to these links and, for this purpose included them in its list of facilities for which priority action is desirable.

5.2.3 The need for regional circuits to comply with the engineering principles adopted for the World Weather Watch was also underlined. In addition, the Meeting drew attention to the importance of scheduling transmissions of
urgent data and warnings related to tropical cyclones so that they could be broadcast without delay.

5.2.4 The Meeting took note of the formation of the ITU Regional Telecommunication Network Survey Project which could take into account the needs of the Meteorological Services for regional links in drawing up its plans. Besides providing high quality telecommunication links between the various countries in the region, it would reduce the demand on the H.F. spectrum and relieve the existing congestion.

National telecommunication networks

5.2.5 An examination of the national collection facilities revealed that improvements are needed in most countries before all the observational data can reach the National Meteorological Centre within the specified time limits and with complete reliability. Attention was already being devoted to this problem by the countries concerned and plans had been established to complete the collection facilities from national resources or through VAP projects. As for the regional telecommunication circuits, it was noted that no offers had yet been forthcoming for some of the requests made under VAP. The Meeting considered that VAP requests for SSB transceiver sets had been successful for countries in many parts of the world and, therefore, expressed the hope that donors would soon be forthcoming for the relatively small number of sets required in the tropical cyclone area. It decided to add this need to its list of facilities requiring priority treatment.

Other telecommunication facilities

5.2.6 Attention was also drawn to the need for the early conversion of morse
broadcasts to RTT wherever this has not already been done.

5.2.7 The Meeting noted that there were approved micro-wave projects for linking Cox's Bazar and Khepupara with Dacca. It felt that Storm Warning Radar Stations should be linked with national collection centres by reliable telecommunication links (micro-wave, co-axial cables etc.)

Conclusions

5.2.8 Having reviewed the regional and national telecommunication systems, the Meeting drew up a list of those facilities which it felt were most urgently needed and to which the Members responsible should give priority. These facilities are listed below:

Global telecommunication system (GTS)

Regional telecommunication links

- Bangkok - New Delhi
- New Delhi - Karachi
- Dacca - Bangkok

National collection facilities

- in Burma (10 SSB Sets)
- India (for 43388 Car Nicobar)
- Indonesia (for radiowind observations from 96011 when established)
- Pakistan (8 SSB Sets)

Other telecommunication facilities

- Reliable telecommunication links from radar stations to national
5.3 Hydrological facilities

5.3.1 The Meeting noted that as it would be impossible to completely provide flood protection works for areas subject to flooding, accurate flood forecasts and timely warnings would effectively minimize loss of life and property. Noting that developed countries like the U.S.A., Australia and Japan had demonstrated the value of flood forecasting and warning systems in considerably reducing flood damage in areas subject to flooding, the Meeting considered that the establishment of such systems was one of the major measures which should be taken in any programme for the mitigation of cyclone damage.

5.3.2 Hydrological facilities are indispensable in setting up such systems which can provide reasonably accurate flood forecasts and timely warnings. Such facilities may be classified into two groups. The first group was the design network which included all hydrologic facilities required for the collection, study and analysis of hydrologic data needed for the formulation of the flood forecasting and warning system to be adopted. The other group, named the operation network, consisted of the hydrologic stations, telecommunication equipment used to transmit and relay hydrologic data and the operation centre where the data was analysed, flood forecasts prepared and warnings issued.

5.3.3 In considering this item the Meeting realised the difficulty of separating the effects of tropical cyclones of different intensities. It, therefore, agreed that the scope of the discussions be expanded to include flooding due to tropical cyclones of different intensities.
5.3.4 Although cyclones do not cause much flooding in Burma, flash floods occasionally occurred in the upper reaches of the Sittang, Mv and Chindwin River Valleys. The Meteorological Department of Burma is operating more than 35 river gauge stations. Seven of the nineteen recording stations are discharge measuring stations. Since 1966, river forecasting had been started on the Sittang, Irrawaddy, Chindwin and Pegu Rivers. At present a survey of these river basins is being undertaken as UNDP Projects.

5.3.5 The river catchments on the East Coast of India which were affected by tropical cyclones from time to time, are the Subarnarekha and the Burhabalang. River gauge and rainfall data of about a dozen important locations in the basin were sent by radio (VHF) to the Flood Forecasting Centre at Balasore. In the West coast, the river basins affected by cyclones were the Narmada and the Tapti. River gauge and rainfall data of ten stations in the basins were sent by radio (HF) to the Flood Forecasting Centre at Surat. In addition, heavy rainfall warnings were issued to irrigation, hydel, railway and communication engineers working in the catchments of several rivers in both eastern and western coasts.

5.3.6 The Central Water and Power Commission of India had established a flood forecasting centre at Delhi for the Yamuna river in 1968. In 1969, six more centres were set up for the Brahmaputra valley in Assam, Teesta valley in West Bengal, Ganga and its tributaries in Uttar Pradesh and Bihar, in coastal areas of Orissa and Andhra Pradesh, and on the Tapti and Narmada in Gujarat State. The centres are located in Gauhati, Jalpaiguri, Patna, Lucknow, Balasore and Surat. The India Meteorological Department assists the CWPC in organizing the flood forecasting services and maintaining and developing the network of raingages. It was considered necessary to establish another flood forecasting and warning centre on the eastern coast of India south of the Balasore Centre.
It was reported that the flood forecasting and warning organization of the Pakistan Meteorological Department at Lahore provided flood forecasts with 70 to 90 per cent accuracy for the Sutlej, the Ravi, the Chenab, and the Jhelum Rivers in West Pakistan which were, however, affected by cyclones to a much lesser extent than those in East Pakistan. In East Pakistan there are as yet no flood forecasting and warning facilities. In this connection, the following measures listed in the order of their priority were recommended as important and necessary components of a comprehensive programme for the mitigation of flood damage in Pakistan:

(i) Organisation of a flood forecasting and warning service in East Pakistan.

(ii) Installation of equipment to complete the design network of the East Pakistan Water and Power Development Authority (EPWAPDA). The required equipment is listed in Annex C.

(iii) Training of meteorologists and engineers in modern methods and techniques of flood forecasting and warning including the application of computers.

(iv) Expansion of the existing flood forecasting service in West Pakistan to cover the lower reaches of major rivers and coastal streams.

(v) Establishment of another Flood Forecast Office in Karachi. The equipment required for this purpose is shown in Annex D.
5.3.8 In Thailand which is only slightly affected by cyclones, the Ping river was sometimes flooded as a result of cyclone rains. Only about 30 per cent of the floods which occurred in the river were due to both cyclones and typhoons.

5.3.9 The Meeting stressed that the fullest possible regional co-operation should be established to ensure the expeditious exchange of hydrological data of international rivers for the purpose of facilitating the preparation and dissemination of accurate and timely flood forecasts. In this connection, specific data required by Pakistan from India for flood forecasting purposes are listed in Annex E. The delegate from India stated that these requirements should be referred for detailed study and examination by experts on a bilateral basis, especially with reference to the tropical cyclones and floods mentioned in para 5.3.3.
5.4 Warning services (including improved liaison between forecast centres)

5.4.1 The Meeting began its study of this item by considering the present arrangements for the preparation and distribution of tropical cyclone warnings in the countries around the Bay of Bengal and the Arabian Sea. It was informed of the various tropical cyclone forecast centres established in these countries and of the methods used in carrying out their functions. The Meeting also heard with great interest of the plans of India and Pakistan for the establishment over the next few years of new cyclone warning and research centres.

5.4.2 The Meeting was of the opinion that the present arrangements whereby cyclone forecasting and warning services were organised on a national basis must continue for the present at least. It recognised that there are variations in the present arrangements and felt that the main task for the immediate future would be to improve these arrangements and to endeavour to reach a more uniform system in all the countries concerned. This could best be affected by much closer collaboration between the Meteorological Services.

5.4.3 The Meeting considered that there were a number of ways in which closer liaison could be attained and made a number of suggestions to this end. It stressed that the list below was not exhaustive and that other items requiring attention would emerge as the collaboration progressed and became closer. The points mentioned are given below:

(a) Regular and reliable exchange of basic observational data. Test checks might be required to isolate the deficiencies in the present system, and their causes;
(b) Regular and reliable exchange of processed data;
(c) Comparison of analysis and forecasting methods, including the exchange of views on the evolution of actual cyclone situations and co-ordination of the forecasts issued;
(d) Exchange of views on the issue of warnings and their contents;
(e) Arrangements for the distribution of warnings to ensure that they reach all concerned speedily;
(f) Exchange of information on research and developments associated with tropical storms;
(g) Exchange of scientists between forecasting and research centres;
(h) Availability of national training facilities to staff from other countries in the area;
(i) Joint operation of facilities, such as meteorological reconnaissance flights, too costly to be supported entirely by one nation;
(j) Periodic meetings between representatives of the countries concerned to compare progress and plan further joint effort to reduce tropical cyclone damage.

5.4.4 The Meeting recognised that, in many areas affected by tropical cyclones, enormous damage is caused by accompanying storm surges. For such areas, it was agreed that a considerable reduction in damage to life and property could be effected if storm surge forecasting and warning systems could be established in coastal areas specially vulnerable to this type of hazard.

5.4.5 It was reported that India would establish at Madras within the next two or three years a Cyclone Warning and Research Centre to coordinate the activities of the various Cyclone Warning Centres in the country and conduct research into tropical cyclones. One of the functions envisaged for this Centre was to study storm surges affecting the coastal belts of India, Pakistan and Burma. In the meantime, storm warnings being issued by the cyclone warning centres at Calcutta, Madras and Bombay included qualitative warnings on storm surges.

5.4.6 The Meeting was informed that in the coastal districts of East Pakistan, by far the greatest damage was caused by storm surges which occasionally reach destructive heights of 30-40 feet. During the period from 1780 to 1969, thirteen storm surges affected East Pakistan. For the purpose of reducing the enormous damage caused by this phenomenon, the Pakistan Meteorological Department had prepared a scheme to organise a Storm Surge Forecast Section in the Regional Storm Warning Centre at Dacca in a few years time.

5.4.7 In order to provide storm surge forecast and warning service, it was considered necessary to install automatic water level recorders
at the following locations:

- Teknaf, Chittagong, Naf River Basin
- Hatia, Noakhali, Hatia Channel
- Sandwip, Chittagong, Sandwip channel
- Chandpur, Comilla, Meghna River Basin
- Tajuddin, Bhola, Meghna River Basin
- Kuokata, Patuakhali, near the Bay of Bengal

5.4.8 The Meeting recommended that special attention be given by all countries concerned to encourage studies of storm surges with a view to provide quantitative forecasts of storm surges for affected coastal areas. Studies should be undertaken for the development of quantitative techniques for forecasting tidal bores particularly in the Hooghly and in the Meghna. Similar studies about tidal action was needed for the Palk Strait.

6. Community preparedness and disaster prevention, including public warning and information services

6.1 Discussion of this item was based upon a number of documents submitted to the Meeting on the community preparedness and disaster prevention measures taken by the countries concerned in the tropical cyclone area. In this connection, the Meeting was informed that community preparedness and disaster prevention involves two elements. The main element consists of the plans and facilities prepared and action taken mainly by the public sector in co-operation with rescue, relief and rehabilitation agencies. The other element consists of the human response to the plans prepared and facilities provided by the government or other agencies.

6.2 With regard to the first element attention was first given to the various long-term measures that can be taken to mitigate cyclone damage. The Meeting considered that the first step in this direction was for each country to draw up a national disaster plan. It was noted in this connection that one country had under preparation a "Model Cyclone Plan for Coastal Districts" giving the guidelines for the action to be taken when cyclones threaten. The Meeting felt that contingency plans of this type were needed in each country and should be as clear and as simple as possible. They should cover arrangements for the evacuation of people
6.3 It was also felt that the holding of periodic exercises to test the efficiency of the plan and to ensure that each individual is fully aware of what he must do were highly desirable.

6.4 Other long-term measures that countries could take were mainly of an engineering type. Thus, the erection of wind breaks, levees and dykes, as well as flood storage and drainage facilities could effectively reduce cyclone damage. Storm shelters in which the population can take refuge should also be constructed and a building code to ensure the structural safety of buildings should be drawn up.

6.5 The Meeting then turned its attention to the action necessary when a cyclone was imminent. The main requirement at this stage would be to ensure that all those in danger were warned and that the emergency plan came smoothly and efficiently into operation. Here again the need for adequate telecommunication facilities was emphasised. It was noted that close supervision of the development of the storm and its associated dangers was essential so that fresh measures to avoid loss of life and damage could be taken as necessary. Here again there was a need for co-ordinated action on the part of all the authorities concerned.

6.6 The Meeting recognized that in spite of all the precautionary steps taken some lives would still be lost and damage would occur. There was accordingly a need for rescue and relief action. It was noted that the League of Red Cross Societies had just published a Disaster Relief Handbook. This publication contained a great deal of valuable material and the Meeting expressed the hope that it could be made available to all interested.

6.7 With regard to the second element which consists of the human response to community preparedness plans, ECAFE engaged a consultant to prepare a case study "Human Response to Cyclone Hazards" on this subject.
For this study, the island of Char Jabbar was selected. It is situated at the mouth of the delta of the Ganges - Brahmaputra - Meghna rivers almost in the northern end of the Bay of Bengal some 16 miles away from the Noakhali mainland in East Pakistan. Being comparatively flat, the island was exposed to cyclones. The socio-economic characteristics of the area were studied in the process of which about 200 people were interviewed and their response to the cyclone hazard was analysed.

6.8 It was found that the key to the human response in the area was the general educational level. Although a large per cent of those interviewed expected cyclones to recur and cause severe damage, most of them had no plans to leave the area due to the uncertainty of making a living elsewhere. Fatalism combined with optimism was the prevailing attitude which was the main factor controlling the decision making process of the residents. Tradition and customs also played an important role in the human response of the area. For example, evacuation plans and measures were often ignored because women did not wish to walk long distances in public. Therefore close relatives of the women preferred to stay with them and risk the dangers involved. Under these circumstances, the residents had evolved their own sets of adjustments which in most cases were independent of the plans and measures prepared and advocated by the government and other agencies.

6.9 Therefore, the Meeting stressed that in the formulation of community preparedness plans to cope with the cyclone hazard, the existing socio-economic conditions in the communities concerned as well as the possible human response to proposed adjustments must be fully considered.

6.10 In conclusion, the Meeting wished to draw attention to the great importance it attached to community preparedness and disaster prevention. It was of the opinion that no programme to reduce cyclone damage could succeed without a soundly-based organization in each country for this purpose. For this reason, it strongly recommended that a survey of community preparedness arrangements be made in each of the countries and suggested that this task might best be carried out by an expert from the League of Red Cross Societies. The Secretary-General was requested to explore the possibility of arranging for such a survey with the LRCS. It was further recommended that the terms of reference of this expert should include a study of building code specifications and arrangements for more publicity in respect of the community preparedness programme.
7. Development of a co-ordinated technical plan to reduce tropical cyclone damage

7.1 Provision of additional facilities

7.1.1 The need for the early implementation of additional meteorological, telecommunication and hydrological facilities was discussed in detail under agenda items 5.1, 5.2 and 5.3 respectively. The Meeting established a list of those facilities which it considered to be of particular importance as part of the tropical cyclone warning system for the area and urged that they should receive first priority in implementation.

7.1.2 The Meeting noted that plans already existed for the early implementation of some of the facilities in the priority list. It pointed out that Member countries should make every effort to adhere to the schedule already established for the setting up of these facilities. If it appeared likely that national resources would not be able to support them until a later date, consideration should be given to seeking assistance from other sources as soon as possible. For those facilities for which there were no plans at present, requests for aid through the WMO VAP, UNDP or bilateral projects should be made at an early date. The Meeting requested the Secretary-General of WMO to provide such advice and assistance as he could for this purpose.

7.1.3 Noting that the facilities in the priority list were primarily those already forming part of the World Weather Watch plan, the Meeting also felt that other additional facilities might be needed purely for cyclone warning purposes. Mention was made of a general need for achieving facilities in the area affected by tropical cyclones and it was also recognized that there would be requirements for some special observing and telecommunication facilities. However, the Meeting did not feel able to specify these facilities in detail during the time available. Taking into account the fact that the Meeting could only draw up a broad outline of a technical plan which would need to be elaborated later, it was decided not to list any additional facilities until further consideration had been given to the precise needs.

7.2 Community preparedness and long-term planning for disaster prevention

7.2.1 The main decisions under this heading were taken under agenda
item 6. However, the Meeting felt it desirable to stress again the special importance of community preparedness as part of any co-ordinated plan to reduce tropical cyclone damage. It was pointed out that the availability of all the technical facilities necessary, together with a sound forecasting and warning service, would serve no useful purpose unless accompanied by the organization of efficient community preparedness. The prime object of the Meeting was to devise measures to save human life and to reduce the damage caused by tropical cyclones; the role of community preparedness and disaster prevention was therefore of paramount importance.

7.3 Regional Tropical Cyclone Warning Centre

7.3.1 The Meeting reconsidered the recommendation made by the Working Group of Experts on Tropical Cyclones in the Bay of Bengal in 1966 for the establishment of a Regional Cyclone Warning Centre with responsibilities for research. It was of the opinion that the functions carried out by the various national warning centres could not be fully centralized at the present time. It felt that it had already recorded in some detail under item 5.4 its views on the need for closer collaboration between the countries concerned and that, for the immediate future, further efforts should be directed towards that end.

7.3.2 At the same time the Meeting was also informed of the plans of India to develop its Cyclone Warning and Research Centre at Madras, and of the plans of Pakistan to build up the new Regional Cyclone Warning Centre in Dacca and to add research responsibilities. The Meeting was of the opinion that the functions of these national centres were of very great importance to the efforts being made to reduce cyclone damage. The Meeting noted that considerable progress has been achieved at Dacca in East Pakistan and at Madras in India. It, therefore, recommended that these two centres be recognised as tropical cyclone warning and research centres in this region. Noting that these two centres could not fully meet the needs of all countries in the cyclone area, the Meeting decided to encourage all countries of the area, specially Burma and Thailand, to set up similar centres. It also felt that the centres would need assistance from external sources in order to carry out their plans fully and that in seeking this aid equal importance should be given to each of the centres in the cyclone area.
involved. This task was evidently not one the Meeting could carry out and it therefore gave its attention to other possible methods of making the detailed studies required. The solution most favoured by the Meeting was that this work should be carried out by the countries themselves under the general guidance of the Panel.

8. Proposals for further concerted action

8.1 Finally, the Meeting considered how best to meet the need for further measures to ensure progress in carrying out the programme it had proposed under earlier items of the agenda. There was unanimous agreement that the successful implementation of an improved cyclone warning system, in all its aspects, could result only from a closely co-ordinated programme. It was felt that an essential feature of such a programme would be the setting up of a Panel consisting of representatives of all the countries participating in the programme to co-ordinate its progress and to plan its further development.

8.2 Because of the highly technical nature of the functions it would have to carry out, the Meeting proposed that the Panel should be composed of representatives of national authorities involved in the design and execution of measures to combat the adverse effects of tropical cyclones. As the Panel would have to depend on both WMO and ECAFE for its support, the Meeting considered that it should be set up under the aegis of these two organizations. It further suggested that the Panel might be termed the WMO/ECAFE Panel on Tropical Cyclones and that provision should be made for it to meet about once a year.

8.3 On the basis of the views expressed above, the Meeting requested the Secretary-General of WMO and the Executive Secretary of ECAFE to:

(a) establish a joint WMO/ECAFE Panel on Tropical Cyclones at the earliest possible date;
(b) invite all countries affected by tropical cyclones in the Bay of Bengal and the Arabian Sea* to participate in the activities of the Panel;

* The Meeting expressed the view that the countries mainly concerned were: Burma, Ceylon, India, Pakistan and Thailand. It, however, felt that some other neighbouring countries might also be interested to participate.
(c) draft the terms of reference for the consideration and adoption by the Panel at its first meeting;
(d) arrange, in consultation with the members of the Panel, for it to hold its first meeting at a mutually convenient time and place;
(e) provide the support needed for the Panel to carry out its functions efficiently and effectively.

8.4 The Meeting suggested that the terms of reference should cover
(a) meteorological, telecommunication and hydrological programmes; and
(b) community preparedness and disaster prevention measures relevant to the mitigation of cyclone damage.

8.5 The Meeting also requested the Secretary-General of WMO and the Executive Secretary of ECAFE to invite the attention of the countries concerned to the importance of full and active participation in the work of the Panel. It also stressed that other countries interested in the tropical cyclone problem should be invited to the meetings of the Panel.

9. Closure of the Session

9.1 On the last day of the session the representatives of WMO, ECAFE and several delegates and observers expressed their sincere gratitude to the Government of Pakistan for providing excellent facilities for the work of the session and for the generous hospitality shown to all participants. The speakers also thanked Mr. Muhammad Samiullah, Chairman of the Meeting, for his able and efficient conduct of the work of the session. They also expressed their warm appreciation to the staff of the Local Secretariat whose hard work had contributed to the success of the Meeting.

9.2 The delegate of Pakistan thanked all those who expressed their appreciation to his country for hosting the session.

9.3 In conclusion, Mr. Muhammad Samiullah, Chairman of the Meeting, expressed appreciation of the spirit of mutual goodwill and co-operation which had prevailed among delegates throughout the session.

9.4 The Meeting closed on 27 October 1970.
ANNEX - A

LIST OF REPRESENTATIVES AND OBSERVERS

**Representatives**

**BURMA**
- U Hla
- U Hla Tin

**INDIA**
- P.K. Das

**PAKISTAN**
- Mohammed Samiullah, T.Pk.
- M.W. Rizwi
- M. Mohiuddin
- A.T.M. Nasiruddin
- S. Jalaluddin Ahmed
- K.G. Mowla
- Zarif Ahmed
- S.A. Hussain, T.K.
- M. Yaseen
- M.R. Tariqdar
- W.U. Khan
- S.N. Naqvi (Adviser)

**THAILAND**
- P. Sontarotock
- C. Swatdirurk

**Observers**

**SWITZERLAND**
- C. Fourcy

**ITU**
- R. Seshasayee

**Secretariat**

**ECAFE**
- A.S. Manalac
- M. Rabomura
- Professor A. Islam (Consultant)

**WMO**
- D.R. Nigam
- P. Rogers

**Conference Secretariat**
- M.S. Haq
- M.H. Siddiqui, T.K.
- M.A. Rauf
AGENDA

1. Opening of the meeting
2. Election of chairman
3. Adoption of the agenda
4. Discussion of the economic effects of tropical cyclone damage and the contribution of these storms to water resources
5. Review of the meteorological, telecommunication and hydrological facilities needed for the reduction of cyclone damage
   5.1 Meteorological facilities
   5.2 Telecommunication facilities
   5.3 Hydrological facilities
   5.4 Warning services
6. Community preparedness and disaster prevention, including public warning and information services
7. Development of a co-ordinated technical plan to reduce tropical cyclone damage
   7.1 Provision of additional facilities
   7.2 Community preparedness and long-term planning for disaster prevention
   7.3 Regional tropical cyclone warning centre
8. Proposals for further concerted action
9. Closure of session
## ANNEX - 0

**HYDROLOGIC EQUIPMENT REQUIRED TO COMPLETE DESIGN NETWORK FOR FLOOD FORECASTING AND WARNING IN EAST PAKISTAN**

1. Seven telemetering rain gauges:

<table>
<thead>
<tr>
<th>Location</th>
<th>River Basin</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Sylhet</td>
<td>Meghna</td>
</tr>
<tr>
<td>b. Penggarh</td>
<td>Feni</td>
</tr>
<tr>
<td>c. Bandarban</td>
<td>Sangu</td>
</tr>
<tr>
<td>d. Ishurdi</td>
<td>Ganges</td>
</tr>
<tr>
<td>e. Dalia</td>
<td>Teesta</td>
</tr>
<tr>
<td>f. Chilmari</td>
<td>Brahmaputra</td>
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<td>g. Rangamati</td>
<td>Karnaphuli</td>
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</tbody>
</table>

2. Six telemetering water level recorders:

<table>
<thead>
<tr>
<th>Location</th>
<th>River Basin</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Bahadurabad</td>
<td>Brahmaputra</td>
</tr>
<tr>
<td>b. Paksey</td>
<td>Ganges</td>
</tr>
<tr>
<td>c. Bhairab Bazar</td>
<td>Meghna</td>
</tr>
<tr>
<td>d. Bandarban</td>
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<tr>
<td>e. Dalia</td>
<td>Teesta</td>
</tr>
<tr>
<td>f. Goalundo</td>
<td>Padma</td>
</tr>
</tbody>
</table>

3. Twenty five rainfall recorders to be installed after the design network is finalised.

      .......
1. Five telemetering rain gauges in the following river basins:
   a. Maitir
   b. Kirthar
   c. Zhob
   d. Jhelum upstream of Mangla
   e. Indus upstream of Tarbela

2. Twenty five rainfall recorders to be installed after the design network is finalised.
DATA REQUIRED BY PAKISTAN FROM INDIA
FOR FLOOD FORECASTING PURPOSES.

1. Daily rainfall observations to be telegraphed to the Regional Meteorological Centre, Lahore during monsoon season June to October.

   1. Bhimber
   2. Riasi
   3. Rajori
   4. Gulabgarh
   5. Jasimgarh
   6. Ranagar
   7. Poonch

2. Daily Synoptic observations to be included in Sub-Regional Broadcasts.

   1. Dharampur
   2. Mandi
   3. Udhampur
   4. Banikhel

3. Daily gauge/discharge data with flood peaks to be telegraphed to the Regional Meteorological Centre, Lahore during the monsoon season June to October.

   1. Pang on the Beas
   2. Harike on the confluence of the Beas and the Sutlej
   3. Paper on the Sutlej
   4. Modhupur on the Ravi
   5. Akhnoor on the Chenab
   6. Munawarwali Tawi
   7. Jatam Tawi
   8. Baramula on the Jhelum

4. Data required to be telegraphed daily to EPWAPDA from June 1 to October 31.

   a. Rainfall and water levels in:
      (i) Dibrugarh, Gauhati (Pandu) and Dhubri in Assam, India on the Brahmaputra Basin
      (ii) Patna (Digha), Allahabad, Delhi and in one station in each of the Kosi and Gandak river tributary to the Ganges in India
      (iii) Siliguri on Teesta Basin in India
      
   b. Rainfall
      (i) Cherapunji and Karimganj on Meghna Basin in India
      
   c. Water level
      (i) Farakka on Ganges in India

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<th>Doc. No.</th>
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<th>Subject</th>
<th>Submitted by</th>
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<td>Provisional agenda.</td>
<td>WMO</td>
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<tr>
<td>TCY/Doc. 2</td>
<td>3</td>
<td>Explanatory memorandum relating to the provisional agenda.</td>
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<td>5</td>
<td>Review of the meteorological telecommunication and hydrological facilities needed for the reduction of cyclone damage.</td>
<td>WMO</td>
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<td>5.1</td>
<td>Meteorological facilities for cyclone detection and warning in India</td>
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<td>Telecommunication organisation in India for cyclone warning work.</td>
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<td>Hydrological facilities for controlling floods caused by cyclones.</td>
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<td>6</td>
<td>Cyclone distress mitigation measures</td>
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<td>Aims and functions of the Cyclone Warning Research Centre, Madras.</td>
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<td>Economic effects of tropical cyclone damage and the contribution of these storms to water resources</td>
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