WMO

WORLD METEOROLOGICAL ORGANIZATION

AND

ECONOMIC AND SOCIAL COMMISSION
FOR ASIA AND THE PACIFIC

ESCAP

WMO/ESCAP PANEL ON TROPICAL CYCLONES

THIRTY-SIXTH SESSION

Muscat, Oman

(2 - 6 March 2009)

FINAL REPORT

GENERAL SUMMARY OF THE WORK OF THE SESSION

1. ORGANIZATION OF THE SESSION

The thirty-sixth session of the WMO/ESCAP Panel on Tropical Cyclones hosted by Oman was held in Muscat, Oman from 2 to 6 March 2009.

Attendance

The session was attended by 54 participants from eight Members of the Panel on Tropical Cyclones, namely, Bangladesh, India, Maldives, Myanmar, Oman, Pakistan, Sri Lanka and Thailand. It was also attended by observers from China, Islamic Republic of Iran, Saudi Arabia, Indian Institute of Technology (IIT) Delhi, United Nations Environment Programme (UNEP), UNICEF, International Civil Aviation Organization (ICAO), EUMETSAT and representatives from WMO, ESCAP and Technical Support Unit (TSU). The list of participants in the session as well as the capacities in which they attended is given in **Appendix I**.

1.1 Opening of the session

1.1.1 The opening ceremony commenced at 10:00 a.m. on Monday, 2 March 2009 at the Golden Tulip Hotel in Seeb, Muscat, with attendance of H.E. Mohamed Bin Sakhr Al-Amry, Under Secretary, Ministry of Transport and Communication for Civil Aviation Affairs.

1.1.2 Mr Abdul Rahim bin Salim Al-Harami, Permanent Representative of Oman with WMO, extended a cordial welcome to all the participants. He emphasized the significance of this session being held in conjunction with the First International Conference on Indian Ocean Tropical Cyclones and Climate Change which is organized jointly with Sultan Qaboos University and other local partners. In this regard, Mr Al-Harami expressed his gratitude to WMO which accepted to be a Co-Sponsor for the Conference. This event will take place from the 8th to 11th March intentionally. He commended the Panel's decision on assigning names to tropical cyclones because national, regional and global media picked up remarkably tropical cyclones GONU, SIDR and NARGIS tropical cyclones that affected the region. In this context, it will be important that the Panel consider devising a permanent and appropriate mechanism for updating the table of the tropical cyclone names. Mr Al-Harami extend his gratitude to the RSMC - Tropical Cyclones New Delhi for the remarkable job it performed during the past tropical cyclones that affected the region. However, there is still some area that the Panel may need to consider for further improvement particularly in the area of exchange and frequency of warnings, cyclone track forecast model, and classification of tropical cyclones within the Panel and also with other TC RSMCs. It is important that all the Members of the Panel get connected to the RSMC - Tropical Cyclones New Delhi by video conference. This mechanism will help the personnel engage in direct dialogue and conduct frequent briefings as deemed necessary. He expressed appreciation to the satellite operators particularly EUMETSAT and INSAT for their cooperation and assistance in sustaining the meteorological geostationary satellites that they operate and maintain over the Panel region. Mr Al-Harami also thanked WMO and ESCAP for their support to the Panel as well as the training program conducted by IIT of India and the excellent work accomplished by the Coordinator and the staff of the TSU who are hosted by Pakistan Met Department. Finally, Mr Al-Harami wished the participants all the success in the deliberations and that their stay in Muscat be pleasant and memorable.

1.1.3 Dr. Qamar-uz-Zaman Chaudhry TSU Coordinator and Vice-President of WMO/RA-II (Asia & Pacific) welcomed the participants at the thirty-sixth Session of the Panel and extended his warmest greetings. He shed light on the role of the Panel for improving the capabilities of the Members in tropical cyclone forecasting, warnings and the associated storm surges in the Bay of Bengal and the Arabian Sea since its establishment in 1973. He

emphasized that the climate change had influenced the intensity and frequency of tropical cyclones in our region, so it would be a great opportunity for the participants of the Session to share their knowledge and experiences about the tropical cyclones with the world's renowned experts on climate change and tropical cyclones during the International Conference on Tropical Cyclones and Climate Change being held back to back with the Session in order to further improve their understanding of these severe weather events in relation to climate change.

1.1.4 Speaking on behalf of ESCAP, Dr Zengpei Xuan expressed his sincere appreciation to the Government of the Sultanate of Oman for hosting this session in Muscat, Oman and the Government of Oman for providing logistical supports. Dr Xuan, mentioned about the recent reform of the conference structure of ESCAP, as adopted by the 64th Commission Session in April 2008. As a result, the Committee on Disaster Risk Reduction (CDRR) was set up, and a new division, the ICT and Disaster Risk Reduction Division (IDD), was established to serve the Committee and to backstop the Panel on Tropical Cyclones, among others. He promised that IDD would continue to give a strong support to the Panel as provided by its predecessor Dr Ti, Chief of the Environment and Development Division of ESCAP. He also highly commanded on the WMO's work in the preparation of the documents for this session including the Coordinated Technical Plan and the need of adequate discussions on them by the Panel. In addition to that, Dr Xuan suggested that the PWG and the Panel give more importance to the issues such as resource mobilization, new membership. In this regards, he cited the practices of some of the similar regional organizations as useful references.

1.1.5 Speaking on behalf of Mr Michel Jarraud, Secretary-General of WMO, Dr Tokiyoshi Toya, Regional Director for Asia and the South-West Pacific, welcomed all the participants and expressed his appreciation to the Government of the Sultanate of Oman through H.E. Mohamed Bin Sakhr Al-Amry, for hosting the thirty-sixth session. He extended his gratitude to Mr Al-Harami, Permanent Representative of Oman with WMO and his staff for the warm welcome and hospitality and for the excellent arrangements made to ensure the success of the session. In referring to the Panel's collaborative effort to support Myanmar following Cyclone Nargis through participation in the WMO fact-finding mission and provision of training, Dr Toya commended and encouraged the consistent effort by the Panel Members to improve their early warning systems for tropical cyclones and the close linkage between the Members within the regional framework of the Panel. With emphasis on the importance of a strategic approach to achieve the goals and objectives of the Panel and to raise its visibility, he expressed his hope that the session makes proactive discussions on challenges and opportunities for the Panel for the re-establishing its Coordinated Technical Plan. In ensuring WMO's continued support to Panel's efforts to mitigate impacts and risks of tropical cyclone-related disasters, he wished the participants a very successful session and a pleasant stay in Muscat.

1.2 Election of the Chairman and Vice-chairman

1. 2.1 Mr Abdul Rahim bin Salim Al-Harami (Oman) and Mr Ali Shareef (Maldives) were unanimously elected as Chairman and Vice-chairman of the Panel, respectively, to hold their posts until the next session.

1. 2.2 Mr G. B. Samarasinghe (Sri Lanka) was elected as Chairman of the drafting committee.

1.3 Adoption of the agenda

The Panel adopted the agenda as given in **Appendix II.**

1.4 Working arrangements

The Panel decided on its working hours and the arrangements for the session.

2. FOLLOW-UP ACTION ON PTC-35

2.1 A detailed review of the follow-up actions taken to the recommendations of the thirty-fifth session was carried out based on the action sheet shown in **Appendix III**. The progress on the activities is incorporated into the relevant paragraphs below.

2.2 The representative of ESCAP informed the Panel that ESCAP participated actively in the Third Asian Ministerial Conference on Disaster Risk Reduction (AMC3) on 2-4 December 2008 in Malaysia. It organized one high-level round table and one technical session during the period and the outcomes from the two events were reported to the ministers and further found in routes to the conference outcome of the Kuala Lumpur Declaration. He also informed that the next AMC will be convened in 2010 in Republic of Korea.

2.3 WMO informed the Panel that Manuals on “Flood Forecasting and Warning”, “Low Flow Estimation and Prediction” and “Stream Gauging” are soon be published and will be distributed to the Members.

2.4 With regard to the development of an Integrated Hazard Awareness Display (IHAD), Thailand informed the Panel that it already developed a website as the prototype of the IHAD with suggestions from the several Members, ESCAP and WMO. The website is accessible at www.ihad.tmd.go.th.

2.5 The Panel was informed by the representative of EUMETSAT that the EUMETSAT Polar System (EPS) will operate at least until 2020. Among many other data sets, EPS delivers sea surface winds derived from the C-band scatterometer ASCAT. EPS consists of a series of three Metop satellites in polar orbit, along with ground-based infrastructure. Metop-A was launched in October 2006. Replacement satellites (Metop-B/C, already in storage) are planned to be launched in 2011 and 2016.

2.6 The Panel requested the Members responsible for the ongoing actions, to continue their efforts towards early achievement.

3. REVIEW OF THE 2008 CYCLONE SEASON (Agenda item 6)

3.1 Report of RSMC – Tropical Cyclones New Delhi

3.1.1 The RSMC New Delhi presented a detailed review of the 2008 cyclone season on the basis of the comprehensive report entitled “Report on Cyclonic Disturbances over North Indian Ocean during 2008” which was distributed to the Members during the session.

3.1.2 The RSMC informed the Panel that the north Indian Ocean witnessed the formation of ten cyclonic disturbances during 2008, against a normal of fifteen. Out of the ten disturbances, six intensified into depressions/deep depressions, three into cyclonic storms and one into very severe cyclonic storm. Out of the ten, one deep depression and one depression formed over the Arabian Sea. However, both the systems dissipated over the Sea itself.

3.1.3 The Bay of Bengal witnessed the formation of one very severe cyclonic storm, three cyclonic storms, two deep depressions, one depression and one land depression during the year. Salient features of cyclonic disturbances like non formation of cyclonic storm over Arabian Sea and monsoon depression during the month of July were also highlighted.

3.1.4 Brief synopses of the four cyclonic storms NARGIS, RASHAMI, KHAI-MUK and NISHA during 2008 were presented. Advisories issued and its Accuracy and timeliness, major synoptic problems from the standpoint of analysis and prognosis like dead easterly movement of Nargis and its slow movement over Irrawady delta causing huge loss of lives and properties, Quasi-stationarity of Nisha close to the coast, Weakening of Khai Muk over the Sea were discussed. The performance of RSMC New Delhi in track and Intensity prediction of the four cyclones compared to various NWP model guidances were highlighted. Average Landfall error of cyclonic storms during 2008 was 43 km for 12 hrs, 95 km for 24 hrs and 137 km for 36 hrs which were less than the long period average errors for the landfalling cyclones over the North Indian Ocean.

3.1.5 Plans for 2009 such as modification of the format of advisories, introduction of multi-model ensemble technique for track prediction, seasonal prediction of cyclonic disturbances over the north Indian ocean and collaboration with IIT New Delhi for storm surge watch scheme etc. were also brought out .

3.1.6 The summary report on the 2008 cyclone season provided by the RSMC is given in **Appendix IV**.

3.1.7 The Panel expressed its appreciation to the RSMC New Delhi for the continued valuable contribution it was making to its Members and emphasized the importance of further strengthening of the existing cooperation and collaboration between the national early warning centres and RSMC New Delhi.

3.2 Reports of Members on the impact of tropical cyclones

The representatives of the Panel Members reported to the session a review of the 2008 cyclone season of their respective countries, summaries of which are given in **Appendix V**.

4. COORDINATION WITH OTHER ACTIVITIES OF THE WMO TROPICAL CYCLONE PROGRAMME

4.1 The Panel was informed by the WMO Secretariat that the Executive Council, at its 60th session in June 2008, gave the following guidance to the Tropical Cyclone Programme:

a) To give greater emphasis to the use of ensemble techniques and probabilistic forecasting in tropical cyclone warning operations in order to improve their utility.
b) To transfer research and development results between the tropical cyclone regional bodies with special emphasis on application of intensity forecast guidance.
c) To continue to support training events to allow forecasters of small NMHSs to achieve the skills and competencies required for effective operational capacity.
d) To develop and incorporate a storm surge watch scheme in the tropical cyclone advisory arrangements and in the regional operating plans and manuals for the risk management in the coastal regions.

4.2 The Panel was pleased to note that various training programmes were arranged by TCP to address the issue of sustainable development of NMHSs. In particular, RA IV Workshop on Hurricane Forecasting and Warning (Miami, USA, 16-28 April 2008 & 7-19 April 2008) was organized in cooperation with Public Weather Services Programme and highly valued for the practical training for operational forecasting as well as media skills. A similar event is planned jointly with PWS to be held in the Typhoon Committee region as a roving seminar in 2009. Attachment training was carried out by 4 RSMCs including RSMC New Delhi which hosted the training in February 2009 for the experts of Bangladesh and Maldives. The Indian Institute of Technology Delhi hosted the attachment training in November 2008 for the storm surge experts in Myanmar and Sri Lanka.

4.3 The Panel was pleased to note that TCP has undertaken the update of "Global Guide to Tropical Cyclone Forecasting" to respond the recommendation of IWTC-VI. A new structure of the Guide is currently under review based on the two major concepts:

1) It should be published primarily as a Web version in view of cost saving and easier access.
2) It should have linkages with associated hazards (storm-surge, flash flood, etc.) from a multi-hazard point of view.

The Panel was informed that the new version is expected to be published during the first quarter of 2010. To support the operational forecasting, TCP is also developing the Tropical Cyclone Forecaster Website, which will carry a comprehensive set of materials on TC forecasts to serve as a part of the Global Guide.

4.4 The Panel was informed that completion of the Study on the Wind Averaging Guideline has been delayed. A main report, which was submitted by the Systems Engineering Australia Pty Ltd (SEA) in January 2008, is currently under review by TCP Technical Coordination Meeting and a one-page summary for inclusion in operational manuals is being produced by SEA.

4.5. The Panel noted that TCP, in cooperation with Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM), held the fifth "TCP/JCOMM Workshop on Storm Surge and Wave Forecasting" in Melbourne, Australia in December 2008 for the island countries in the South Pacific. The Panel was informed that TCP plans to organize the Workshop also in the Panel region in the near future to support the development of a regional storm watch scheme in the region.

5. REVIEW OF THE COORDINATED TECHNICAL PLAN AND CONSIDERATION OF THE WORK PROGRAMME FOR THE NEXT THREE YEARS (Agenda item 8)

5.0.1 The Panel reviewed the Coordinated Technical Plan 2009-2011 which was prepared by the High level Policy Working Group (PWG) of the Panel. The Panel also reviewed the format of the Annual Evaluation Report (AER) which was also developed by the PWG to be submitted to TSU by each Member annually for evaluation of performance of CTP. The Panel was informed that the PWG Meeting was held on 27-28 February, 2009 under the chairmanship of Dr Chaudhry, Coordinator of the Panel with participation of the delegates from Bangladesh, India, Oman, Pakistan, Sri Lanka, Thailand, TSU and representatives of WMO and ESCAP. The Panel appreciated the efforts of PWG in preparation of the CTP and the format for AER.

5.0.2 The Panel was informed by the Chair of PWG that while preparing the CTP work Plan, PWG has taken into account especially the Mission and the Priorities of the Panel in addition to the WMO Strategic Plan and the Strategic Plan for the Enhancement of National Meteorological and Hydrological Services (NMHSs) in Regional Association II (RA-II, Asia) (2009-2011).

5.0.3 The Panel was also briefed by WMO on the concept and process of the development of the RA II Strategic Plan. The Panel noted that the RA II Strategic Plan has been developed on the basis of the survey results for the period 2005-2008, by analyzing the likely trends, developments, evolving needs and deficiencies of the Region, to identify a set of deliverables. These deliverables are action-oriented and categorized under Regional Expected Results in accordance with WMO's set of Expected Results identified in the WMO Strategic Plan (2008-2011).

5.0.4 The Panel agreed that it takes a similar approach as taken for development of the RA II Strategic Plan, for the re-establishment of the Panel's CTP.

5.0.5 The Panel agreed on the inclusion of "Partnership" and "Management and Governance" as part of the Expected Result (ER) of CTP in addition to the ERs for the five components; meteorology, hydrology, DPP, training and research. Accordingly, it adopted the CTP with some minor amendments. The Panel's new CTP and the format of AER for 2009 are shown in **Appendix VI**. With a view to raising visibility of the Panel, it requested TSU for the documentation of the CTP and its distribution to the Members and other stake holders under intimation to WMO and ESCAP.

5.0.6 The Panel noted that in most of the Panel Member countries, there are different organizations responsible for provision of services in two of the three main components i.e. hydrology and DPP, therefore it urged the Members that PRs of the Members may circulate the CTP to the concerned organization(s) if other than NMHS(s) to take necessary action and initiatives for the effective implementation of the CTP with regards to hydrology and DPP. Panel also urged the Members for coordination with these organizations to designate their focal points on hydrology and DPP to be submitted to TSU.

5.0.7 The Panel agreed that Chairman of PWG should report to the Panel at annual sessions on the progress of implementation of CTP based on annual surveys to the Members. In this regard, the Panel requested PWG to carry out the surveys at an appropriate timing before the sessions. It also urge the Members to provide their adequate feedbacks to PWG through the surveys.

5.0.8 The Panel reviewed the activities of its Members and WMO in the five components of meteorology, hydrology, DPP, training and research since the last session, details of which are presented in **Appendix V**.

5.1 Meteorological component (agenda item 8.1)

Activities of the Members

5.1.1 The representative of Bangladesh informed the Panel that data from RTH New Delhi and 10 synoptic observatories of BMD are exchanged on routine basis through WMO's GTS. All the 35 observatories of BMD have been connected with NMCC Dhaka either by TP or Telephone and single sideband (SSB) etc. or by all the three systems. Some of the observatories are connected through internet with NMCC and data are collected on real time basis by using Meteorological Data Acquisition software. The communications between Storm Warning Centre (SWC) and Radar Station at Cox's Bazar and Khepupara have been upgraded to VSAT link. NMCC uses MSS software obtained from WMO/UNDP Regional Computer Network programme for reception and transmission of all meteorological data.

5.1.2 The representative of India informed the Panel that a new Geostationary Meteorological Satellite INSAT-3D is being designed by ISRO. It will have a six channel imager and a nineteen channel sounder. In addition to satellite imagery in six channels several new derived products will be available after processing the data from INSAT-3D. These products will be useful in NWP and in day-to-day weather forecasting. In addition to ground level products the vertical profiles of atmospheric temperature, moisture and ozone will be available from the satellite data of INSAT-3D. It will provide 1Km resolution imagery in visible band, 4 Km resolutions in IR band and 8 Km. in water vapor channel. This new satellite is scheduled for launch in fourth quarter of 2009 and will provide much improved capabilities to the meteorological community and users.

5.1.3 The representative of Myanmar informed the Panel that the main improvement in Communication Network In DMH for the last three years are (1) installation of PCVSAT in 2005 (WMO/VCP from China), (2) Fengyuncast Satellite Receiver in 2008 at Nay Pyi Taw (WMO/VCP from China), (3) Upgrading of GTS system in 2008 at Yangon (WMO/VCP), (4) UHF Radio Communication (Yangon), (5) AWOS (Yangon, Sittwe, Dawei), (6) GPS (Yangon,

Sittwe, Dawei), (7) Automatic Raingauge (6 stations), (8) 40 sets of HF Transceivers in 2009 (Mitsubishi Co., Yangon), (9) Internet Facilities in 2008-2009 (National Resources).

5.1.4 Pakistan Meteorological Department (PMD) has been using High resolution Regional Model (HRM) of DWD (the national meteorological service of Germany) is an operational model for numerical weather prediction since January, 2007. The initial and later boundary conditions for HRM are taken from DWD's global model GME with the multilayer soil model. Initially the model was run with 28 Km resolution and the simulations were done once daily by using GME date of 0000 UTC. However, since March, 2008, the model is being run with the resolution of 22 Km and the simulation are also being performed twice a day by using GME date of 0000 UTC and 1200 UTC. Further, the model outputs are also updated twice a day accordingly at PMD's website www.pakmet.com.pk. During 2009-2010, PMD is planning to update the existing computer system with processing power of 384.0 GHz (1.54 T-FLOPS) and run the model with the resolution of 7 km.

5.1.5 The representative of Sri Lanka informed the Panel that with the new GTS system received as a USAID grant in operation, the exchange of data and information with RTH New Delhi was very good. Synoptic and upper air observations were performed satisfactorily except for some lapses due to security reasons and human resources deficiencies. Procurement of Doppler Radar with the expert guidance from WMO is underway with financial evaluation pending and the equipment is expected in a Sri Lanka by end of 2010. Two new meteorological stations at agriculturally important places are to be operational by March, and to be included in the WMO network.

5.1.6 Thai Meteorological Department established two C-band Doppler Radars in the northern region, increased automatic gauge networks up to 930 stations, established Low Level Windshear Alert System (LLWAS) for air navigation during takeoff and landing at Chiang Mai International Airport, and upgraded GTS Circuit between RTH Bangkok and Beijing, Yangon and New Delhi, respectively. Thailand also improved weather and storm surge forecasting by cooperation with Office of Marine Prediction, Japan Meteorological Agency. In addition to technical advancement, Thailand supported ICAO APAC in updating AOP for Basic ANP and FASID, and participate on-line Air Navigation Deficiency Database, including new provision of TAF.

Activities of WMO

5.1.7 The Panel was informed that according to the results of Special MTN Monitoring (SMM) exercises carried out in in 2007 and 2008 on a quarterly basis each year, the availability of expected SYNOP reports on the Main Telecommunication Network (MTN) from a total of 252 surface stations in the RBSN operated by the Panel Members ranged from 56 to 100 per cent in 2008 and TEMP reports from a total of 53 upper-air stations ranged from 0 to 55 per cent.

5.1.8 The AMDAR Panel recently established two new AMDAR Pilot Projects, one covering the South-West Pacific region and the other covering the North African and Western Asian region. These two areas were selected because of their relative sparsity of upper-air meteorological observations resulting in forecasting difficulties in the region. A major component of the regional projects would be to encourage other countries in the region to participate and establish a Regional AMDAR Programme.

5.1.9 The representative of ICAO commented on the AMDAR programme with regards to the proposed Amendment 75 to Annex 3 applicable November 2010. Specifically, the proposed deletion of the requirement of routine voice reporting of meteorological observations for aircraft not equipped with air-ground data link will be considered by the Air Navigation Council in April 2009. This is due to the large number of automatic aircraft observations of meteorological data; over 200,000 reports globally per day.

5.1.10 He also informed the Panel that recent SIGMET tests for Tropical Cyclone, Volcanic Ash and other weather phenomena were recently conducted in the ASIA/PAC Region. Tropical Cyclone SIGMET test involved all 7 Tropical Cyclone Advisory Centres (TCACs) as La Réunion who serves the SW part of the Asia Region participated this year. More States were involved this year such as the Maldives and Fiji. Volcanic Ash SIGMET will be enhanced within the next year to include air traffic services and the airlines. In addition, the Toulouse VAAC will be considered to participate because the States in the western area receive VA advisories from Toulouse. The ASIA/PAC western area was recently expanded to include Afghanistan and Pakistan making the involvement of Toulouse more important. ICAO encourages continued involvement in the SIGMET tests and encourages more States to be involved for their own practice and improvement on the issuance of SIGMET. The change in TAF requirements involves the issuance of 30-hour TAF at selected aerodromes as indicated by IATA. ICAO was informed from many States present that these TAF requirements are being considered.

5.1.11 Regarding the marine and ocean observations, the Panel was informed that dramatic progress has been made in the implementation of the ocean observing networks in the last decade. The plan was based on the system targets identified in the ocean chapter of the GCOS Implementation Plan for the Global Observing System for Climate in support of the UNFCCC (GCOS 92). Overall, the ocean in situ observing system is now 60% implemented, with the JCOMM plan driving to full implementation, in principle by 2012. All data are being made freely available to all Members in real time. However, completion will require substantial additional yearly investment by the Members/Member States.

5.1.12 The Panel was informed that EUMETSAT's Indian Ocean Data Coverage (IODC) mission based on Meteosat-7 is currently planned and funded until the end of 2010; the possible extension of the IODC mission beyond this date will be considered in due time by the EUMETSAT Council in the light of the operational status of the spacecraft and of the financial impact of its operation, taking into account the financial contribution from WMO Members benefiting of the IODC coverage in accordance with the License Fee Structure for the IODC mission that entered into force on 1 January 2009.

5.1.13 In this regard, the representative of EUMETSAT informed the Panel that EUMETSAT's 0°-longitude service, provided by Meteosat Second Generation satellites, covers the North (marginally) and South-west Indian Ocean.

5.1.14 Three LEO operational satellites were launched since the beginning of 2008: the new generation polar-orbiting FY-3A satellite launched in May 2008 on a morning orbit by China; the Jason-2 ocean surface topography monitoring satellite provided by CNES-EUMETSAT-NASA-NOAA, launched in June 2008; and the last polar-orbiting satellite of the NOAA POES series, NOAA-19, launched in February 2009 by the USA.

5.1.15 The Panel was concerned that by 2012 or so, EUMETSAT First Generation Satellite (Metesat-7) operating over the Indian Ocean will cease and thus discontinuing the reception of high quality imagery over the region. The Panel urged WMO to request EUMETSAT to consider exploring the possibility of extending its Second Generation Satellites over the Indian Ocean before the end of the life time of Meteosat-7.

5.2 Hydrological Component

Activities of the Members

5.2.1 The representative of Bangladesh informed the Panel that BMD provides all sorts of data, information and weather forecast to the Flood Forecasting and Warning Centre (FFWC) of Bangladesh Water Development Board (BWDB). A Metropolitan Area Network (MAN) between SWC, Dhaka and FFWC was established in 1998 through which FFWC receives meteorological and hydrological data (including rainfall and water discharge data of

up stream) along with Radar and Satellite images. Through the completion of the establishment of Meteorological and Hydrological Doppler Radar at the north-eastern part of Bangladesh under JICA Grant Assistance, FFWC is being connected by VSAT link to get all the radar information for flood and flash flood monitoring and forecasting. Also during execution of JICA's Technical Cooperation on the Human Capacity Development training will be imparted to FFWC for radar data calibration and its utilization.

5.2.2 Flood Forecasting in India is jointly carried out by the coordination of two organizations IMD under Ministry of Earth Sciences (MoES) and Central Water Commission (CWC) under Ministry of Water Resources (MoWR). IMD has established 10 FMOs and CWC 20 Central Flood Forecasting Division (CFFD) in flood prone river basins of India. This scheme has an exclusive network of 380 part time rainfall station (FMO Stations) reporting rainfall on real time basis during flood season (generally from 15th May to 15th October) in addition to other rainfall observatories. The main work of FMOs is to issue QPF. 7 FMOs are co-located with the Meteorological Centres (MCs) which are issuing general weather forecast and prepares all related weather charts which are also utilized by FMOs for issuing QPF. 3 FMOs are not co-located with MCs, so prepares all weather charts also in addition to rainfall chart and require more officers / staff. A total of 4085 QPFs were issued by all the ten FMO:S during the flood season of 2008.

5.2.3 The representative of Myanmar informed the Panel that during 2008, discharge measurements were accomplished at Maubin (Toe river), Yeni (Sittaung river) and Sagiang (Ayeyarwady river). Hydrological data of full-time stations are checked, processed and published annually as Hydrologic Annual Volume I and II by Hydrological Division. Volume I comprise of river stage data from 67 stations, discharge data from 37 stations and sediment discharge data from 21 stations. In Volume II, rainfall data from 111 stations, water temperature data from 39 stations and evaporation data from 41 stations are composed.

5.2.4 Water management in Thailand comes under the care of two government agencies: the Royal Irrigation Department (RID) and the Water Resource Department (DWR). RID has strategies for flood prevention and mitigation with aims to reduce the loss of lives and properties of population at risk, and also impacts in urban and cultivated areas. Management plans were set in terms of monitoring, prediction and warning by establishment of Water Watch and Monitoring System for Warning Center (WMSC) to monitor flood situations a 24 hours basis. In addition, the collaborations with national related agencies for implementation plan to cope with local flood protections in economic zones where severe flood may be occurred. The state-of-art technologies were established, such as telemetry and flood forecasting systems. There are 11 of 25 main river basins have telemetry systems installed for water resources management and flood prevention and mitigation. DWR established Water Crisis Prevention Center (WCPC) named 'MEKKHALA' since 2005 and developed an operational system for flash flood and landslide warning system over the mountain and highland areas. The conceptual designed the alert activation systems when heavy rainfall was reported and water levels in the rivers or basins were reported to critical and alarm stages and warning will be sent with light signals in green > yellow > red, like a traffic signal, to subscribers and communities in real time. DWR installed the systems in 458 villages of 2370 villages in disaster risk areas. In 2008, 95 villages were reported to install this system.

5.2.5 The representative of Pakistan informed the Panel that the Projects "Up-gradation & strengthening of Radars Network" and "Strengthening of Flood Risk Management in Lai Nullah Basin (twin cities of Rawalpindi and Islamabad)" through capacity building of local authorities and communities to promote awareness and preparedness among the people for the floods and to mitigate flood damages are in progress. The Phase-I of the project has been implemented during December 2007 to November 2008, while the Phase II of the project is being executed from December 2008 to November 2009.

5.2.6 The representative of Oman informed the Panel that the Ministry of Regional Municipalities and Water Resources is responsible for the collection and processing of the hydrological data. A Hydrological network of 4,681 Stations including 315 Rain Gauges, Weather Stations, 161 Wadi Gauges, 2015 wells ,524 Aflaj, 31 Dams 64 sprigs and salinity monitoring on more than 1000 point both surface and ground water are monitored regularly. The Ministry also has prepared flood risk maps and installed telemetry weather and Rainfall Stations to obtain real-time data. Considering the dangers of flood especially after Guno Cyclone on June 2007, The Ministry has constructed flood protection dams on main cities and also working towards instillation of early flood warning system.

Activities of WMO

5.2.7 Based on a decision of the WMO Regional Association-II (Asia), henceforth referred to as Association, during its thirteenth session, a Strategy for the Enhancement of National Hydrological Services had been developed for the region. Recognizing that an integrated draft Strategic Plan for the Enhancement of National Meteorological and Hydrological Services (NMHSs) in RA II (2009-2011) was developed taking into account the previous Strategic Plan for NMSs (2005-2008) and the Strategy for NHSs (2006-2008) as well as WMO Strategic Plan 2008-2011, the Association agreed that for the next intersessional period the updated version of the Strategy for the Enhancement of National Hydrological Services in Asia (2009-2012), based on the findings of the survey conducted in 2008 and accompanied by an action plan, be used as a guideline by NHSs to improve their overall performance in the national and regional context.

5.2.8 In the context of the need for enhanced regional and institutional cooperation, the Association agreed that a closer linkage with the ESCAP/WMO Typhoon Committee should be maintained to harmonize the work of the WMO RA II WGH with activities undertaken by Members represented in the Typhoon Committee and likewise in the WMO/ESCAP Panel on Tropical Cyclones. The Association encouraged Members to include more hydrological experts in both the Typhoon Committee and the Panel on Tropical Cyclones. The Association further agreed that possible mechanisms for enhanced cooperation between the Typhoon Committee and the WGH should be explored. This has materialized in the decision of the Typhoon Committee during its forty-first Session from 19-24 January 2009 in Chiang Mai, Thailand that the Working Groups of both the Association and the Typhoon Committee liaise closely to plan and implement joint activities with respect to the mandates of the working groups.

5.3 Disaster Prevention and Preparedness (DPP) Component

Activities of the Members

5.3.1 The representative of Bangladesh informed the Panel that BMD disseminate the warnings and signals for disasters especially for tropical cyclones and its associated storm surges to Cyclone Preparedness Programme (CPP), Disaster Preparedness Bureau (DPB) and concerned ministries etc. for early evacuation. He informed the Panel that CCP is a strong body with huge number of volunteers who work in coastal areas of Bangladesh.

5.3.2 The representative of Oman informed the Panel that a new Natural Disaster Management Plan was drawn up by Directorate General of Meteorology and Air navigation in coordinating with the National Civil Defense as a part of the National Natural Disaster Plan.

5.3.3 Department of Disaster Prevention and Mitigation (DDPM), under the Ministry of Interior, is a primary government agency in Thailand disaster management, responsible for imposing and implementing program policy, formulating operational guidelines and establishing criteria on disaster management. DDPM role is to promote disaster prevention and preparedness, assist in disaster management with specialists, hardware, and software as well as reduce loss of life and negative impact of all disasters. Therefore, DDPM is

involved in the process of disaster management as promoting public awareness of disaster, facilitate and assist while disaster occur, and presume rehabilitate and recovery role after the disaster. DDPM has been using Community Based Disaster Risk Management (CBDRM) concept to generate the awareness and implant the culture of safety in disaster prone areas as well as in general public. DDPM's highlight projects are: 1) CBDRM training in 3,354 villages in 75 provinces, 2) Flash Flood and Mudslide Warning Program or "Mr. Warning" with 7,817 villagers trained, 3) Civil Defense Volunteer Program with approximately 1 million volunteers trained in holistically assist the government's operation in all type of disaster management, 4) One Tamboon One Search and Rescue Team or OTOS program which successfully established 7,255 search and rescue team throughout the country. Furthermore, DDPM established Disaster Prevention and Mitigation Academy (DPMA) since October 2004 as National Training Centre for Disaster Management. DDPM cooperated with various agencies both national and international organizations in developed countries to develop curriculum and mobilize technology, including know-how for standard training. DPMA has extended to 6 campuses in upcountry. The standard curriculum consists of Fire Fighting, Building Collapse (Search and Rescue), Hazmat Emergency Management, Civil Defense Volunteer and Disaster Management.

5.3.4 Sri Lanka Meteorological Department (SLMD) and Disaster Management centre (DMC) continued collaborative work while National Disaster Relief Services Centre (NDRSC) engaged in during and post disaster activities, especially during heavy rain events and associated floods and landslides. It is noteworthy that flood related events claimed increasingly major share (66%) of total rehabilitation and reconstruction expenditure in the year with preceding years 2007 and 2006 too leading with 65% and 62% respectively. Chikungunya fever claimed the next highest expenditure with 12%. Early warnings on hydro-meteorological hazards were issued by the SLMD to DMC and other important recipients in time that DMC took appropriate effective and efficient action.

5.3.5 The representative of Pakistan informed the Panel that establishment of a Tropical Cyclones Warning Centre (TCWC) is under progress by PMD with the financial assistance by the Government of Pakistan. Under this project, ten (10) Automatic Weather Stations (AWS) with five (05) High Gust Anemometers, Data Collection Platform and satellite transmitters for communication of data would be installed along the coastal areas of Pakistan (Sindh-Makaran Coast) for recording and transmission of real time weather data. TCWC will also facilitate the NMHSs of neighboring countries by covering North Arabian Sea, Gulf of Oman, Central North Arabian Sea and Gulf of Aden.

5.3.6 Panel Members agreed to the proposal of Pakistan that all the Member may share their countries' Standard Operating Procedures (SOP) regarding Multi-hazard Early Warning Systems in their countries with special reference to Tropical Cyclone warning, its follow-up actions and responsibilities of other stakeholders, etc. with TSU. Then TSU may prepare a document for the Panel.

5.3.7 The Panel reconstituted the Working Group on DPP (WGDPP) with its Chairman from Thailand and its members from Panel Member countries. Thailand proposed to hold a kickoff meeting of the WGDPP during 2009. The Panel agreed to the proposal and decided to use the Panel's Trust Fund (PTCTF) for organization of the meeting. Due to the limitation of financial resources, the Panel authorized the use of PTCTF for 4 to 5 participants other than from Thailand to attend the meeting. As the Panel adopted the new Coordinated Technical Plan (CTP), it viewed WGDPP to take the lead in promoting the Panel's activities in the Expected Result 5 (DPP) of CTP and requested the WGDPP to propose actions to take to achieve strategic objectives of the ER-5.

5.3.8 The representative of Myanmar informed the Panel that, following Cyclone Nargis, the disaster prevention and preparedness measures were carried out in Myanmar by the Ministry of Social Welfare, Relief and Resettlement (MSWRR), Ministry of Construction, Ministry of Science and Technology, the Myanmar Engineering Society and DMH under the

guidance of the National Committee on Disaster Management, which is chaired by the Prime Minister. Construction works on 21 Shelters and five communication roads; identification of the life saving grounds; and building of new embankments along the coastlines were underway in the Deltaic area. A National Multi-hazard Early Warning Centre was established in NayPyiTaw. Ten training courses on Disaster Management were conducted by the MSWRR for the trainers.

Activities of WMO

5.3.9 WMO has initiated an integrated effort by setting up or strengthening existing collaboration mechanisms among the Tropical Cyclone Programme regional bodies, the Regional Associations and the technical commissions concerned, foremost JCOMM, CAS, CHy and CBS for developing and improving the service delivery in coastal risk management, with an emphasis on: (1) Developing guidelines for early warning systems related to detecting and forecasting marine-related hazards; (2) JCOMM guide on storm surge forecasting and a set of guidelines for coping with tsunami, storm surge and other sea-level related hazard are foreseen to be published by mid-2009); and (3) Implementing, through forecast demonstration projects, improved operational forecast and warning systems for coastal inundation.

5.3.10 The socio-economic impacts of the disaster during 2007-2008 resulting from tropical cyclones such as Gonu in June 2007 and Nargis in May 2008 and their associated coastal marine hazards stressed the need for a storm surge watch scheme to help increase advisory lead-time and thus contribute to saving lives and property. Such a scheme would be the first step towards a comprehensive and integrated marine multi-hazard forecasting and warning system for improved coastal risk management. In this regard, RSMC New-Delhi, based on technical advice from JCOMM, is invited to consider participation in a regional storm surge watch scheme and to develop a proposal for consideration by the WMO/ESCAP Panel on Tropical Cyclones.

5.4 Training component

Activities of the Members

5.4.1 The representative of Sri Lanka informed the Panel that SLMD continued to offer training for general public, media and other relevant groups on hazardous weather phenomena and action to be taken on these, in addition to offering expert advisory and resource services to other organizations. DMC had many programs for assistant / directors, coordinators and all other district, divisional, village level, school, health sectors etc, especially in formulating CBDM guidelines.

5.4.2 PMD conducted a special Preliminary Meteorology Course (BIP–MT Programme) from 25th February to 28th June, 2008 the participants from the National Meteorological Services and Hydrological (NMHSs) of the neighboring countries for their capacity building through WMO Voluntary Cooperation Programme (VCP). Ten (10) trainees with two from each of Bangladesh, Bhutan, Maldives, Nepal and Sri Lanka participated in this training programme. PMD provided complete financial support to the participants in lieu of travel and per diem. The second such training course has also been scheduled from 20th March, 2009. In this course eleven (11) participants from NMHSs of the neighboring countries with one from Afghanistan and two from each of Bangladesh, Bhutan, Myanmar, Nepal and Sri Lanka are expected to attend.

Activities of WMO

5.4.3 The Panel noted the training events and workshops which were organized in 2008 for the benefit of its Members. Since its last session, the Panel had benefited from WMO's education and training activities through the provision of fellowships, relevant training

courses, workshops, seminars, the preparation of training publications, and the provision of advice and assistance to Members, which include “Attachment of Storm Surge Experts from Myanmar and Sri Lanka to the Indian Institute of Technology (Delhi, India, 10 - 21 November 2008)” and “Attachment of Tropical Cyclone Forecaster from Maldives and Bangladesh to RSMC New Delhi (9- 20 February 2009).

5.4.4 The Panel expressed its gratitude to IIT Delhi and RSMC New Delhi for their valuable contribution to the Panel’s capacity building activities and requested that WMO make similar arrangements with the IIT and RSMC for the attachment training in 2009.

5.4.5 The Panel noted that WMO fellowships for long-term and short-term training continued to be granted to the Member countries of the Panel under the various WMO programmes. Staff from the Panel Members completed 25 man month of training in 2008.

5.5 Research component

Activities of the Members

5.5.1 The representative of India informed the Panel that Forecast Demonstration Project (FDP) on landfalling tropical cyclones over the Bay of Bengal has been taken up. It will help us in minimizing the error in prediction of tropical cyclone track and intensity forecasts. The programme has been divided into three phases (i) Pre- pilot phase: Oct-Nov. 2008 (ii) Pilot phase: Oct-Nov. 2009, 2010 (iii) Final phase: Oct-Nov 2011. During pre-pilot phase (15 Oct-30 Nov 2008), several national institutions participated for joint observational, communicational & NWP activities..

5.5.2 PMD has been carrying out wind power potential survey of the Northern Areas of Pakistan. The results of this study will ultimately provide a platform for the probable establishment of Wind Mills / Farms for power generation. The project was initiated in 2005 and would be completed in 2009. Previously in first of such project, PMD has already completed a study for the coastal areas of Pakistan (Sindh-Makaran coast). On the basis of the wind data analysis, a wind corridor in Gharo has been identified in Sindh, which covers an area of about 9,700 Square Kilometers and which has the exploitable Electric Power Generation Potential of 11000 Mega Watt.

5.5.3 DMH of Myanmar has laid out several programmes on research and development. DMH has run the IPCC Models on climate scenarios for Myanmar for the year 2020 and 2050. DMH was able to send two officials to Regional Centre affiliated by ADPC. Research works on climate change and Earthquake Potentials were carried out recently by these two officials at the regional centre. Some research work on climate change has carried by the DG and his team. The research work reveals that the climatology relating to storm formation and movement has changed dramatically near the sea waters of Myanmar after 1978.

Activities of WMO

5.5.4 The Tropical Cyclone Panel of the World Weather Research Programme’s (WWRP) Working Group on Tropical Meteorology Research (WGTMR) organized an “Expert Meeting to Evaluate Skill of Tropical Cyclone Seasonal Forecasts”. The meeting held in Boulder, Colorado, USA from 24 to 25 April 2008 reviewed the status of a number of statistical and dynamical techniques for seasonal forecasts. As recommended by the Sixth International Workshop on Tropical Cyclones (San Jose, November 2006) the meeting formally established a website for seasonal tropical cyclone forecasts on the WMO/WWRP/TMR website. In developing this website, the expert group defined the metrics, set the guidelines for verification measures (seven measures for deterministic forecasts and three for probabilistic forecasts), and choose appropriate reference score so that these seasonal forecasts could be systematically evaluated. The website has been on test mode since December 2008.

5.5.5 The first phase of THORPEX Pacific Asian Regional Campaign (T-PARC) is one of the largest field campaigns conducted to date that focuses on advancing the understanding and prediction of high impact weather over the Northwest Pacific Basin. The Tropical cyclone and extratropical transition phases of the T-PARC modeling and field campaign took place during 1 August to 6 October 2008 to advance the understanding and prediction of the initial tropical convection cloud clusters through to genesis, further development, structural changes, re-curvature, track prediction, land-fall and extratropical transition. The field phase was considered successful and involved operational centres, the academic research community and research institutes in Asia, North America, Europe and Australia plus international organizations such as EUCOS and ECMWF with the largest field phase contributions from Canada, France, Germany, Korea, Japan, and the US. One tropical cyclone prediction issue for T-PARC is reducing the uncertainty in ensemble predictions of tropical cyclone recurvature and landfall through adaptive measurement strategies and the application of new technologies such as Doppler lidar. The tropical cyclone studies was undertaken in conjunction with the Tropical Cyclone Structure (TCS08) field experiment (see item 5.5.5). A second phase of T-PARC will take place in January-March 2009 and focus on extratropical (winter) cyclones.

5.5.6 WMO's Commission on Atmospheric Science's WWRP-THORPEX programme continues to work on the delivery of the THORPEX Interactive Grand Global Ensemble (TIGGE) data archive, conducting research that identifies areas where forecast skill and confidence might be improved by the multi-model approach and demonstrating the concept of a multi-centre Global Interactive Forecast System (GIFS). Recently, ensemble track predictions based on the TIGGE archive have been distributed in real-time for the T-PARC experiment. In a recent meeting, the TIGGE-GIFS Working Group has recommended an expansion of activities to include Forecast Demonstration Projects (FDP) based on TIGGE for tropical cyclones and heavy rainfall. A WMO ad-hoc committee across the Regional, CBS and CAS efforts has been formed to make recommendations on the implementation of these FDPs.

5.6 New Joint Initiatives

5.6.1 Dr Xuan informed the Panel that the first session of the Committee on Disaster Risk Reduction (CDRR) of ESCAP will be convened on 25-27 March 2009 in Bangkok. This session is expected to provide guidance to the Committee and the secretariat on a number of very important issues, such as its future directions and its work priorities, among many others. So far, the member countries have reacted very positively to the invitation of the Executive Secretary of ESCAP to the session. As of 26 February, a large number of participants had confirmed officially or by email their participation in the meeting, including ministers from China, India, Japan, Malaysia, Myanmar, Korea, and the mayor of Incheon City, the host of the next AMC in 2010. Mr. Salvano Briceno, Director of UN ISDR, has confirmed that he will attend the opening ceremony. There is also a high possibility of some Ministers from the Pacific Island countries to joint the meeting. In addition, a number of senior officials from other countries at the level of permanent secretary, additional secretary and joint secretary, or director general/deputy director general have also confirmed their participation. Many private companies have also registered as observers.

5.6.2 ESCAP has invited the Panel and the Typhoon Committee to the first CDRR session, and built their report to the CDRR into the official agenda. The ESCAP representative suggested that one representative from the Panel be sent to the meeting as it would help it raise the visibility of the Panel, and explore the possibilities of cooperation with others including the donor agencies. The Typhoon Committee has informed ESCAP that it would send one representative all on a self financed basis to the meeting from its secretariat, in addition to several others from its member countries as the official national delegates.

5.7 Publications

5.7.1 Publications issued under the programmes of the Panel fall into two categories (a) Panel News and (b) the Annual Review of the Tropical Cyclones affecting the Bay of Bengal and the Arabian Sea. Information on the current status of each is presented below:

Panel News

5.7.2 Panel News issue No.25 was published in April 2008 and distributed among the Panel Members, WMO, ESCAP and other concerned in May, 2008 during the 35th Session of the Panel (Manama, Bahrain 5-9 May, 2008) as well as by post. The Panel News Issue No. 26 has also been published and distributed among the Panel Members by post and copies of the same have also been distributed to the participants of thirty-sixth session of the Panel (Muscat, Oman 2-6 March 2009). The publication of Panel News issue No. 27 has been scheduled in April 2009. The Panel therefore, requested the Members to kindly provide their contributions to TSU through their Panel News correspondents more actively to avoid any delay in the publication of the next Panel News issue. The Panel also requested the Members to please send updated information about their News Correspondents especially if there is any change.

6. REVIEW OF THE TROPICAL CYCLONE OPERATIONAL PLAN

6.1 The Panel expressed its appreciation to Mr. Bandayopadhyay of India who kindly served as rapporteur to finalize the 2008 Edition of the Operational Plan.

6.2 As a result of the comprehensive review of the Operational Plan, which was assigned to the rapporteur by the Panel at the last session to improve the Plan, Mr. Bandayopadhyay proposed modification of format of the RSMC bulletins; (i) Tropical Weather Outlook, (ii) Special Weather Outlook and (iii) Tropical Cyclone Advisory. Since such modifications are expected to make those bulletins more informative as well as effective, the Panel unanimously agreed with the proposal of the rapporteur. Detailed description of the proposed modifications is presented in **Appendix VII**.

6.3 With regard to the storm surge watch scheme as one of the strategic objectives of ER-1 of the Coordinated Technical Plan, RSMC New Delhi offerred its view that it could issue watch for storm surge for inclusion in the RSMC bulletin, if the hydro-dynamical model developed by IIT Delhi is made available to the RSMC for operational use. The storm surge guidance can be given in ranges or in qualitative terms corresponding to the range of height of the expected storm surge.

6.4 In this regard, the representative of IIT Delhi expressed its commitment to contribute positively to the establishment of the storm watch scheme in the Panel region. He further clarified the cooperative relationship between the RSMC and IIT as follows;

RSMC: (1) Once the cyclone is forecasted to landfall in the particular country of the Panel region, RSMC may provide storm surge watch for that country using IIT storm surge model developed for that particular coastal region.
(2) RSMC is to provide the watch in the expected amplitude range.
(3) The issue whether the expected range of water level is dangerous or not may be decided by the county concerned on the basis of detailed knowledge of coastal geomorphology as well as using high resolution location specific IIT storm surge model.

IIT: (1) IIT Delhi will provide to RSMC the models developed for the countries of the region. IIT will also provide necessary training to RSMC to use the models.
(2) Besides helping RSMC to implement location specific models of storm surge, IIT will continue to provide training to the Panel Members to further improve storm

surge model such as inclusion of rivers/estuaries so that inland inundation of the surges be estimated.

6.5 For the early issuance of the 2009 Edition of the Operational Plan, the Panel urged the Members to communicate with Mr. B.K.Bandyopadhyay, Rapporteur on the Operational Plan, by 31 March 2009 with or without their amendments.

6.6 The Panel requested WMO to issue the 2009 Edition as early as possible.

7. TECHINAL SUPPORT UNIT

7.1 The Panel expressed its gratitude to the Government of Pakistan for hosting the Technical Support Unit (TSU) and appreciated the services being rendered by Dr Qamar-uz-Zaman Chaudhry, Director-General of Pakistan Meteorological Department (PMD) in his capacity as Coordinator of TSU and Mr. Ata Hussain, Deputy Director (Coordination and International Met. Section) PMD as the Meteorologist of TSU.

7.2 The Panel was briefed by Mr. Hussain on the activities of TSU during the intersessional period. The Panel expressed its satisfaction with the work of the TSU. The summary of the activities of TSU is given in **Appendix VIII**.

7.3 While reviewing the current status of the legal and institutional framework of TSU, the Panel decided to restructure the TSU and its status. It agreed that TSU be renamed as Panel on Tropical Cyclone Secretariat (PTC Secretariat) and Coordinator be the Secretary of the Panel on Tropical Cyclones (Secretary of PTC). Dr. Chaudhry welcomed the new status and informed the Panel that PMD will provide more staff to the PTC Secretariat with a view to promoting the activities of the Secretariat and offered his thanks to the Panel on the confidence that Panel imposed on him and PMD with regards to the hosting of the PTC Secretariat.

7.4 TSU provided the Panel with a detailed breakdown of its expenses incurred during the Inter-sessional period (see **Appendix IX**). Keeping in veiw some savings, TSU requested the Panel for provision of US$ 4,000 for its expenses during the year 2009.

8. SUPPORT FOR THE PANEL'S PROGRAMME

8.1 The Panel was informed of the technical cooperation activities of WMO and ESCAP in support of the programmes of the Panel carried out in 2008, including the WMO Voluntary Cooperation Programme (VCP), Trust Fund arrangements, Emergency Assistance Fund scheme and Technical Cooperation among Developing Countries (TCDC) activities, and expressed its appreciation to WMO, ESCAP and collaborating partners for providing assistance to Members of the Panel.

8.2 The Panel noted that, in 2008, Maldives, Myanmar and Pakistan made cash contributions to the Voluntary Cooperation Fund (VCP(F)). Two VCP project requests were submitted by two Members of the Panel. The Meteorological Information Comprehensive Analysis Process System (MICAPS) was provided to Bangladesh, Maldives and Myanmar by China. The installation of an Automatic Weather Station (AWS) was completed in January 2009 in Myanmar with the support of MEISEI Electric Co. Ltd, Japan. Sri Lanka has received support from Japan; MEISEI Electric Co. Ltd, Japan; TOTEX Corporation, Japan; and the VCP(F) for the replacement of an upper-air system and provision of radiosondes and balloons in 2007-2008. China supported Myanmar and Sri Lanka for the provision of FengYunCast systems in 2007-2008.

8.3 The Panel was informed of the progress of the Trust Fund project for Oman and UNDP project for Maldives. It also noted with satisfaction that the GTS upgrade project for

Myanmar had successfully been completed through the WMO/ISDR Trust Fund/VCP in January 2009 before Cyclone Nargis. The Panel welcomed the progress on the implementation of the Trust Fund project for a Doppler weather radar in Sri Lanka.

8.4 Within the framework of the TCDC, China organized the WMO Symposium on Strengthening NMHSs External Relations followed by the 2008 Study Tour in China from 13 to 23 October 2008 for 20 participants, mainly International Advisors, from 16 Members of WMO in Africa and Asia. India and Sri Lanka participated in the Symposium and Study Tour in 2008. The Panel noted with appreciation the implementation of a preliminary meteorology course by Pakistan in 2008 for junior meteorological personnel from neighboring countries, including Bangladesh, Maldives and Sri Lanka. It further noted that the second training course in 2009 was offered to Bangladesh, Maldives, Myanmar, Oman and Sri Lanka and other five neighboring countries. With appreciation to India and Pakistan for their active contributions to Panel's training requirements through TCDC, the Panel encouraged other Members to exploit similar training opportunities for other Members as contribution to the VCP, and agreed on sharing the information on the training opportunities available for Panel Members.

8.5 The Panel also noted the recent emergency assistance provided under the Emergency Assistance Fund scheme to WMO Members affected by natural disasters, including Bangladesh and Pakistan. Affected Members who need emergency assistance were advised to utilize this scheme, and all Members were requested to consider possible support to the affected NMHSs. The Panel further noted with appreciation that WMO emergency assistance was provided to Myanmar following Cyclone Nargis with the support of Australia, China and Japan as well as the Emergency Assistance Fund and the VCP(F). The Panel was pleased to note the major outcomes of the recent WMO fact-finding mission to Myanmar carried out from 9 to 13 February 2009 in collaboration with ESCAP and PTC Members, further to various WMO initiatives including the WMO preliminary assessment mission sent immediately after Nargis in May 2008. The Panel welcomed Myanmar's effort to convert the crisis to the opportunity and expressed full support to the proposed WMO's programme of action for further assistance to Myanmar, including provision of high-priority and urgent equipment and of training opportunities, to develop effective early warning systems for cyclone and storm surge forecasting and warning to minimize impacts of future cyclones.

8.6 The Panel welcomed that WMO and the Asian Disaster Preparedness Centre (ADPC) concluded on 8 July 2008 a Memorandum of Understanding concerning cooperation on capacity building for preparedness, mitigation and early warning of natural hazards, in the area of the enhancement of capacity of NMHSs to deliver their products to end-uses for early warning arrangements for disaster risk reduction. The Panel noted that the concept of Severe Weather Forecasting Demonstration Project was included as WMO responsible actions into the proposed joint project for "Reducing risks in low elevation coastal zones to tsunami and other natural hazards" for Maldives, Myanmar, Sri Lanka and Thailand, submitted in August 2008 to the fifth round of UNESCAP Multi-donor Voluntary Trust Fund on Tsunami Early Warning Arrangements in the Indian Ocean and Southeast Asia. The Panel reiterated the benefit to the above countries, in particular Myanmar, in their efforts to enhance capacity of NMHSs for early warning arrangements for disaster risk reduction.

8.7 The Panel noted with appreciation that WMO and UNESCAP would continue to undertake activities in support of the Panel on Tropical Cyclones.

Panel on Tropical Cyclones Trust Fund (PTCTF)

8.8 The establishment of the Panel on Tropical Cyclones Trust Fund (PTCTF) indicated a step towards achieving self-reliance of the Panel. At the moment, the Fund is being used not only for the provision of institutional support but also as funding support to the representatives of Panel Members attending training events and conferences.

8.9 Members were urged to continue to enhance their contributions to the Trust Fund as a substantial support for the Panel's activities.

8.10 A detailed financial report on the Trust Fund as of 31 December 2008 was submitted (see **Appendix X**).

8.11 The Panel endorsed the use of the Trust Fund for 2009 for the following specific purpose:

- Support for the attachment training at RSMC New Delhi for per diem of the participants (US$ 6,000)
- Support for organizing the first meeting of Working Group on DPP to be held in Thailand during 2009. (US$ 5,000)
- Support to TSU for its operating expenses including those for printing Panel News and running TSU-website. (US$ 4,000)
- Support to TSU for its participation in the first meeting of Commission of DRR ESCAP (US$ 2,000)

Any other emergency expenditure that can be justified for the use of the PTCTF requires the concurrence of both the TSU Coordinator and the Chairman of the Panel on Tropical Cyclones.

9. SCIENTIFIC LECTURES

9.1 The Panel devoted a session for the presentation of lectures. The list of presentations is as follows:

- Tropical Cyclones and Climate Change – Some of the Issues
  Dr John McBride (Centre for Australian Weather and Climate Research)

- Tropical Cyclones and Climate Change – An Indian Ocean Perspective
  Dr Tom Knutson (GFDL, Princeton, New Jersey, USA)

- EUMETSAT's Contribution to Monitoring Tropical Cyclones over the Indian Ocean
  Dr HansPeter Roesli (EUMETSAT)

- IIT Storm Surge Model
  Prof. Shishir Dube (IIT Delhi, India)

- Tropical Cyclone GONU in June 2007
  Mr Badar Ali Alrumhi (Director of Forecasting and Observing Practices, Department of Meteorology, Oman)

9.2 The Panel expressed its deep appreciation to the above lecturers for their informative and excellent presentations.

10. DATE AND PLACE OF THE THIRTY- SEVENTH SESSION

10.1 The representative of Thailand informed the session of their willingness to host the 37th session in 2010 subject to the Government's approval.

10.2 The Panel expressed its deep appreciation to Thailand for considering to host the 37th session..

10.3 The next session is expected to be held in February, 2010 but the exact dates and venue would be determined based on consultation between WMO, ESCAP, the host, Chairman of the Panel and TSU Coordinator.

11. ADOPTION OF THE REPORT

The report of the thirty-sixth session was adopted at 1245 hours on Friday, 6th March 2009.

12. CLOSURE OF THE SESSION

12.1 The Panel expressed its sincere appreciation to the Government of Oman, the host country, for providing the excellent facilities, the venue, other arrangements and its warm hospitality. The Panel also expressed its deep appreciation to Mr Abdul Rahim bin Salim Al-Harami, Chairman of the Panel, Mr Ali Shareef, Vice-chairman of the Panel as well as Mr G.B. Samarasinghe, Chairman of the Drafting Committee, for their successful conduct of the session. The Panel wished to express its gratitude to Mr Badar Ali Alrumhi (Chairman, Local Organizing Committee) and staff of Department of Meteorology for their hard work in organizing the session, assistance provided to the participants and producing a session report.

12.2 The thirty-sixth session of the Panel was concluded on 6th March 2009 at 1315 hours.

LIST OF APPENDICES

List of Participants

Name	Designation	Contact Information
Bangladesh		
1. Mr. Md. Amirul Hussain	Deputy Director BMD	Bangladesh Meteorological Department (BMD) Meteorological Complex, Agargaon, Dhaka-1207, Bangladesh. Tel: +88-2-9118384 Email: directorbmd2005@yahoo.com, info@bmd.gov.bd
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3. Mr. Ali Shareef	Assistant Director General	Department of Meteorology, Hulule 22000, Maldives. Tel: + 960-3326200 Fax: +960-3341797 Email: shareef@meteorology.gov.mv
Myanmar		
4. Dr. Tun Lwin (DMH)	Director General DMH & P R of Myanmar with WMO	Department of Meteorology & Hydrology Yangon, Myanmar. Tel: + 95-1-665944 Fax: +95-1-660823 Email: dg.dmh@mptmail.net.mm
Oman		
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6. Mr. Ahmmed Al-Harthy	Director (Operations and Services)	DGMAN Muscat International Airport P.O.Box:1 Area Code:111 Sultanate of Oman Tel: + 968-99330306 Email: a.alharthi@met.gov.om

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9.	Dr. Juma Al Maskari	Assistant Director for Meteorology	DGMAN Met. Office Muscat International Airport Sultanate of Oman, Oman, P.O.Box: 868 Pin 211 Tel: + 968-99262656 Fax: +968-24519363 Email: j.almaskari@met.gov.om
10.	Mr. Amer Mansoor Al Rawas	Assistant Director for Meteorology	DGMAN Met. Office Salalah Airport Sultanate of Oman, Oman, P.O.Box: 868 Pin 211 Tel: + 968-9494063 Fax: +968-23204205 Email: amerkmm@yahoo.com
11.	Mr. Rashid Yahya Al Abri	Director	Ministry of Regional Muncipalities and Water Resources Water Resources Monitoring Department P.O.Box 2575, Ruwi, P.C. 112 Sultanate of Oman, Tel : + 968-24478760 Fax: +968-24478767 Email: rashid70y@yahoo.com
12.	Mr. Ahmed Said Al Barwani	Water Resources Expert	Ministry of Regional Muncipalities and Water Resources Water Resources Monitoring Department P.O.Box 2575, Ruwi, P.C. 112 Sultanate of Oman, Tel: + 968-24478760 Fax: +968-24478767 Email: asbarwan@yahoo.com.uk
13.	Mr. Jassim Nadhar Al Zadjali	Water Resources Specialist	Ministry of Regional Muncipalities and Water Resources Water Resources Monitoring Department P.O.Box 468, Al Khoudh, P.C. 132 Sultanate of Oman, Tel : + 968-99366117 Fax: +968-24478767

			Email: zadjalij@yahoo.com.uk
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15.	Mr. Hamdan Al Hasani	Director of Technology & Projects	Ministry of Environment and Climate Affairs P.O.Box 1174, Muttrah, P.C. 114 Sultanate of Oman, Tel : + 968-95188885 Email: hamdanalhasani@yahoo.com
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APPENDIX II

PROVISIONAL ANNOTATED AGENDA

1. ORGANIZATION OF THE SESSION

1.1 Opening of the session

At the kind invitation of the Government of Oman, the thirty-sixth session of the WMO/ESCAP Panel on Tropical Cyclones will be held in Muscat, Oman from 2 to 6 March 2009.

1.2 Election of the Chairman and Vice-chairman

The Panel will elect a chairman and a vice-chairman to serve during the session and for the period until the thirty-fifth session.

1.3 Adoption of the agenda

The provisional annotated agenda will be submitted to the session for approval. The order of the agenda may be modified during the session and additional items introduced.

1.4 Working arrangements

The Panel will agree on the details concerning the organization of its work, including working hours. The meeting may wish to appoint rapporteurs on its consideration of specific topics.

2. FOLLOW-UP ACTION ON PTC-35

The Panel may wish to review the recommendations of the thirty-fifth session and the action taken, if any.

3. REVIEW OF THE 2008 CYCLONE SEASON

The Panel is concerned with seeking ways of improving tropical cyclone warning services for the benefit of the Members. It may wish, therefore, to carry out a detailed review of the actual events of the past cyclone season as a prelude to discussing ways of improving the facilities available, the existing cooperative and coordinated arrangements and the services provided.

3.1 Report of RSMC - Tropical Cyclones New Delhi

The Panel will make an overall review of the 2008 cyclone season based on the seasonal summary submitted by the RSMC - Tropical Cyclones New Delhi as a technical report. Behaviours of individual cyclones and forecast performance of RSMC New Delhi will be presented in the report.

3.2 Reports of Members on the impact of tropical cyclones

Members will review the impact of tropical cyclones and related floodings/storm surges during the 2008 season. The review is expected to cover meteorological and hydrological aspects as well as assessments of damage and the effectiveness of disaster prevention and preparedness arrangements in each Member country.

4. COORDINATION WITH OTHER ACTIVITIES OF THE WMO TROPICAL CYCLONE PROGRAMME

Discussion of this item will be based mainly on the thirty-fourth status report on the implementation of the WMO Tropical Cyclone Programme (TCP). Additional information available since the issue of the document will be presented by the WMO Secretariat at the session.

5. REVIEW OF THE COORDINATED TECHNICAL PLAN AND CONSIDERATION OF THE WORK PROGRAMME FOR THE NEXT FIVE YEARS

Discussions will focus on progress at the national and regional levels in each of the three major components of the Panel's programme of activities, namely in meteorology, hydrology and disaster prevention and preparedness, as well as in the supporting components of training and research. The Panel will also consider re-establishment of the Coordinated Technical Plan.

5.1 Meteorological Component

A detailed review will be made regarding meteorological facilities and services such as telecommunications, cyclone detection radars, upper-air observations, ships' and aircraft reports, and meteorological satellites.

5.2 Hydrological Component

The Panel will be informed of progress made under the hydrological component of the Panel's programme since May 2008.

5.3 Disaster Prevention and Preparedness Component

In addition to national activities, regional and international coordinated activities related to tropical cyclone disaster prevention and preparedness will be reviewed at the session.

5.4 Training Component

The Panel will be informed of training events relevant to the Panel's programme carried out since May 2008. Information will also be provided in respect of planned group training, such as courses and seminars/workshops in 2009 and 2010. Members will discuss the future training programme, taking into account the possibility of financial assistance.

5.5 Research Component

Panel Members will also be asked to specify their needs for exchange of recent research information on tropical cyclone monitoring, analysis and forecasting.

5.6 New Joint Initiatives

The Panel will consider to develop an implementation strategy and programme for the new joint initiatives, of which the concept was agreed in principle at the 34th session to enhance regional cooperation to support ongoing efforts of all the Members in developing their respective multi-hazard early warning systems.

5.7 Publications

Publications issued under the programmes of the Panel fall into two categories, (a) *Panel News*, and (b) the *Annual Review of the Tropical Cyclones affecting the Bay of Bengal and the Arabian Sea.* Information on the current status of each is presented below:

(a) Panel News

Members may wish to give their views on the format and contents of *Panel News* at the session. Contributions brought to the session for inclusion in the next issue in 2009 would be welcomed.

(b) Annual Review

Further information is expected to be available from the Chief Editor for presentation at the session.

6. REVIEW OF THE TROPICAL CYCLONE OPERATIONAL PLAN

Discussions will centre on a review of the Tropical Cyclone Operational Plan for the Bay of Bengal and the Arabian Sea which is published in the TCP series. In doing so, the Panel may wish to update and supplement the information in the Plan, as well as to consider if there are changes which could be made to the regional cooperative arrangements to strengthen the forecasting and warning systems and hence to be reflected in the Operational Plan. A rapporteur will be appointed for the revision of the Plan.

7. TECHNICAL SUPPORT UNIT

The Panel will be informed of the activities of and other matters related to the TSU.

8. SUPPORT FOR THE PANEL'S PROGRAMME

The Panel will review the resources currently available from all sources to support its programme of activities, both with regard to the contributions made by Members themselves and external support available from a variety of sources such as WMO/VCP, WMO Regular Budget, ESCAP, TCDC, bilateral assistance, etc.

The Panel will also discuss details on the Panel's Trust Fund, potential external resources/donors, and pending and proposed WMO/VCP requests.

9. SCIENTIFIC LECTURES

It is proposed that one half day of the session be devoted to lectures/presentations relevant to Panel’s activities. Details of the programme will be distributed in due course.

10. DATE AND PLACE OF THE THIRTY- SEVENTH SESSION

By convention, annual meetings of the Panel were normally held on a rotating basis. If possible an approximate date and location for the thirty-seventh session should be determined, leaving the final arrangements to be fixed by consultation between the host country, WMO, ESCAP and TSU.

11. ADOPTION OF THE REPORT

The report of the meeting will be submitted for adoption of the Panel.

12. CLOSURE OF THE SESSION

The session is tentatively scheduled to close on 6 March 2009.

APPENDIX III

ACTION SHEET

THIRTY-FIFTH SESSION OF THE WMO/ESCAP PANEL ON TROPICAL CYCLONES

(Manama, Bahrain, 5 – 9 May 2008)

Para. No.	Subject	Action Required	Responsible	Deadline	Remarks
6.3	Strengthening the existing cooperation and collaboration between the national warning centres and RSMC New Delhi	secure direct communications between the RSMC and the national warning center of the Member coutries and to establish the point of contact on both sides	RSMC New Delhi and Panel members	ASAP	
7.5	Update of the Global Guide to Tropical Cyclone Forecasting	The updated version of the Global Guide to be published.	WMO (TCP)	ASAP	Expected to be published in 2009
7.7	Finalization of the study on suitable conversion factors between the WMO 10-minute standard average wind and 1 minute, 2 minute and 3-minute “sustained” winds.	Include a one page executive summary of the study in the Global Guide to Tropical Cyclone Forecasting and in the Operational Plans/Manual of the TC regional bodies in a suitable format.	WMO (TCP)	ASAP, and to be discussed at the next session of PTC.	The updated Global Guide to Tropical Cycloe Forecasting expected to be completed in 2009
8.	Early re-establishment of the Coordinated Technical Plan and Work Programme	High Policy Working Group (PWG) requested to present a draft	Panel	at the next session	

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Para. No.	Subject	Action Required	Responsible	Deadline	Remarks
8.1.10	Concern about possible discontinuation of sea surface wind observations by satellites over the next decade	Urge relevant space agencies to give due consideration on the continuation of this service	Panel		
8.2.2	Regional workshop on flood forecasting	Arrangements for provision of financial and technical assistance to organize such a regional workshop by UNESCAP, WMO and other international organizations, and decision by their respective Governments of the Panel to organize the workshop.	Panel, Bangladesh, and India	Within 6 weeks after the PTC-35	
8.2.7	Development of Manuals on "Flood Forecasting and Warning", "Low Flow Estimation and Prediction", "Stream Gauging" and PMP	To disseminate them to members	CHy	Once published	
8.2.10	Implementation of the FFI with inclusion of the Implementation of the Flash Flood Guidance System (FFGS) project	Establishment of regional system components in the Panel region.	Panel		
8.3.1	Multi-hazard early warning concept paper together with a draft work plan	Establishment of a Task Force to assist the WG-DPP to implement the proposed Multi-hazard early warning concept in cooperation with UNESCAP and WMO	Chair of WG-DPP of the Panel		
8.3.3	DRR integrated capacity development action plan	Implementation of the action plan through concrete regional and national projects	WMO (DRR)		
8.3.8	the Third Asian Ministerial Conference on Disaster Risk Reduction in Kuala Lumpur	The Panel Members invited to join UNESCAP in the preparation for this Conference	Members	Before its holding from 2 to 4 December 2008	
8.4.6	Attachment of tropical cyclone forecasters at the RSMC New Delhi and the attachment of storm surge experts at IIT Delhi	Request for the RSMC New Delhi and IIT Delhi to continue this training activity for the Members	RSMC New Delhi and IIT Delhi	Annually	

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Para. No.	Subject	Action Required	Responsible	Deadline	Remarks
8.6.2	Development of an Integrated Hazard Awareness Display (IHAD) as a mechanism to promote the development of multi-hazard early warning systems in the Panel Area	Establishment of a Task Force on IHAD for the development of such project proposal for submission to UNESCAP		Before 15 August 2008	
8.6.3	Meeting of PWG (High-level Policy Working Group)	Preparation of all background documents in cooperation with WMO and UNESCAP before the meeting of PWG, lead by the Chair of PWG	PWG, WMO, UNESCAP	Before the 36th Session	
9.4	Update the Operational Plan for Edition 2008	Communication of members' amendments to the rapporteur for the update;	Members	not later than 15 June 2008	
9.4	Update the Operational Plan	Comprehensive review of the structure and format of the current Opeartinal Plan and offer suggestions for improvements	the rapporteur	at the next session.	
9.5	Update of the list of address/telephone of the Members in the Operatinal Plan	Each Member to designate two or more focal poinsts and send their names, phone/fax number and e-mail address to the rapporteur through TSU	Members, the rapporteur	not later than 15 June 2008	
9.6	2008 Edition of the Operational Plan	To be issued as early as possible	WMO (TCP)		
10.3	TSU's major role in the management of joint projects of the Panel	WMO, UNESCAP and TSU are urged to review the current status of the legal and institutional framework of TSU with a view to recommending possible strengthening measures and report the findings to all the Members	WMO, UNESCAP and TSU	ASAP	
11.6	WMO initiatives for the emergency assistance for Myanmar	Financial support for Myanmar's participation in the relevant international meetings, provision of training opportunities with higher priority as well as the technical assistance for the restoration of damaged basic meteorological and hydrological networks	WMO		

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Para. No.	Subject	Action Required	Responsible	Deadline	Remarks
11.7	Capacity building on disaster risk reduction	Cooperation between WMO and ADOC on capacity building for preparedness, mitigation and early warning of natural hazards, in the area of the enhancement of capacity of NMHSs to deliver their products to end-uses for early warning arrangements for disaster risk reduction	WMO, ADPC		
12.3	Interaction of NMHSs Members among themselves and with prominent experts.	Enhancement of NMHSs Members on interaction among themselves and also with other prominent experts on this subject so as to provide inputs for the identification of possible scenarios for better assessment of adaptation costs, and good assessment of adaptation costs in the ongoing global process of negotiation for better coping with climate change beyond 2012.	Panel		
14.1	First Indian Ocean International Conference on Climate Change and Tropical Cyclone, and the the thirty sixth Session of PTC	WMO sponsorship, and Oman hosting of the Conference and the Session	WMO, Oman		

APPENDIX IV

BRIEF REPORT ON DEPRESSIONS/STORMS DURING 2008 OVER THE NORTH INDIAN OCEAN

(BAY OF BENGAL AND ARABIAN SEA)

1. Introduction

During 2008, in all 10 intense low pressure systems formed over the Indian seas. These include one Very Severe Cyclonic Storm (NARGIS), three Cyclonic Storms (RASHMI, KHAI MUK and NISHA), 3 Deep Depressions, 2 Depressions and 1 land Depression. Out of these 10 systems, one (Very Severe Cyclonic Storm (NARGIS)) occurred during the pre-monsoon season, four (1 Deep Depression, 2 Depressions and a land Depression) occurred during the southwest monsoon season and the rest five (Cyclonic Storms (RASHMI, KHAI MUK and NISHA and 2 Deep Depressions) occurred during the post-monsoon season.

The Very Severe Cyclonic Storm (NARGIS) crossed Myanmar coast. Out of the three cyclonic storms which formed over Bay during the post monsoon season, 2 had landfall over the Indian coast and one struck Bangladesh coast.

One Depression each formed during the monsoon season and post monsoon season over the Arabian Sea. Both the Depressions moved in a northwesterly to westnorthwesterly direction and dissipated over Sea.

WINTER SEASON *(JANUARY AND FEBRUARY)*

No Depression or Cyclonic Storm formed during the season.

PRE-MONSOON SEASON *(MARCH TO MAY)*

One Very Severe Cyclonic Storm 'Nargis' (27 April - 3 May) formed over the Bay of Bengal.

I. *Very Severe Cyclonic Storm NARGIS over the Bay of Bengal (27 April – 3 May 2008)*

A trough low lay over the southeast Bay and adjoining south Andaman Sea on 24. It persisted with a cyclonic circulation extending upto 1.5 km a.s.l. over the region on 25 and organised into a low pressure area over the southeast Bay and neighbourhood on 26. It concentrated into a Depression and lay centred at 0300 UTC of 27, near Lat. 12.0°N/ Long. 87.0°E, about 750 km eastsoutheast of Chennai. Moving slightly westwards, it intensified into a Deep Depression and lay centred near Lat. 12.0°N/ Long 86.5° E at at 1200 UTC of 27. Subsequently moving northwestwards, it further intensified into a Cyclonic Storm (NARGIS) and lay centred at 0000 UTC of 28, near Lat. 13.0°N / Long. 85.5°E, about 550 km. east of Chennai. For the following 24 hrs, it remained practically stationary and intensified into a severe Cyclonic Storm at 0900 UTC of 28. Then it moved northwards and intensified into a Very Severe Cyclonic Storm and lay centred at 0300 UTC of 29, near Lat. 13.5° N/ Long. 85.5° E and at 1200 UTC, near Lat. 14.0° N/ Long. 85.5 °E. Re-curving northeastwards, it lay centred near Lat. 14.5° N/ Long. 86.5° E at 0300 UTC and near Lat. 14.5° N/ Long. 87.0 °E at 1200 UTC of 30 April, respectively. It continued to move northeastwards and lay centred at 0300 UTC of 1 May, near Lat. 15.5° N/ Long. 89.0°E and at 1200 UTC, near Lat. 16.0° N/ Long. 90.5°E. Subsequently moving eastwards, it lay near Lat. 16.0° N/ Long.93.0°E at 0300 UTC of 2, near Lat. 16.0° N/ Long.94.0°E at 1200 UTC and crossed southwest coast of Myanmar between 1200 & 1400 UTC, along Lat. 16.0°N. It moved northeastwards across Myanmar and weakened into a Severe Cyclonic Storm at 0300 UTC of 3 and lay centered near Lat. 17.0° N/ Long.96.0°E. It further weakened into a Cyclonic Storm near Lat. 18.0° N/ Long.97.0°E at 0900 UTC of 3 and further into a well marked low pressure area over east central Myanmar by the evening of 3.

The lowest Estimated Central Pressure (ECP) was 962 hPa. The maximum estimated mean wind speed was 90 kts. The system moved initially in northwesterly direction, then northerly and then

recurved into northeasterly direction and crossed southwest coast of Myanmar between 1200-1400 UTC of 2 May.

Widespread rainfall activity from 27 April to 2 May with isolated heavy falls (on 29 April, 1 and 2 May) occurred at A & N Islands.

Some chief amounts of rainfall are:

29/4 : Port Blair 8, Maya Bandar 7
1/5 : Car Nicobar 7
2/5 : Long Island 11, Maya Bandar, Port Blair 6.

The system was mainly tracked by satellite. The maximum intensity of T. No. 5.0 was reported from 0500 to 1200 UTC of 2 May. "Eye" was seen from 0400 UTC of 1 May to 1200 UTC of 2nd May.

The system centre was never closer than 550 km from DWR Chennai, but at that distance it remained practically stationary for quiet some time.

MONSOON SEASON (JUNE – SEPTEMBER)

Four Depressions formed during the season, 2 over the Bay of Bengal and 1 each over the Arabian Sea and over the Land.

I. Depression over the east central Arabian Sea (5 - 6 June 2008)

A low pressure area formed over the eastcentral Arabian Sea and neighbourhood on 4. It concentrated into a Depression and lay centred at 0000 UTC of 5, near Lat. 15.5 °N/ Long. 66.0°E. It lay centred near Lat. 16.0°N/ Long. 66.0°E, about 800 km southwest of Mumbai at 0300 UTC and near Lat. 17.0° N/ Long 65.0° E at 1200 UTC of 5. Moving westwards, it lay over the west central and adjoining northwest Arabian Sea, centred near Lat 19.5°N/ Long. 62.0°E at 0300 UTC and near Lat. 20.0°N/ Long. 61.5°E at 1200 UTC of 6. Further moving northwestwards, it weakened and lay as a well marked low pressure area over the northwest and adjoining west central Arabian sea and adjoining Oman coast in the early morning of 7 and as a low pressure over the same region in the morning hours. Subsequently it moved away westwards.

The lowest estimated central pressure was 996 hPa. The maximum estimated mean wind speed was 25kts. The system moved initially in northerly and then in a northwesterly direction and dissipated over west central and adjoining northwest Arabian Sea.

As the system moved away from the west coast, it did not cause any damage.

The maximum intensity of T. No. 2.0 was reported by satellite imagery from 0300 to 1100 UTC of 6 June. As per the satellite account, the central feature started disorganizing due to dry air and land interaction from Saudi Arabia after 1100 UTC of 6 June.

As the system moved away from the coast, it was not tracked by RADAR.

II. Depression over the North Bay of Bengal (16 – 18 June 2008)

A cyclonic circulation extending upto mid tropospheric levels lay over the northwest Bay and adjoining West Bengal-north Orissa coasts on 14. Under its influence, a low pressure area formed over the northwest Bay off West Bengal – north Orissa coasts on 15. It concentrated into a Depression over the North Bay off Bangladesh coast and lay centred at 0300 UTC of 16, near Lat. 21.5°N/ Long. 90.0°E, about 220 km southeast of Kolkata. Moving northwards, it crossed Bangladesh coast along Long. 89.5° E, between 1100 & 1200 UTC of 16 and lay over coastal Bangladesh, near Lat. 22.0°N/ Long. 89.5°E at 1200 UTC. It lay over Gangetic West Bengal and adjoining Bangladesh, centred close to Krishnanagar (Lat. 23.0°N/ Long. 88.5°E), about 80 km northnortheast of Kolkata, at 0300 UTC of 17 and over Gangetic West Bengal, close to Burdwan (Lat. 23.0°N/ Long. 88.0°E), about 100 km northwest of Kolkata at 1200 UTC. Further moving northwestwards, it lay centred at 0300 UTC of 18, over Jharkhand (near Lat. 24.0°N/ Long. 87.0°E), about 50 km southwest of Dumka. It subsequently weakened and lay as a well marked low pressure area over Jharkhand and neighbourhood, in the

evening. It further weakened into a low pressure area and lay over east Uttar Pradesh and adjoining east Madhya Pradesh on 19 & 20 and became less marked on 21.

The lowest ECP was 988 hPa. The maximum estimated wind speed was 25 kts. The system moved in a northwesterly direction and crossed Bangla Desh coast along Long. 89.5 ° E between 1100 UTC and 1200 UTC of 16 near 22.0/ 89.5.

Widespread rainfall activity with very heavy to extremely heavy falls at isolated places occurred from 16 to 18 in Orissa; on 17 and 18 in Gangetic west Bengal and on 18 in Jharkhand. The system caused flood over East Midnapore district of Gangetic West Bengal and Orissa, many people affected and huge crops damage occurred.

Some chief amounts of rainfall are:

Gangetic West Bengal:

16 June: Alipore 7
17 June: Contai 26, Uluberia 24, Midnapore 21, Canning town 18, Digha 17, Durgachak 14
18 June: Midnapore 37, Digha 7

Orissa:

16 June: Chandbali 17
17 June: Rairangapur 32, Jaleswar 25
18 June: Rairangapur 32, Jaleswar 29, Rajghat 28

Jharkhand:

18 June: Jamshedpur 34

The maximum intensity of T 1.5 was reported by satellite imagery from 0600 to 1200 UTC of 16.

III. Land Depression over Orissa (9 – 10 August 2008)

Under the influence of a cyclonic circulation extending upto mid tropospheric levels over the northwest Bay and adjoining coastal areas of Orissa and Gangetic West Bengal, a low pressure area formed over the northwest Bay and adjoining coastal areas of Orissa and adjoining Gangetic West Bengal on 8. It became well marked over the same region on 9 morning and concentrated into a Depression over south Orissa-north Andhra coasts, close to Puri (Lat. 20.0°N/ Long. 86.0°E) at 1200 UTC of 9. Moving in a northwesterly direction, it lay over interior Orissa, close to Keonjhargarh (Lat. 21.5°N/ Long. 85.5°E) at 0300 UTC of 10 and weakened into a well marked low pressure area in the evening. It lay as a low pressure area over north Chattisgarh and neighbourhood on 11 morning and became less marked in the evening. The associated cyclonic circulation extending upto mid tropospheric levels tilting southwestwards with height lay over Madhya Pradesh on 11 evening. It lay over southeast Rajasthan and adjoining Gujarat region on 12 & 13; over west Rajasthan and neighbourhood on 14 & 15; over Punjab and neighbourhood during 16 – 21 and became less marked on 22.

The lowest pressure 988.0 hPa was reported by Bhubaneswar at 1200 UTC of 9. The maximum estimated wind speed was 25 kts.

Widespread rainfall activity with isolated very heavy falls occurred at Orissa from 8 to 11 and at coastal Andhra Pradesh and Telangana on 9 and 10.

In Andhra Pradesh, heavy rain caused the rivers Nagavali, Vamsadhara etc., to overflow above the danger levels and resulted in floods in the districts of Srikakulam and Vizianagaram. The rivers/drains flooded with heavy rains inundating many villages in East & West Godavari, Krishna and Guntur districts. Due to heavy to very heavy rain standing crops were damaged in Orissa.

Some chief amounts of rainfall are:

Andhra Pradesh:

9 Aug: Paleru Bridge 21, Nandigama 14, Prakasam Barrage 12, Nuzivedu 11, Gannavaram 10, Avanigadda 10, Machilipatnam 9, Amalapuram 9, Tiruvur 7, Gudivada 7.

10 Aug: Nuzivedu 17, Tiruvur 13, Eleru 12, Paleru Bridge 12, Prakasam Barrage 11, Koyyalagudem 11, Amalapuram 11, Nandigama 11, Chintalapudi 11, Tanuku 10, Bhimavaram 9, Guntur 9, Kaikalur 9

Orissa:

8 Aug: Madanpur-Rampur 19, Baragaon 17, Junagarh 14, Lanjigarh, Jaipatna 11

9 Aug: Madanpur-Rampur 22, Kotagarh, Lanjigarh 16, Blangir, Bhawanipatna 13, Paradip 12

10 Aug: Nawarangapur 15, Gunpur 12, Koshagumuda, Kotagarh, Junagarh 11, Jaipatna 10, Parlakhemundi 9

11 Aug: Rengali 12, Bhubaneswar 11

2.4.4 Action taken

Action taken by CWC Bhubaneswar and CWC Visakhapatnam were timely and adequate.

IV. Deep Depression over the north Bay and neighbourhood (15 -19 September 2008)

Under the influence of a cyclonic circulation over the north Bay and neighbourhood, a low pressure area formed over there on 15. It concentrated into a Depression and lay centred at 1200 UTC of 15, near Lat. 19.5°N/ Long. 88.5°E, about 230 km eastsoutheast of Paradip. Moving northwestwards, it intensified into a Deep Depression and lay centred at 0300 UTC of 16, near Lat. 20.0° N/ Long 87.5°E, about 130 km southeast of Chandbali. It lay centred near Lat. 20.5°N/ Long. 87.0°E, about 50 km southeast of Chandbali at 1200 UTC of 16. Further moving westnorthwestwards, it crossed Orissa coast near Chandbali between 1600 & 1700 UTC of 16. It lay centred at 0300 UTC of 17, over Orissa, near Keonjhargarh (Lat. 21.5°N/ Long. 85.5°E) and at 1200 UTC, near Jharsuguda (Lat. 22.0°N/ Long. 84.5°E). Continuing the westnorthwestward movement, it lay centred at 0300 UTC of 18, over north Chattisgarh (Lat. 22.5°N/ Long. 82.5°E), about 50 km north of Champa. It subsequently weakened into a Depression and lay centred at 0900 UTC of 18, close to Pendra (Lat. 23.0°N/ Long. 82.0°E) and remained practically stationary over there at 1200 UTC. Thereafter it moved westnorthwestwards and lay centred at 0300 UTC of 19, over northeast Madhya Pradesh, close to Satna (Lat. 24.5°N/ Long. 80.5°E)and weakened into a well marked low pressure area over Central parts of Uttar Pradesh in the evening. It further weakened into a low pressure area over northwest Uttar Pradesh and neighbourhood on 20 morning and became less marked on 21. However, the associated upper air cyclonic circulation extending upto mid-tropospheric levels persisted there on 21 and 22, which lay over west Uttar Pradesh and neighbourhood on 23, over east Uttar Pradesh and neighbourhood on 24 and 25 and became less marked on 26.

The lowest ECP was 986.0 hPa. The maximum estimated wind speed was 30 kts. The maximum wind of 40 kts and lowest pressure of 982.9 hPa was reported by Chandbali at 1700 UTC of 16, at the time of crossing coast. The system initially moved in a westerly direction and then in a westnorthwesterly direction and crossed Orissa coast near Chandbali between 1600 and 1700 UTC

2.5.2 Weather and damage caused

Widespread rainfall activity with isolated heavy to very heavy rainfall occurred over Orissa on 15 & 16; on 18 & 19 in Chattisgarh and on 19 in east Madhya Pradesh and with isolated extremely heavy falls on 17 & 18 in Orissa. Some chief amounts of rainfall are:

Orissa:

15 Sept. : Chandbali, Angul, Jharsuguda 7

16 Sept: Paradeep 16, Lanjigarh, Madanpur-Rampur 11, Paikmal 10

17 Sept: Akhuapada 31, Jenapur 30, Baliguda 24, Rajkanika 23, Patamundai , Mundali 22, Tikabali 21, Nawana 20

18 Sept.: Patnagarh 27, Titlagarh 25, Rairakhol 24, Sambalpur 22, Batagaon, Komna, Bolangir 20

Chattisgarh:

18 Sept.: Naharpur 19, Pusor 17, Nagari 18. Gariaband, Raigarh 13, Champa 12, Raipur Churra 11

19 Sept.: Katghora 17, Durg 16, Bilaigarh 14, Pithora 13, Bansa 13, Pamgarh, Pendra 12

East Madhya Pradesh

19 Sept.: Umaria 15

In Orissa, due to extremely heavy to very heavy rain, many districts were affected. Damage caused due to floods are furnished below:

Affected districts	19
Affected Block	137
Affected Grampanchayat	1581
Affected villages	6339
Total people affected	42,02,065
Total number of human casualties	72 lives
Total number of livestock casualties	314
Total livestock affected	40,35,545
Total areas of crop affected	4,78,387 hectare

In coastal Andhra Pradesh, the overflowing rivers Nagavali, Vamsadhara etc. caused floods in the districts of Srikakulm and Vizianagaram in north Coastal Andhra Pradesh.

The maximum intensity of T2.0 was reported by the satellite imageries from 0300 UTC to 1700 UTC of 16. As per the satellite account, the system crossed coast at 2100 UTC of 16.

POST MONSOON SEASON (OCTOBER – DECEMBER)

In all, 5 intense systems formed during the season. The rest five (Cyclonic Storms (RASHMI, KHAI MUK and NISHA and 2 Deep Depressions) occurred during the post-monsoon season. Out of the three cyclonic storms which formed over Bay during this season, 2 had landfall over the Indian coast and one struck Bangla Desh coast.

I. Deep Depression over the Arabian Sea (19 – 22 October 2008)

A trough of low at sea level lay over the southeast Bay on 10 & 11; the southwest and adjoining southeast Bay on 12 and over the southwest Bay on 13. It organized into a feeble low pressure area over Commorin area and neighbourhood on 14 and lay over Maldives and adjoining Commorin areas on 15 and over the southeast Arabian Sea on 16 & 17. Moving westwards, it became well marked over the southwest Arabian Sea and neighbourhood on 18. It subsequently concentrated into a Depression in the evening of 19 and lay centred at 1200 UTC, near Lat. 9.0oN/Long. 59.5oE. Moving westnorthwestwards, it lay centred at 0300 UTC of 20 over the southwest Arabian Sea near Lat. 10.0oN/
Long. 57.5oE and at 1200 UTC near Lat. 10.0oN/Long. 56.5oE. Continuing the westnorthwestward movement, it intensified into a Deep Depression and lay centred at 0300 UTC of 21, over the southwest Arabian Sea, near Lat. 10.5oN/Long. 54.5oE and at 1200 UTC near Lat. 11.0oN/Long. 54.0oE. Further moving northwestwards, it weakened into a Depression and lay centred at 0300 UTC of 22 over the westcentral Arabian Sea, near Lat. 13.0oN/Long. 53.0oE and at 1200 UTC near Lat. 13.5oN/Long. 52.5oE. It further moved in a northwesterly direction and weakened into a well marked low pressure area over west central Arabian Sea and adjoining Gulf of Aden on 23.

The lowest ECP was 1002 hPa. The maximum estimated wind speed was 30 kts. The system moved in a westerly to westnorthwesterly direction and dissipated over west central Arabian Sea and adjoining Gulf of Aden.

No damage was caused as the system was far away from the west coast. It caused flood over Yemen, according to media report.

The system was mainly tracked by satellite. The maximum intensity of T 2.0 was reported from 0600 UTC of 21 to 1200 UTC of 21.

II. Cyclonic Storm (RASHMI) over the Bay of Bengal (25 – 27 October 2008)

Under the influence of a trough of low over the southwest Bay of Bengal off Andhra Pradesh-Tamil Nadu coasts, a low pressure area formed on 24 over the west central Bay of Bengal off Andhra Pradesh coast. It rapidly concentrated into a Depression at 0300 UTC on 25 with its center near Lat. 16.5°N/ Long. 86.5°E and at 1200 UTC, near Lat. 17.5°N/ Long. 87.0°E. It moved northwards and intensified into a Deep Depression, at 0300 UTC of 26, centered near Lat. 18.5°N/ Long. 87.5°E, about 460 kms southwest of Kolkata. Moving in a northnortheasterly direction, it intensified into a Cyclonic Storm (Rashmi) and lay centred at 1200 UTC of 26 near Lat. 19.5°N/ Long. 88.0°E about 350 km south of Kolkata. It futher moved in a northnortheasterly direction and crossed Bangladesh coast near Long. 89.5°E about 50 km west of Khepupura between 2200 & 2300 UTC of 27. Subsequently, it weakened into a Deep Depression and lay centred at 0300 UTC of 27 near Lat. 23.5°N/ Long. 91.0°E. It rapidly weakened into a low pressure area over Meghalaya on 27 evening and became less marked on 28. However associated cyclonic circulation between 1.5 & 2.1 km a.s.l. lay over the region on 28 & 29.

The lowest ECP was 984 hPa. The maximum estimated wind speed was 45 kts. The system moved in a northeasterly direction and crossed Bangla Desh coast near 89.5 oE (about 50 km west of Khepupura) between 2200 and 2300 UTC.

Widespread rainfall with isolated heavy to very heavy falls occurred on 27 in Gangetic West Bengal and on 27 & 28 in Assam & Meghalaya.

Some chief amounts of rainfall are:

Gangetic West Bengal -

27 Oct.: Canning Town 14, Basirahat, Kolkata, Diamond Harbour 8, Krishnanagar 7

Assam & Meghalaya -

27 Oct: Shillong 11, Cherrapunji 10

28 Oct: Cherrapunji 15, Shillong 8

The maximum intensity of T 2.5 was reported from 1300 to 1700 UTC of 26. As per the satellite account, the vortex moved in northeasterly direction and crossed the Bangladesh coast near 22.1°N/89.3°E at 2100 UTC of 26th October, 2008.

CDR Paradip: Special RADAR observations were taken from 0000 UTC of 25 to 0300 UTC of 27 and three hourly observations from 0000 UTC of 25 to 0300 UTC of 26. The centres were fixed based on curved line till 1300 UTC and the spirals at 1500 and 1800 UTC. No echoes were observed from 0600 UTC of 27 on the RADAR scope. Curved lines with some banding features could be seen at 1200 UTC of 26 when the system was along the Stations latitude. Centre reported was Lat. 20.4o N/Long. 88.4 o E. Similar observations found at 1300 UTC and 1500 UTC of 26. There after the echo strength reduced gradually and no centre could be defined due to absence of prominent features.

The centres of the Cyclonic Storm 'RASHMI' of 25-27 October 2008 , as fixed by the Radar, based on the Curved line(LN) / Spiral band echoes, at various times are furnished below.

Date	Time (UTC)	Latitude (Deg.)	Longitude (Deg.)	Confidence	Character
26-Oct-08	0000	19.7 N	87.6 E	Poor	LN
26-Oct-08	0300	19.1 N	88.2 E	Poor	LN
26-Oct-08	0600	18.8 N	87.8 E	Poor	LN
26-Oct-08	0900	19.7 N	88.3 E	Poor	LN
26-Oct-08	1200	20.4 N	88.4 E	Fair	LN
Date	**Time (UTC)**	**Latitude (Deg.)**	**Longitude (Deg.)**	**Confidence**	**Character**
26-Oct-08	1300	20.6 N	88.5 E	Fair	LN
26-Oct-08	1500	20.6 N	88.5 E	Fair	Spiral
26-Oct-08	1800	21.2 N	88.6 E	Fair	Spiral
26-Oct-08	2000	21.7 N	88.3 E	Poor	LN
26-Oct-08	2100	Not Defined			

III. Cyclonic Storm (Khai Muk) over the Bay of Bengal (13 – 16 November 2008)

A trough of low over the southeast Bay and neighbourhood organized into a low pressure area over there on 12 evening and became well marked over the southeast and adjoining southwest Bay on 13 morning. It concentrated into a Depression and lay centred at 1200 UTC of 13, near Lat. 11.5°N/ Long. 85.5° E. Moving northnorthwestwards, it intensified into a Deep Depression and lay centred at 0300 UTC of 14, near Lat. 12.5°N/ Long. 85.0°E, (about 550 km eastsoutheast of Nellore). Moving in a northwesterly direction it intensified into a Cyclonic Storm (Khai muk) and lay centred at 1200 UTC of 14, near Lat. 14.0°N/ Long. 84.0°E (about 400 Km southeast of Machilipatnam). Subsequently moving westnorthwestwards, it lay centred at 0300 UTC of 15, near Lat. 14.5°N/ Long. 82.5°E (about 230 km southeast of Machilipatnam). Then it remained practically stationary and weakened into a Deep

Depression at 0600 UTC of 15. Further moving westwards, it lay centred at 1200 UTC of 15, near Lat. 14.5°N/ Long. 81.5°E. It slowly moved westnorthwest-wards and crossed south Andhra coast to the north of Kavali between 2200 & 2300 UTC of 15. Continuing the westnorthwest-ward movement, it weakened into a Depression and lay centred at 0300 UTC of 16, close to Nandyal (Lat. 15.5°N/ Long. 78.5°E). It weakened into a: well marked low pressure area over Rayalaseema and neighbourhood in the afternoon; into a low pressure area over the same region in the evening of 16 and became less marked on 17. However, the associated upper air cyclonic circulation extending upto lower tropospheric levels lay over the eastcentral and adjoining southeast Arabian Sea off Karnataka-Goa coasts during 17 – 19.

Surface observations (Machilipatnam)

Hourly surface observations were taken and transmitted w.e.f. 1200 UTC of 13.11.2008 to 00UTC of 16.11.2008.

The maximum surface wind observed was	i) N/28KMPH at 09UTC of 15.11.2008 ii) N/28KMPH at 12UTC of 15.11.2008 iii) NE/28KMPH at 14UTC of 15.11.2008
The lowest surface pressure observed was	1000.1 hPa at 10UTC of 15.11.2008
The Highest surface Pressure Fall (P24)observed was :	4.4 hPa at 09UTC of 15.11.2008

The lowest ECP was 994 hPa. The maximum estimated wind speed was 40 kts. The system moved in a northwesterly to westnorthwesterly direction and crossed south Andhra Pradesh coast between 2200 and 2300 UTC of 15.

Widespread rainfall activity with isolated heavy to very heavy falls occurred over coastal Andhra Pradesh on 16 and 17. Widespread rainfall activity also occurred over Rayalaseema on 16. Some chief amounts of rainfall are:

Andhra Pradesh:

16 Nov. Buntumilli, Kruthivennu 17, Machilipatnam 14, Seetharampuram 13, Kaikalur 12, Narsapur, Kothapeta, Allavaram, P.Gannavaram, Sakinetipalli, Koduru, Movva, Gudivada, Mandavalli, Mudinapalli, Pamarru 11, Palkol, Penumanthra, Penuganta 10.

17 Nov.: Polavaram 23, Mogaltur 19, Pamarru 11, Kajuluru, Mummidibvaram 10, RC Puram 9, Eluru 9, Pedapadu 9, Bhimavaram 9, Kaikalur 9, Ambajipeta 9.

Damages : In Andhra Pradesh

1. Major erosion of coast seen at Uppada near Kakinada.
2. In many areas in East & West Godavari and Krishna districts, paddy fields got inundated.
3. Twenty Catamarans, twenty country boats and one boat washed off in the sea off Konapapapeta in Kothapalli Mandal of East Godavari.

4. A big ship was carried away by the waves along the Wakalapudi beach near Kakinada of East Godavari districts.
5. Many boats and fishing nets were swept off in the areas adjoining Wakadu, Alluru, Mypad, Gangapatnam in Nellore district.
6. A big old tree (100 years old) fallen down in Bhimavaram in West Godavari district.

Total loss estimated by state Govt.

(A) Krishna District:

Population affected	4112
Number of cattle/live stock perished	26
Crop area affected	29287 hectares
Number of houses damaged (fully) (partly)	12 12
Irrigation loss	11.70 lakhs
Electricity loss	157.24 lkahs
R&B loss	257 lakhs
Fisheries loss	21.77 lakhs

(B) Guntur District

Human Loss	1
Live stock perished	2 bulls
Houses damaged (fully)	6
(partly)	3

(

C) Prakasam District

Agriculture Crop Area affected	50.80 hectres
Fisheries dept. loss	140.30 lakhs

(D) Visakhapatnam District

House damage	1
Fisheries dept. loss	Rs. 7,41,000/-

(E) East Godavari District

No. of Mandals affected	26
No. of Villages affected	124
No. of Fisheries affected	838
Houses fully damaged	237
Houses severely damaged	297
Agricultural Loss	Rs. 625.0 Lakhs
Loss to fishermen	Rs. 1.20 lakhs
Road damage	Kakinada to Uppada roads damaged (10 kms) and loss about Rs. 400 Lakhs

(F) West Godavari District

Paddy fields got inundated leading to crop loss

(G) Nellore District

No. of Coastal Mandals affected	11
No. of villages affected	104
No. of persons affected	7509
No. of boats / nets damaged	846 boats
Estimated loss : boats	Rs. 171.07 lakhs
: Nets	Rs. 972.03 lakhs

The maximum intensity of T 2.5 was reported from 1100 UTC of 14 to 0500 UTC of 15

CDR Chennai:

Neither 'EYE' nor any spiral band could be seen in the RADAR during the course of the system and hence no Cyrep issued.

CDR Machilipatnam :

The Doppler weather radar was in continuous operation and ten minutes radar observations of PPZ, PPV, CAZ, SRI and VVP2 were sent to DGM (Telecom) in near-real-time mode to host on IMD web site. Also Hourly images were e-mailed to NHAC, ACWC, CWC, MC etc. Raw data was also transmitted to DGM (Telelcom) in near-real-time mode for use in NWP models.

Most of the Radar observations did not show any clear spiral bands to fix the center. However, a Vortex (an ill defined eye) featuring Maximum Reflectivity of 54 dBZ, Maximum Velocity of 30 mps at 3.3 Km height centered at 14.3°N/81.2°E was observed with Very Poor confidence level. Track of cyclone could not be drawn since centre could not be fixed confidently.

IV. Cyclonic Storm (Nisha) over the Bay of Bengal (25 – 27 November 2008)

A low pressure area formed over Sri Lanka and neighbourhood on 24. It became well marked on 24 evening. It concentrated into a Depression over Sri Lanka and neighbourhood at 0900 UTC of 25 near Lat. 8.5° N/ long. 81.0°E. It further intensified into a Deep Depression at 1200 UTC on the same day near Lat. 8.5 °N/ Long. 81.0°E, about 200 kms southeast of Pamban. It further intensified into a Cyclonic Storm (NISHA) at 0300 UTC on 26 near Lat. 10.5°N/ Long. 80.0° close to Vedaranyam and at 1200 UTC near Lat. 10.8° N/ long. 80.0°E. It crossed Tamil Nadu coast to the north of Karaikal between 0000 and 0100 UTC on 27 and lay centred 50 kms northwest of Karaikal (Lat. 11.5° N/ long. 79.5°E) at 0300 UTC on 27. It further weakened into a Deep Depression at 0900 UTC of 27 over coastal Tamil Nadu and lay centered near Lat. 12.0° N/ long. 79.0°E. Moving, westwards it further weakened into a Depression over interior Tamil Nadu and lay centered at 1200 UTC on 27 near Lat. 12.0° N/ long. 78.5°E. Moving northwestwards, it further weakened into a well marked low pressure area over North Interior Tamil Nadu and adjoining areas of south interior Karnataka and Rayalaseema in the early morning of 28. It moved westnorthwestwards and lay as a feeble low pressure area over Southeast Arabian Sea off Karnataka – Kerala coasts on 28 morning. A trough from this system extended upto west central Bay of Bengal across south Karnataka, Rayalaseema and south coastal Andhra Pradesh with an embedded cyclonic circulation extending upto mid-tropospheric level over south Interior Karnataka and neighbourhood. The feeble low pressure area lay as a low pressure area over southeast Arabian Sea and neighbourhood at 1200 UTC of 28 and the trough from this system extended to north Maharashtra across north Konkan-Goa and south Madhya Maharashtra. This low pressure area lay over eastcentral and adjoining southeast Arabian Sea off Karnataka coast and a trough from the low pressure area extended upto south Gujarat coast on 29 and 30 Nov. The low pressure area and the trough from the system became less marked on 1 Dec.

The lowest ECP was 996 hPa. The maximum estimated wind speed was 45 kts. The system moved in a northwesterly direction and skirted the Tamil Nadu coast from 1200 UTC of 26 to 0000 UTC of 27 and crossed Tamil Nadu coast, north of Karaikal, between 0000 and 0100 UTC of 27. The hourly observation of Karaikal at the time of crossing coast are:

261200 UTC: NNE/25 kts, 998.1 hPa

270000 UTC: Calm, 995.8 hPa

270300 UTC: SW/21 kts, 1001.1 hPa

The lowest pressure of 995.8 hPa was recorded at Karaikal at 0000 UTC of 27 Nov. at Karaikal The maximum wind speed of 37 kts was recorded at Karaikal at 0900 UTC of 26.

Post Cyclone Survey Report: The extensive survey of the areas from Chennai to Vedaranyam and with the available information gathered from various coastal villagers and their weather experience on 26 and 27, the exact place of landfall could be located near Kaveripatinam (11º 54'N / 79º 31'E), close to Poombukhar, a Cauvery river outlet, about 12 Km north of Karaikal. Local people around these areas experienced strong winds from north direction on 27 around 0500 hrs, suddenly wind became calm, lasting for nearly one hour, and then strong wind started to flow from southerly direction after 1 hour. Trees started falling by this time. The system came very close to Karaikal from Nagapattinam, remained stationary over the same position and then moved in the north- westerly direction along Karaikal coast and crossed this point.

From the post cyclone survey report, the maximum sustained winds associated with this system have been of the order of 50 to 60 Kmph and in some isolated pockets reached upto 80 Kmph. At CDR Karaikal, High Wind Speed Recorder recorded the maximum wind of 63 Kmph on 27.11.2008 at 0018 hrs UTC. The lull period lasted for a max of half an hour to one hour, suggesting that the eye diameter could be of the order of 30 to 40 kms range at the time of landfall. Radar pictures show that the system had circular-open eye. M. O. Nagapattinam which was close to the system recorded the lowest pressure of 994.3 hPa on 26th at 0900 UTC. On 27th after 0500 UTC it started moving slowly along the coast in North-westerly direction and the cyclonic eye crossed coast near Kaveripattinam 12 Km north of Karaikal around between 0000-0100 hours UTC of 27th and moved through Virudhachalam areas weakening into a Depression and moved westerly direction after weakening as a low pressure area over Salem region on 27th (1200UTC). No significant storm surge seems to have occurred in the coastal areas

Fairly widespread rainfall activity with very heavy falls to extremely heavy falls at a few places occurred over Tamil Nadu from 25 to 29. Heavy to very heavy falls also occurred over Rayalaseema on 27 and 28 and over coastal Andhra Pradesh from 27 to 29.

Tamil Nadu:

25 Nov.: Thiruvidalmarthu 30, Tanjavur 25, Rameswaram 23, Orathanadu 19, Mayiladuthurai 17, Pamban 16, Viralimalai, Tirukattupalli 15

26 Nov: Vedaranniyam 33, Chidambaram, Parangipettai 28, Thiruvidalmarthu, Mayiladuthurai 26, Sirkali 25, Kattumannarkoil 23, Cuddalore 22, Kollidam 21

27 Nov.: Orathanadu 66, Tanjavur 53, Vedaranniyam 42, Adirampattinam 33, Muthupet 30, Kumbhakonam 26, Mannargudi 25, Needamangalam 24, Tiruthuraipundi, Pattukottai, Kattumannarkoil 23, Valangiman 22, Thiruvidalmarthu 20, Tiruvaiyaru 19, Tirukattupalli 18

28 Nov.: Minambakkam 28, Anna University, Guind 23, Cuddalore, Kallakurichi 22, Puducherry 21, Tirutani 20, Thanjavur, Tiruchi town 18, Ariyalur, Pullambadi 17

29 Nov.: Arakonam 25, Erode 19, Sriperumbudur 14, Attur 11

Andhra Pradesh:

27 Nov.: Srikalahasti 16, Tirupati 14, Sullurpeta, Tada 12, Satyavedu 11, Puttur 10, Gudur 9.

28 Nov.: Udayagiri 16, Vinjamur 15, Ongole, Puttur 14, Satyavedu, Tirupati, Rapur 13, Kaveli, Atmakur, Venkatgiri, Chittur 12, Pakala, Sullurpeta, Gudur 11, Palamaner, Kaudukur 10, Nellore 9.

29 Nov: Rapur 18, Srisailam, Cumbum, Ongole 16, Udayagiri, Podili 15, Kandukur 13, Badvel 12, Macherla 11, Srikalahasti, Sattenpalli, Darsi 10, Kavali 7

As per the Tamil Nadu Govt. Revenue site, Loss of life was 100 over the state during 24 to 28 Nov. due to drowning/ electrification/wall collapse/tree fallen etc. As per media reports, 8 lakhs acres of Paddy in Nagapattinam, Thanjavur and Tiruvarur (delta) districts and 55,250 hectares of Paddy in Cuddalore district were submerged due to heavy rain. The uprooted trees those fallen across roads or on electric wires resulted in cut off power supply and disruption in road traffic.

The general public was of the opinion that “Nisha’ is a friendly cyclone which brought copious rain to Tamil Nadu that will help to enhance agricultural activities, improve ground water level and also solve drinking water problem.

The top most revenue officials, Port officers, fishermen and agriculturist appreciated the department’s services.

As per the post Cyclone Survey report, the system did not generate any tidal waves. The damage due to the Gales was also less owing to heavy downpour

In Andhra Pradesh, Chittur, Nellore and Prakasam districts of South Coastal Andhra Pradesh were affected by heavy rains / strong winds. As per News paper reports, 3.63 lakh hectors of crop were damaged due to heavy rains. The heavy rains led to floods in these districts.

The maximum intensity of T 3.0 was reported by the satellite imageries from 0800 UTC to 1100 UTC of 26. The system attained the intensity of T 3.0 at 0800 UTC of 26th Nov, 08 with centre 10.3N/79.9E and crossed the coast near centre 10.5N/79.8E with intensity T3.0.

Throughout its sea-track the system features as seen by DWR Chennai were not sufficient to attempt centre-fixing. However after crossing the coast, as the system came closer to DWR Chennai, features grew prominent and thus could fix the centre, based on a few spiral bands and in some cases with partial eye-wall. Confidence from poor to fair only could be assigned. Centre fix was done from 0500 to 1300 UTC of 27.

Maximum velocity observed in the cyclone field was not associated with the eyewall region, but mostly associated with strong echoes in spiral bands. Maximum observed radial velocity was around 28mps Maximum observed reflectivity was about 52 dBZ.

On a few occasions when “eye” in the form of Bounded Weak Echo Region (BWER) could be seen around the centre, the shape was irregular and reflectivities were much weaker than the spiral band values.

Date	Time UTC	LAT. ˚N	LONG. ˚E	AZ.Deg.	Range Km	Confidence
27.11.08	0500	11.55	79.60	204	185	Fair
27.11.08	0600	11.65	79.51	208	180	Fair
27.11.08	0700	11.77	79.31	216	180	Poor
27.11.08	0800	11.67	78.93	223	215	Poor
27.11.08	0900	12.0	79.0	230	185	Poor
27.11.08	1000	11.92	79.26	221	170	Poor
27.11.08	1100	11.62	78.69	227	237	Poor
27.11.08	1200	11.52	78.69	225	245	Fair
27.11.08	1300	11.48	78.52	227	262	Fair

CDR Karaikal:

The Radar Observations were started at 0600 UTC of 25 and RAREPS were reported as broken clouds at 12 – 15 km.

Three-hourly Radar Cloud imageries were reported to ACWC Chennai upto 0000 UTC of 26 November 2008.

At 2100 UTC of 25 November, Spiral Bands were first noticed in the Radarscope and the System Centre was located at 10.4°N/ 80.3°E.

Spiral Bands were reported to ACWC Chennai upto 0000 UTC of 26 November. Hourly RAREPS were started at 0000 UTC of 26 to 0600 UTC of 27.

The first CYREEP was reported at 0700 UTC of 26 at 10.8°N/ 80.2°E. The system centre was reported at 0800 UTC of 26 at 10.8°N/ 80.2°E.

The centres fixed by CDR Karaikal are:

Date	Time UTC	LAT. ˚N	LONG. ˚E	Features
26.11.08	0900	10.8	80.1	Spiral
26.11.08	1000	10.8	80.3	Spiral
26.11.08	1100	10.8	80.2	Spiral
26.11.08	1130	10.8	80.2	Spiral
26.11.08	1200	10.9	80.3	Spiral
26.11.08	1400	10.9	80.3	Spiral
26.11.08	1500	-	80.3	Spiral
26.11.08	1600	-	80.2	Spiral
26.11.08	1700	-	80.3	Spiral
26.11.08	1800	10.9	80.2	Spiral
26.11.08	1000	10.8	80.3	Spiral
26.11.08	2000	10.9	79.9	Spiral
26.11.08	2100	10.9	79.8	Spiral
26.11.08	2200	10.9	79.8	Spiral
26.11.08	2300	10.9	79.8	Spiral
27.11.08	0000	11.0	79.7	Spiral
27.11.08	0100	11.4	79.8	Spiral
27.11.08	0300	11.5	79.6	Spiral
27.11.08	0400	11.5	79.5	Spiral
27.11.08	0500	11.6	79.6	Spiral

V. Deep Depression over the Bay of Bengal (4-7 December, 2008)

A trough of low at sea level lay over the southeast Bay of Bengal and neighbourhood on 2 and 3. Under its influence a low pressure area formed over the same area in the evening of 3. It concentrated into a Depression and lay centred at 0300 UTC of 4, near Lat. 6.5 °N/ Long 90.0°E (about

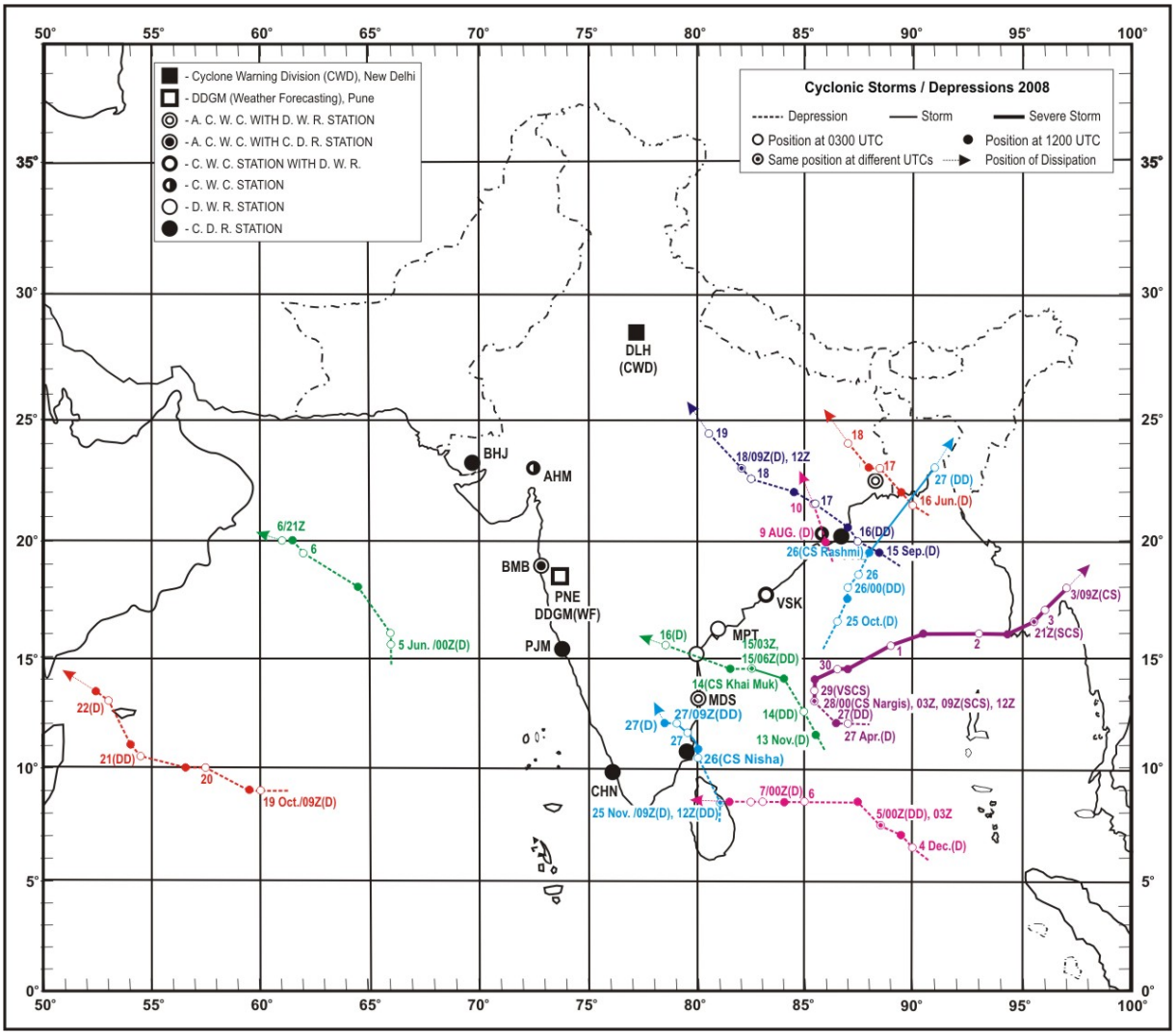
1300 Km southeast of Chennai). It moved northwestwards and lay centred at 1200 UTC of 4, near Lat. 7.0°N/ Long. 89.5°E. Continuing the northwestward movement, it intensified into a Deep Depression at 0000 UTC of 5, near Lat. 7.5°N/ Long. 88.5°E, remained practically stationary over there upto 0300 UTC and lay centred near Lat. 8.5°N/ 87.5°E at 1200 UTC. Thereafter, it moved westwards and lay centred at 0300 UTC of 6, near Lat. 8.5°N/ Long. 85.0°E and at 1200 UTC, near Lat. 8.5°N/ Long 84.0°E. Subsequently it weakened into a Depression and lay centred at 0000 UTC of 7 near Lat 8.5°N/ Long 83.0°E, at 0300 UTC, near Lat. 8.5°N/ Long 82.5°E and at 1200 UTC, near Lat. 8.5°N/ Long. 81.5°E (close to Trincomalee). Moving further westwards, it weakened into a well marked low pressure area over Sri Lanka and adjoining southeast Bay at 1500 UTC of 7. It lay as a low pressure area over Sri Lanka and neighbourhood at 0300 UTC 8 and lay over Sri Lanka and adjoining Commorin area at 1200 UTC of same day. The low pressure area moved over to Commorin area and neighbourhood on 9 and lay over Lakshadweep – Maldives areas on 10.

The observational details are given in Table

The lowest ECP was 1004 hPa. The maximum estimated wind speed was 30 kts. The system moved in a northwesterly direction initially and then in westerly direction. Due to interaction with land surface , the system weakened into a well marked low pressure areas over Sri Lanka and adjoining southwest Bay of Bengal at 1500 UTC of 7.

As the system was far away from the coast and the movement of the system was mostly westerly, no damage reported along the east coast.

The system was mainly tracked by Satellite. The maximum intensity of T 2.0 was reported from 0300 UTC of 5 to 2300 UTC of 6.



Country Report of Members

BANGLADESH COUNTRY REPORT

The WMO/ESCAP Panel on Tropical Cyclones activities during 2008

Presented

At

The Thirty-sixth Session of the WMO/ESCAP Panel on Tropical Cyclones

02 to 06 March 2009
Muscat, Oman

By
Bangladesh Meteorological Department
Dhaka, Bangladesh.

1. GENERAL INFORMATION

1.1 Geographical Environment

Geographical environment

Bangladesh is roughly located approximately between 20.57^{o}N and 26.63^{o}N and 88.02^{o}E and 92.68^{o}E. It is surrounded on the west, north and east by India and on the south by the Bay of Bengal. In the extreme southeast, there is also a common border with Myanmar. Bangladesh is one of the largest deltaic countries in the world with the extremely flat plain having only a small hilly area in the northeast and southeast regions. The entire area of Bangladesh is about 1, 44,000 sq. km.

The country is also subject to flooding almost every year starting from late April or early May to the end of September due to up stream flows of three major tributaries i.e. Padma, Jamuna and Meghna rivers. Three recent worst floods occurred in 1987, 1988 and 1998.

Population: The population is about 140 millions of which about 80% live in the rural areas.

Climate: Bangladesh is in the sub-tropical monsoon climate regime. Based on the analysis of pressure, rainfall and temperature, the climate of this country can be described under the following four seasons:

a. **Winter or Northeast Monsoon (December-February):** This season is characterized by very light northerly winds, mild temperature and dry weather with clear to occasionally cloudy skies over the country. The mean temperature is in the range of 18-21°C.

b. **Summer or Pre-Monsoon (March- May):** The mean temperature during the summer months remains within 23-30^{o}C. April and May are the hottest months. The highest temperature ranging from 41-45^{o}C is attained in the northern and northwestern districts. Over rest of the country it ranges from 38-41^{o}C. The season characterized by cyclogenesis in the Bay of Bengal. Some of the depressions may develop into cyclonic storms, which travel generally northwestwards initially and then recurves towards northeast moving towards Bangladesh and Myanmar coasts. Some of these storms may attain hurricane intensity and are associated with storm surges. The cyclone that hit the east coast of the country on 29 and 30 April 1991 reportedly killed nearly 1,38,882 people.

c. **Southwest Monsoon or Monsoon (June-September):** In this season, the surface wind changes to southerly direction over the southern and the central districts and to southeasterly over the northern parts of the country. Wind speed is light to moderate. Tropical depressions and storms form in the Bay of Bengal during the season and generally move northwestwards over India and sometimes cross Bangladesh coasts. Storms, however, seldom attain hurricane intensity in this season.

d. **Autumn or Post-monsoon (October-November):** This is the transitional season from summer monsoon to the winter. Rainfall decreases considerably in October and November and the dry period starts setting in over the country. This season is also characterized by cyclogenesis in the Bay of Bengal. The recent devastating cyclone SIDR crossed southwestern coast of Bangladesh on 15 November, 2007 with death toll of 3,363 and estimated damage cost was in the tune of 450 million USD. The mean temperature falls from 28-29^{o}C in September to 25-26^{o}C in October and to 23-25^{o}C in November.

2. BANGLADESH METEOROLOGICAL DEPARTMENT (BMD)

2.1 Structure

2.1.1 Headquarters

Government Department:	Ministry of Defence
Service:	Bangladesh Meteorological Department
Address:	Meteorological Complex, Agargaon, Dhaka-1207.
Telephone	:(88 02) 8116634; 8119832.
Telefax	:(88 02) 8118230
Telex	:METEOR, DHAKA.
E-mail	:info@bmd.gov.bd
Web site	: www.bmd.gov.bd

2.1.2 Organization

The Bangladesh Meteorological Department (BMD) has eleven divisions at its Headquarters in Dhaka namely, Administration Division, Planning Division, Agrometeorology Division, Meteorological Training Institute, Forecasting Division, Synoptic Division, Climate Division, International Meteorology Division, Workshop and Laboratory, Electronic and Instrument Division and Communication Division. The Department also maintains two regional offices: Storm Warning Centre, Dhaka and Meteorological and Geophysical Centre, Chittagong.

2.1.3 Staff and budget

Officers: 134

Staff: 923

Total: 1057

2.1.4 General fund contribution to WMO

Contribution paid (CHF)	
Year	Total payment
1998	12,493.00
1999	12,493.00
2000	12,444.00
2001	11,544.00
2002	12,441.50
2003	12,429.79
2004	12,076.77

2005	12,490.00
2006	12,490.00
2007	12,490.00
2008	

2.1.5 Development Plans of BMD

To equip BMD with the latest meteorological development and attain qualitative advancement in forecasting as well as other fields of meteorology, a number of projects have been taken up:

a. Establishment of Numerical Weather Prediction (NWP) system.

It is under implementation with full GoB money. The first phase (assessment and technical documentation) has already been completed. Second phase is likely to start from July 2009.

b. Improvement of Seismological Services in Bangladesh

It is being implemented with full GoB money and likely to be completed within June 2009 with the addition of another Borehole Broad-band Seismometer and telemetry connection to three universities for data sharing. Since May 2007, newly established four earthquake stations with central data acquisition and processing system are in operation.

c. Replacement of Cox's Bazar and Khepupara S-band Conventional Radars by Doppler Radars.

The project has been implemented under grant assistance of the Government of Japan. The radar at Cox's Bazar and Khepupara has been operational from March 2007 and March 2008 respectively.

d. Establishment of Doppler Meteorological and Hydrological Radar at Moulavi Bazar.

It is under implementation with the grant assistance of the Government of Japan. It is likely to be completed by March 2009.

e. Establishment of 14 new observatories in the riverine area for safe riverine navigation.

It is under implementation with full GoB money. It is supposed to be completed within June 2010.

f. Strengthening of Agro-meteorological Services in Bangladesh including Establishment of 7 (Seven) Agro-met stations within the existing 12 Agro-met observatories.

The project is being implemented with GoB money. It is expected to be completed by June 2010.

g. Establishment of 5 (Five) First Class Meteorological Observatories in BMD.

The project is under implementation with the GoB money and is expected to be completed by June 2010.

h. Under local UNDP support, all existing 35 stations are being connected with internet connectivity for reception of data form the observatories at SWC, Dhaka for gradual switch over from Teleprinter and SSB

i. Human capacity building on operational weather analysis & forecasting and relevant technical issues.

The project is now in the planning stage under JICA Technical Co-operation and execution is likely to be started from July 2009 for three years.

- **Long-term Development Plans:**

  - Automation of BMD's existing 35 stations. .

  - Up-gradation of the Training Institute and Research & Development Cell.

3. FOLLOW-UP ACTION ON PTC-33 (Agenda item 5)

3.1 Attachment training at IIT Kharagpur (Delhi) (Appendix III, Para-8.4.6)

Mr. Sujit Kumar Debsarma of BMD has developed a Tsunami Propagation Model by solving gravity equation using ETOPO2 data in 2006. One to two BMD personnel can be attached to the IIT for further training on Tsunami Propagation and Amplitude Modeling. They may also be attached with Mr. Sujit Kumar Debsarma for learning Tsunami Modeling. BMD also received Tsunami Model of NOAA (i.e. ComMIT Model) which is in operation. But due to lengthy processing time (3-4 hours) of the ComMIT Model it could not be used operationally on real time basis. However, it could be used for research/post event evaluation purposes.

3.2 Storm Surge Project (Appendix III, Para-8.8.6)

IIT Storm Surge Model has been installed on two Linux PCs. Meteorologists have been trained on how to operate the model with real world and fictitious storm data. Validations of the model with few historic storms were also done. Performance of the model is found good and the model has been made operational at the Storm Warning Centre of BMD.

3.3 2007 Operational Plan (Appendix III, Para-9.4)

It is already done on scheduled time.

4. REVIEW OF THE 2008 CYCLONE SEASON (Agenda item 6)

4.1 Extreme Weather Events in Bangladesh and Tropical Cyclones in the Bay of Bengal during January-December 2008

4.1.1 Extreme Weather Events in Bangladesh

4.1.2 Cyclones and depressions in the Bay of Bengal in 2008

a. Cyclone "Nargis" (25 April - 02 May, 2008): A low developed over Southeast Bay and adjoining area on 25 April, 2008. It intensified into a well marked low over the same area at 0600UTC of 27 April and further intensified into a depression (near lat. 12.0°N and long. 86.5°E) at 1200 UTC of the same day. Then the system moved initially in a northwesterly direction and concentrated into a deep depression over southwest Bay and adjoining southeast Bay at 1800 UTC. After that the system

remained practically stationary for sometime and then moved slightly northwards and concentrated into a cyclonic storm "Nargis" (with ECP 993 hPa) at 0300 UTC of 28 April. Then the system changed its direction of movement and started to move north-northeastwards and lay centred at 1800 UTC of 28 April near lat. 13.5° N and long. 85.5°E. After that it moved northeastwards into west central Bay and adjoining southwest Bay, intensified into a severe cyclonic storm (with ECP 984 hpa) at 0600 UTC of 29 April (near lat. 13.8°N and long. 85.5°E). The system remained stationary for sometime and then moved northeastwards into west-central Bay and adjoining east-central Bay and then eastwards over the same area and concentrated into a severe cyclonic storm with a core of hurricane winds (with ECP 972 hPa) at 0600 UTC of 02 May (near lat. 16.0°N and long. 93.5°E). Then the system moved eastwards continuously and started cross Myanmar coast near Bassein at 1200 UTC of 02 May and completed crossing the coast at about 0000 UTC of 03 May. After crossing the coast the system weakened into a land depression by giving heavy precipitation with high winds over Bassein and adjoining area and then moved slowly northeastwards and weakened gradually. The track of severe cyclonic storm 'Nargis' is given in Figure 1.

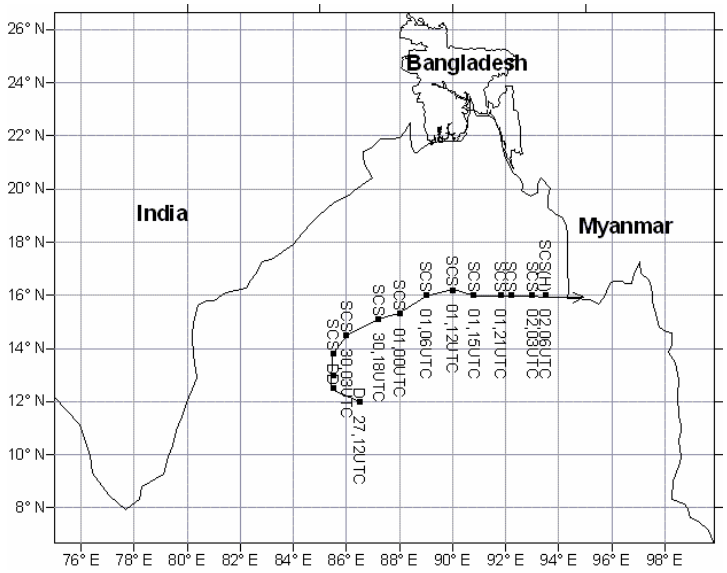


Figure 1: Track of the cyclone 'Nargis' during 25 April-02 May 2008

b. **Cyclone Rashmi (during 24-27 October 2008):** A low formed over west central Bay and adjoining area on 24 October 2008 and intensified into a well marked low over the same area at 0000 UTC of 25 October 2008. At 0600 UTC of the same day the system concentrated into a depression over the same area (positioned near lat 16.5°N and long. 86.5°E) and started to move in northerly direction initially. At 0300 UTC of 26 October the system intensified into a deep depression over northwest Bay and adjoining west central Bay. After that the system changed its direction of movement and moved north-northeastwards and concentrated into a cyclonic storm

'Rashmi' at 1200 UTC of the same day over northwest Bay and adjoining area (near lat. 20.2°N and long. 88.2°E). By moving rapidly towards the same direction the system started to cross Khulna-Barisal coast of Bangladesh near Patharghata at 2100 UTC of the same day and completed crossing the coast by 0300 UTC of 27 October and lay over south-central part of the country as a land depression. Then the system moved towards the same direction further and became unimportant by giving precipitation. The track of the cyclone 'RASHMI' is given in Figure 1. Under its influence heavy rainfall with high winds were recorded over most part of the country. The recorded maximum winds were at Hatiya, Patuakhali, Mongla, Barisal 45 Kts (83 km/hr) each, Khulna and Dhaka 35 kts (64 km/hr) each, Bhola and Jessore 30 kts (56 km/hr) each. No causalities were reported. The track of cyclonic storm 'Rashmi' is given in Figure 2.

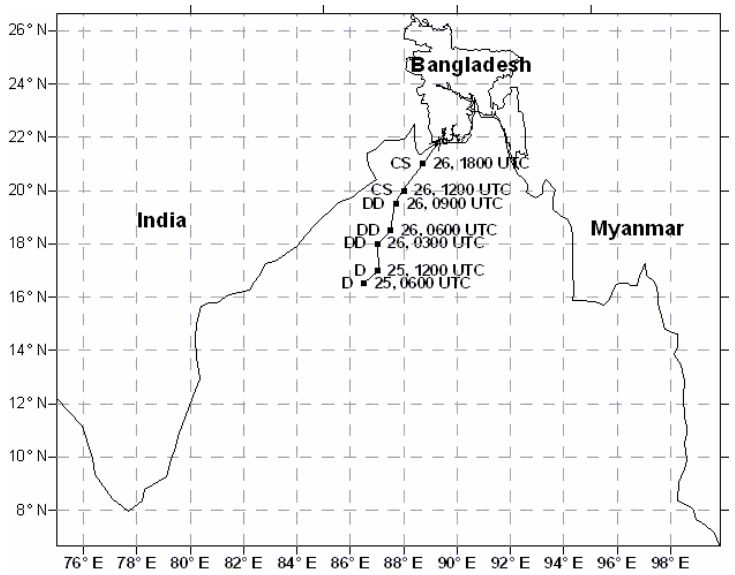


Figure 2: Track of the cyclone 'Rashmi' during 24-27 October 2008

c. Cyclone Khai-muk (during 13-16 November 2008): A low formed over east-central Bay and adjoining southeast Bay on 13 November 2008 and intensified into a well marked low over the same area. At 1500 UTC of the same day the system concentrated into a depression over the same area (positioned near lat 13.5°N and long. 88.0°E) started to move westward initially. At 0600 UTC of 14 November the system intensified into a deep depression over west-central Bay and adjoining southwest Bay and at 1800 UTC of the same day it concentrated into a cyclonic storm 'Khai-muk' over the same area (positioned near lat. 14.0°N and long. 84.5°E). Then the system moved west-northwestwards on and crossed Andhra coast of India near Muchilipatnam by the morning of 16 November 2008 and then weakened gradually by giving precipitation. The track of cyclonic storm 'Khai-muk' is given in Figure 3.

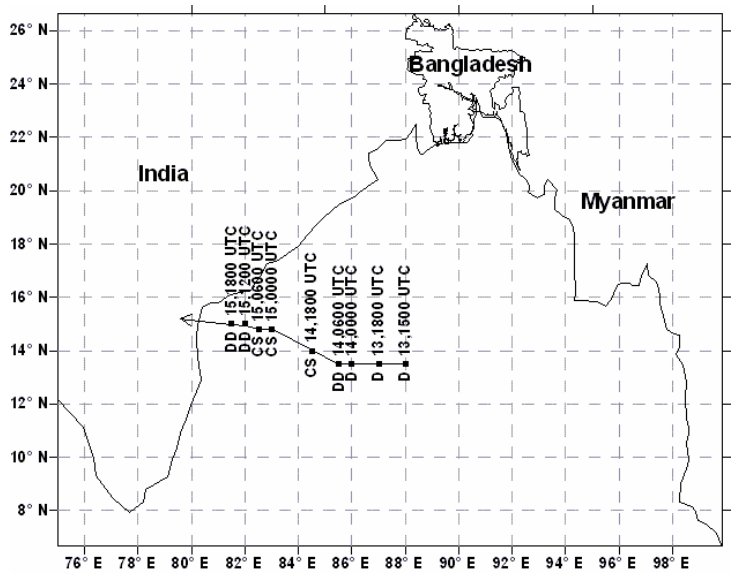


Figure 3: Track of the cyclone 'Khai-muk' during 13-16 November 2008

d. **Cyclone Nisha (25-27 November 2008):** A low formed over southwest Bay on 25 November 2008 and intensified into a well marked low and then into depression over the same area at 1500 UTC of the same day (positioned near lat 08.5°N and long. 81.0°E). Then the system started to move northwestwards initially and concentrated into a deep depression at 0000 UTC of 26 November 2008 and at 0600 UTC of the same day the system again concentrated into a cyclonic storm 'Nisha' over the same area. Then the system moved northwestwards and crossed Tamilnadu coast of India near Nagapatnam at 0300 UTC of 27 November and weakened gradually afterwards. The track of cyclonic storm 'Nisha' is given in figure 4.

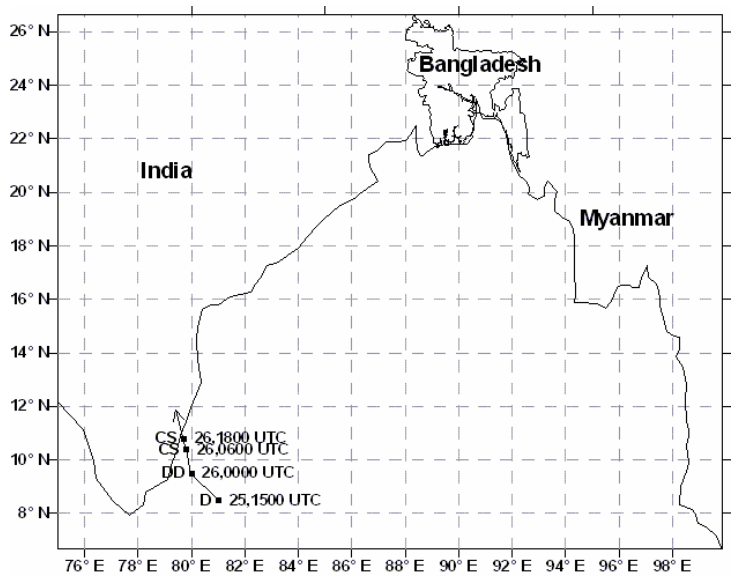


Figure 4: Track of the cyclone 'Nisha' during 25-27 November 2008

e. **Deep Depression (03-08 December 2008):** A low formed over southeast Bay and adjoining area on 03 December 2008 and intensified into a well-marked low and then into a depression over the same area at 0600 UTC of 04 December (positioned near lat 07.0°N and long. 89.8°E). Then the system started to move in west-northwesterly direction and intensified into a deep depression at 0000 UTC of 05 December over the same area. After that the system moved west-northwesterly direction and weakened into a depression over southwest Bay at 0000 UTC of 07 December and moved further westwards and weakened into a well-marked low at 0000 UTC of 08 December. Then the system moved further westward and weakened into a well marked low and then into a low and merged with the seasonal low. The track of deep depression is given in Figure 5.

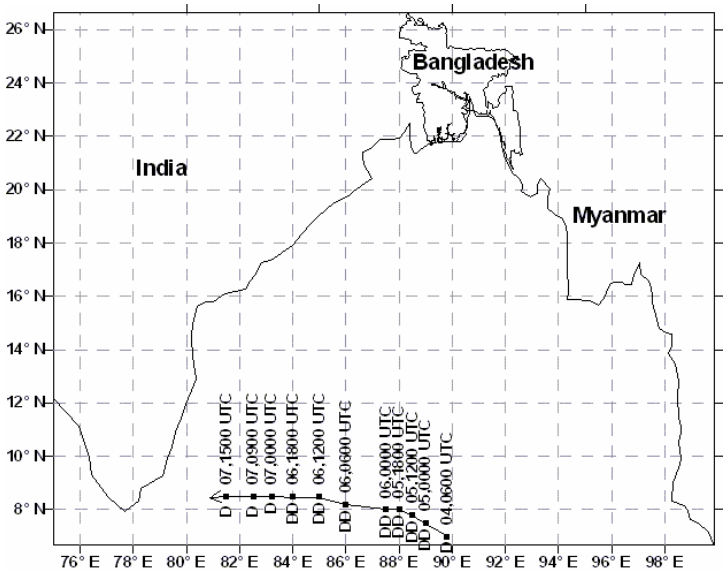


Figure 5: Track of the deep depression during 03-08 December 2008

5. REVIEW OF THE COORDINATED technical pLAN and CONSIDERATION OF THE WORK PLAN FOR THE NEXT FIVE YEARS (Agenda item 8)

5.1 Meteorological Component

a. With the local UNDP support on behalf of the Comprehensive Disaster Management Program (CDMP) of Ministry of Food and Disaster Management (MoFDM), BMD has developed a website in the Government domain (http://www.bmd.gov.bd).

b. BMD is receiving ECMWF global model output having 14 parameters with the support of Asian Disaster Preparedness Centre (ADPC), Thailand since October 2008. The model output is being analyzed using GrADS software.

c. BMD is receiving JMA global and regional model output having 13 parameters with the resolution of 2.5°x2.5° and 1.25°x1.25° for each domain since November 2008. The model outputs are being analyzed using GrADS software.

d. BMD is receiving EPS gram for 10 cities from ECMWF since June 2008 and the products are being used in forecasting.

e. The WMO Secretary General Mr. Michael Jarrad, accompanied with Dr. Shivakumar head of Agro-meteorological Division, WMO, visited Bangladesh Meteorological Department in August 2008. As per decision of the Secretary General, WMO, Dr. Shivakumar along with other two experts visited Bangladesh during 14-17 December 2008 for strengthening the agro-meteorological activities. A day long seminar was held on 17 December 2008 in BMD and scientists from agriculture related organizations and BMD were attended.

5.1.1 Observations and Basic observing networks

A total of 35 synoptic stations are in operation in Bangladesh. BMD also has 10 Pilot Balloon stations and 3 Rawinsonde stations. All observed data are received and gathered at the National Meteorological Communication Centre (NMCC), Dhaka and transmitted through GTS to RSMC New Delhi.

BMD installed new RS system at Chittagong and Bogra in 2006.

At present one observation at 0000 UTC is made at Dhaka, Chittagong and Bogra. Bangladesh is facing difficulties in maintaining these observations due to financial constraints.

Four 10 cm S-band radars with modern facilities have been operated at very strategic points of Bangladesh with a scanning radius of 400 km. Among them the Radars at Khepupara and Cox's Bazar were provided for storm warning purposes and up-graded with Doppler facilities by JICA assistance. The establishment of new radar at Moulvi Bazar (northeastern part of Bangladesh) is going on with JICA assistance for better monitoring of flash flood and flood in the Meghna river basin.

Storm Warning Centre (SWC) receives raw NWP products from ECMWF and JMA, Japan and then visualizes them. SWC also receives city specific forecast from Hong Kong Observatory and ECMWF. World Area Forecast (WAFS) products are also received from Bracknell, UK through Internet.

Network of meteorological observations in BMD:

Type of station	No. of station	Remarks
Synoptic • RBSN-SYNOP • RBSN-CLIMATE • RBSN-TEMP	 35 35 03	The network has an average density of a synoptic station per 4,100 km^2.

Upper-air • Rawinsonde stations • Pilot balloon stations	03 10	Dhaka Rawinsonde station is in operation now and takes one observation at 0000 UTC a day. Other two Rawinsonde observatories are taking observations at 0000 UTC on demand basis due to shortage of meteograph. Ten pilot balloon stations carrying out observations four times a day. Because of the establishment of the Hydrogen Plant in BMD, the gas production is regular and uninterrupted. As a result, pilot balloon observations have become uninterrupted.
Weather radar	04	10 cm S-band radars at Dhaka and Rangpur are in full operation. The replacement of Cox's Bazar and Khepupara radars with doppler facilities has already been done. For flood monitoring establishment of a new Doppler Radar at Moulavi Bazar (north eastern part of the country) is in progress and likely to be completed within March 2008.
AWS	02	Operating in ZIA International Airport Kurmitola, Dhaka and Shah Amanat International Airport at Patenga, Chittagong.
Agrometeorological stations	12	Are in operation.
Climatological stations	35	Are in operation.
Rainfall stations	35	Are in operation.
Aeronautical stations	09	Are in operation.
Evaporation stations	12	Are in operation.
Marine meteorological station • Ship	01 03	Working at Chittagong Sea Port
Satellite receiving station	03	MTSAT, NOAA, INSAT(not functional)
Others Seismological stations	01	Dhaka, Rangpur, Sylhet and Chittagong and networking between them are completed and are in operation from November 2007.

5.1.2 Telecommunication Systems

5.1.2.1 Automation of telecommunication system.

- National telecommunication networks.

  35 BMD Stations are connected to the Dhaka NMCC.

Data from RTH New Delhi and 10 synoptic observatories of BMD are exchanged on routine basis through WMO's GTS. All the 35 observatories of BMD have been connected with NMCC Dhaka either by TP or Telephone and single sideband (SSB) etc. or by all the three systems. Some of the observatories are connected through internet with NMCC and data are collected on real time basis by using Meteorological Data Acquisition software. The communications between Storm Warning Centre (SWC) and Radar Station at Cox's Bazar and Khepupara have been upgraded to **VSAT link.** NMCC uses MSS software obtained from WMO/UNDP Regional Computer Network programme for reception and transmission of all meteorological data.

5.1.2.2 GTS circuits

Dhaka is linked with New Delhi through a WMO circuit of speed of 6400 bps. The circuit is now operational through PC Hardware/Software developed by Oriental Electronics Inc., Japan financed by WMO.

Status of implementation of GTS circuits

Circuits Dhaka	Type of GTS	Status of implementation	Future plan
New Delhi	Regional circuit	6400 bps.	up-gradation of the GTS link to 128 kbps or higher

The existing speed of GTS is upgraded to 64 kbps. Further up-gradation required and BMD requested WMO to take initiative accordingly so that cyclone and tsunami warnings will be received on real time basis.

5.1.3 Weather Forecasting

5.1.3.1 Weather forecasting services

The Storm Warning Centre (SWC) of BMD issues routine day-to-day weather forecasts and tropical cyclone warnings. Two Main Meteorological Offices carry out aviation weather forecasting for the international flights; one at ZIA International Airport, Kurmitola, Dhaka and the other at Shah Amanat International Airport at Patenga, Chittagong and another airport at Shah Jalal International International Airport at Sylhet has recently been started international flights as such BMD has taken action to perform its responsibilities.

Except aviation weather forecasts, which are issued by Meteorological Offices at the International Airports, eight domestic airports weather forecasts are issued by the Storm Warning Centre. Cyclone bulletins for national and international users in various sectors are issued at frequent interval whenever cyclones develop in the Bay of Bengal. Due to issuance of timely and accurate forecasts and warnings by BMD, as such the preparedness and mitigation measures by CPP and the Government of Bangladesh has achieved the significant success in the reduction of losses in every sector of the national economy. Recently Government of Bangladesh has finalized the existing Standing Orders on Disaster incorporating earthquake and Tsunami disaster and also mode changes in cyclone warning signals foe easy understanding.

Except aviation weather forecasts, which are issued by Meteorological Offices at Zia International Airport at Dhaka and eight other airports, major weather forecasts are issued by the Storm Warning Centre. Cyclone bulletins for national and international users in various sectors are issued at frequent intervals whenever cyclones develop in the Bay of Bengal and there has so far been much achievement in reducing human loss and properties in this way. BMD has submitted a signal system to

the Govt. of Bangladesh in relation to cyclone intensity and location for easy understanding of the public and it was approved by the Government in March 2008. BMD is waiting for Government decision to go for implementation. Due to issuance of timely and accurate forecasts and warnings by BMD and the preparedness and mitigation measures by CPP and the Government of Bangladesh, it has now been possible to reduce the loss of lives and damage to properties significantly.

5.1.3.2 Dissemination of Cyclone Forecasts and Warnings

BMD transmits the warnings to Cyclone Preparedness Programme (CPP) related agencies, mass media through Fax, Telephone, E-mail and web-page as per **Standing Orders on Disaster**.

5.1.4 NWP activities

The project for the introduction of Numerical Weather Prediction (NWP) techniques is introducing in the forecasting system of BMD with GoB funds. The first phase of the project has completed in the last December 2008 and the second phase is likely to start by July 2009.

5.1.5 Climatological Services

5.1.5.1 Computerized system for climate data management

BMD uses its own Fortran Programs for data processing but it needs to be up-graded for its overall capacity enhancement to face the challenge of participation in climate change activities. We are hopeful that through JICA's technical cooperation on Human Capacity Development Project the existing gap would be minimized.

5.1.5.2 Data storage and climatological publications

Data storage and archiving are regular phenomena in Bangladesh Meteorological Department. BMD supplies the Meteorological Data to the end users and also for research purposes with minimum charge. The archival system needs up-gradation.

5.1.5.3 Climate change-related activities

Bangladesh Meteorological Department (BMD), Bangladesh University of Engineering and Technology (BUET), Space Research and Remote Sensing Organization (SPARRSO) and Department of Environment (DOE) are jointly working on Climate Change in Bangladesh by using PRECIS Model of Hadley Centre; U.K. BMD has already received the model with computer facility through DOE from DFID. BMD has started collaboration with SMRC in this initiative through SMRC's RCM modeling as well as ICTP's support towards installation of MM5 model in BMD

5.1.6 Meteorological Satellites

INSAT MDD Receiving System was installed at Storm Warning Centre, Dhaka and the System was fully operational for reception of Satellite image, Cloud Motion Vector (CMV) and Outgoing Longwave Radiation (OLR) charts along with GTS and aviation data (METAR, SPECI etc.). But because of the change of INSAT from analogue to digital system, INSAT Ground Receiving System (MDD) at BMD can not receive INSAT images nor can it receive GTS and other mentioned data and charts. The system needs to be upgraded to digital System. In this regards, BMD seeks Indias kind assistance.

MTSAT ground receiving station is operational. NOAA ground receiving station is not working properly. Experts are trying to solve the problem and hopefully it will be solved immediately.

BMD has received **PC VSAT System** from China under VCP programme in July 2006. It was comissioned in April 2007 and is operational. GTS data and NWP products (ECMWF, T213, HLAFS) are received through PCVSAT. MICAPS is used to visualize the NWP products and to analyze GTS data.

SADIS system for receiving ECMWF NWP Forecast charts, WAFS charts and upper air charts has become inoperative. **Assistance is required in this respect.**

BMD seeks assistance in the following sectors:

a. Doppler Weather Radar (DWR) Training Programme
b. More teaining on Storm Surge modelling
c. The e-atlas software is expected to be circulated to the members states. It will help BMD for inspect.
d. High wind speed recorders are requiered.
e. Rediation network-Inter comparison of residual standard prranometer with .....
f. Central radiation laboratory, Pune, is a national centre for India and also designated as Regional Radiative Centre for RA-III .....

5.1.7 Tropical Cyclone Names

BMD is practising naming convention of Tropical Cyclones formed in the Bay of Bengal since the cyclone season of 2006. Accordingly, “Sidr” in 2007, “Nargis”, “Rashmi”, “Khai-muk” and “Nisha” in 2008 were used by BMD in compliance with RSMC, New Delhi. People have gladly accepted the naming system.

5.1.8 ICAO: Aeronautical Meteorological Services in Bangladesh

The Bangladesh Meteorological Department operates its nine Aeronautical Meteorological Offices for supporting aviation operation in international and domestic routes.

5.2 Hydrological Component

BMD provides all sorts of data, information and weather forecast to the Flood Forecasting and Warning Centre (FFWC) of Bangladesh Water Development Board (BWDB). A Metropolitan Area Network (MAN) between SWC, Dhaka and FFWC was established in 1998 through which FFWC receives meteorological and hydrological data (including rainfall and water discharge data of up stream) along with Radar and Satellite images. Through the completion of the establishment of Meteorological and Hydrological Doppler Radar at the north-eastern part of Bangladesh under JICA Grant Assistance, FFWC is being connected by VSAT link to get all the radar information for flood and flash flood monitoring and forecasting. Also during execution of JICA’s Technical Cooperation on the Human Capacity Development training will be imparted to FFWC for radar data calibration and its utilization.

Floods continue to be a major hazard in Bangladesh. Floods in 1987, 1988, 1998 and 2004 caused widespread damage in rural and urban areas and set back the country’s efforts to alleviate poverty. For the flood protection both structural and nonstructural measures are often taken. Bangladesh started

National flood Forecasting and Warning Services in its FFWC (Flood Forecasting and Warning Centre) since 1972. FFWC is using MIKE11 model of Danish Hydraulic Institute (DHI) for flood forecasting services. WMO has taken up Pilot project for Flash flood in the northeastern part of the country. Rain estimation by Satellite technology has been adapted to increase the lead time beyond 72 hours. The regional forum ICIMOD has extended this technology. Improved inundation maps based on topographic and latest information on structures are issued from the FFWC. Bangladesh is also enjoying the regional hydro-metrological information flow from upper riparian countries, India, Nepal and China. CFAB/CFAN of Georgia Institute of Technology (GATECH) is helping FFWC by providing water discharge data with a view to enhancing the flood forecasting lead time. BMD provides all sorts of data, information and weather forecast to the Flood Forecasting and Warning Centre (FFWC) of Bangladesh Water Development Board (BWDB).

5.3 Disaster Prevention and Preparedness (DPP) Component (Agenda item 8.3)

5.3.1 Cyclone Preparedness Programme

The Cyclone Preparedness Programme (CPP) of Bangladesh Red Crescent Society (BDRCS) came into being in 1972 to minimize loss of lives and properties of the community people in cyclonic disaster. Since 1973, the programme is being implemented jointly by the BDRCS and the Government of Bangladesh. The Government of Bangladesh accepted the programme responsibilities for recurring expenses while the International Federation of Red Cross and Red Crescent Society provide the administrative and operational cost.

5.3.1.1 Working Area

The programme covers 11 coastal districts and is aided by 42,675 volunteers including 14,225 female in 2845 units (village). Recently numbers of female volunteers has been increased.

5.3.1.2 Objectives

- Disseminate cyclone warning signals issued by the Bangladesh Meteorological Department (BMD) to every nook and corner of the cyclone prone area.
- Assist people in taking shelter.
- Rescue distressed people affected by a cyclone.
- Provide First aid to the people injured by a cyclone.
- Assist in relief and rehabilitation operations.
- Assist in the implementation of the BDRCS disaster preparedness plan.

5.3.1.3 Cyclone Preparedness during 2008

The CPP volunteers were alerted and kept ready for rescuing the victims from the capsized fishing trawlers in the sea during the cyclones that crossed Bangladesh coast.

5.3.1.4 Training

- ♦ Arranged dissemination meeting with the students of 116 educational institutions of 29 Upazila under CPP command area. A total of 32,480 students participated in the meeting. The ultimate result of arranging this meeting is very much positive and significant.

- Arranged orientation on Cyclone Preparedness, self-preparedness & guideline for the fishermen in 29 centers. A total of 1450 fishermen participated in the orientation Programme.
- The community trainers (TOT holding volunteers) and local CPP officers undertook short training of RC/RC principles, movements, basic DM, role of volunteers, cyclone warning signal etc. with the volunteers attending in their regular unit and union committee meetings.
- Arranged refresher training on DM, HR, First Aid tracing and rescue among 2340 volunteers in 39 centers under CPP command area.
- Arranged three days long (TOT) and refresher TOT on DM first Aid tracing, search and rescue for CPP officer's and community trainers at Barisal, Nokhali and Cox's Bazar. 68 Participants from 31 Upazala under CPP Command area participated in the training courses. The respective Zonal officer's and youth volunteers of RC unit conducted the training while Director (operation), CPP, BDRCS to monitors /evaluate training.
- Arranged VHF operator's refresher training at Cox's Bazar from 24 December 2006. A total of 29 participants attended the training conducted by Radio Engineer and concerning zonal officer.

5.3.1.5 Awareness Raising Activities

- Volunteers of Tajunuddin and Pathargatha arragned two separate cyclone field demonstration in their respective Upazala. About 10,300 community people, local elites, Govt. officials NGOs and students of educational institution witnessed the demonstration, which reflected the potential impact of cyclone awareness, preparedness and mitigation issues.
- 13 October 2008, the International Disaster Reductions Day (IDRD) was observed by the Bangladesh Red Crescent Society in a befitting manner. With the spontaneous participation BDRCS officials a colourful rally and a discussion meeting was arranged to mark the day. In collaboration with the local administration all CPP field level offices observed the day.
- BMD is giving all sorts of support to all Government and NGO’s in awareness raising activities like introduction in national education, posters, pamphlet, seminar, workshop, rallies, operation of training etc.

5.3.1.6 Wireless Network

- There are 3 radio workshops in the programme. In view of repair and maintenance of the wireless networks the following warning equipment and wireless sets have been repaired in those workshops and in the field by the concern radio engineer and technician.

Name of equipments	Quantity
HF wireless	22
VHF wireless	34
Radio	21
Megaphone	83
Solar panel cage pointing	52
Re-installation VHF center	01
Re-installation of VHF sets	05
Re-installation of HF Antenna	07
Torch light	24
Hand siren	28

Antenna mast painting	53

- 50 new VHF sets and 26 dip cycle battery received from International Federation of Red Cross & Red Crescent (IFRC) for strengthening the wireless network.

- 7,100 big size and 33,320 medium size battery procured and sent to the CPP field stations for to be used in the equipment lying with the warning group volunteers.

5.3.1.7 Organizational Activities

As a continuous process, 3,289 units, 466 unions and 110 Upazilas committee meeting were conducted with the volunteers in the stipulated year.

5.3.1.8 Activities of DMB

BMD disseminates the Tropical Cyclone Warnings and other adverse weather warnings as per Standing Orders on Disaster to the Disaster Management Bureau (DMB) and Ministry of Food and Disaster Management (MOFDM) in time. The MOFDM and DMB take necessary steps for Disaster Prevention and Preparedness (DPP) in Bangladesh during the impending tropical cyclone.

5.4 Training Component (Agenda item 8.4)

5.4.1 Foreign Training attended by BMD during 2008

Besides participating in different Workshops, Seminar and Conference, officers of BMD underwent foreign training and have participated in 30 training program abroad.

5.4.2 METEOROLOGICAL TRAINING INSTITUTE OF BMD

5.4.2.1 ACTIVITIES

This institute imparts in service training to BMD's officers and staffs. The training courses include both theoretical and practical aspects. The practical courses include weather observation at surface and upper levels, recording, data analysis and issue of forecasts. Besides the departmental employees, this institute also conducts special training courses on meteorology for other organizations too. Training on meteorological instruments and meteorological communication system are also imparted to the students of various educational institutions. The institute also guides the M. Sc. /M.S. /Ph. D students of various universities, who are doing their theses in the field of Meteorology and Environment. In every training course, clear conceptions about disaster preparedness and management and related Standing Orders are also imparted. This institute also conducts and coordinates research and investigations on various meteorological problems particularly relating to Bangladesh and the region. The institute conducts ....courses in 2008.

5.4.2.2 Regular Courses

The regular scheduled courses are:

i. Class-II Forecaster’s Course for Class-I Officers.

ii. Class-III Assistant’s Course.

iii. Class-IV Observer’s Course

iv. Class-II Forecaster's Refresher Course for Class-I Officers.

5.4.2.3 Areas of Training and Training Method

i) Science and Meteorology,
ii) Observation of weather phenomena,
iii) Transmission and exchange of weather data,
iv) Analysis of weather elements and charts,
v) Forecasting & monitoring of the all types of weather & natural disasters
vi) Recording and monitoring of Earthquakes,
vii) Satellite & Radar Meteorology,
viii) Electronics and communication,
ix) Research on Meteorology,
x) Seminars and workshops in the disaster prone areas,
xi) Practical training on IIT Storm Surge Model (Dube et al.) with two hours training everyday for two months.

Training Institute imparts training to all Meteorological personnel on the above-mentioned fields through theoretical and practical classes as per the syllabi of World Meteorological Organization.

5.4.2.4 Monitoring Evaluation

The Meteorological Training Institute of BMD needs to be upgraded according to the latest technological development in the field of meteorology to make the ongoing process of switching to IT based technology successfully.

5.6 Research (Agenda item 8.5)

A Research and Development Cell (R&D Cell) has been established in the Meteorological Training Institute of BMD for undertaking research in Meteorology. But more facilities are required.

5.7 Storm surge project (Agenda item 8.6)

BMD already submitted a project entitled "**Storm Surge Disaster Reduction in the North Indian Ocean"** as per proforma to TSU. TSU can highlight the status on the project.

5.9 Publications (Agenda item 8.7)

BMD publishes a Journal "The Atmosphere" every year under the banner of Abhawa Karmakarta Parishad (Meteorological Officers Association) financed by the Ministry of Science, Information and Communication Technology (SICT).

6. REVIEW OF THE TROPICAL CYCLONE OPERATIONAL PLAN (Agenda item 9)

In the existing signal system there are two types of signals used for maritime or sea ports and inland river ports. For maritime ports eleven individual signals are used in different stages of disaster and for inland river ports four separate signals are used. Therefore, different signals are used for maritime ports

and inland river ports for monitoring same disaster formed in the Bay of Bengal. This makes confusion among the general mass, maritime port authorities, inland river port authorities as well as those who are related with disaster management activities. It has also been observed in the case of recent cyclone SIDR.

Therefore, to avoid confusion about this situation and to unify both (maritime and inland) the signal system, the number of maritime signals has been reduced into eight and the number of signals used for inland river ports are increased into six (starting from three). The comparison of these signal systems are given below:

Sl. No.	Signal system for maritime ports	Signal system for inland river ports	Wind speed (km/h)
1	Distant Cautionary signal number -1	-	51-61
2	Distant Warning signal number - 2	-	62-88
3	Local Cautionary signal number - 3	Local Cautionary signal number - 3	40-50
4	Local Warning signal number -4	Local Warning signal number -4	51-61
5	Danger Signal -6	Danger Signal -6	62-88
6	Great Danger Signal -8	Great Danger Signal -8	89-117
7	Great Danger Signal -9	Great Danger Signal -9	118-170
8	Great Danger Signal -10	Great Danger Signal -10	171 and above

The proposed signal system has been approved by the Government of the People's Republic of Bangladesh and in the next April new signaling system will be in operation. The brief descriptions of new signal systems are as follows:

a. Signal system for Maritime Ports

Sl. No.	Signals	Explanation
1	Distant Cautionary Signal Number -I	There is a region of squally weather in which a storm may be forming (well marked low or depression) with surface winds up to) 61 km/h. (33 knots))
2	Distant Warning signal number -II	A storm has formed (cyclonic storm with surface winds 62-87 km/h. (34-47 knots))
3	Local Cautionary signal number -III	The port is threatened by squally weather (cyclonic circulation with surface winds 40-50 km/h. (22-27 knots)) or squalls due Nor'westers)
4	Local Warning signal number -IV	The port is threatened by a storm, but it does not appear that the danger is as yet sufficiently great to justify extreme measures of

		precaution (cyclonic circulation) with surface winds 51-61 km/h (28-33 knots))
5	Danger Signal -VI	The port will experience severe weather from a cyclonic storm of moderate intensity (cyclonic storm with surface winds 62-88 km/h (34-47 knots))
6	Great Danger Signal - VIII	The port will experience severe weather from a storm of great intensity (Severe Cyclonic Storm with surface winds 89-117 km/h (48-63 knots))
7	Great Danger Signal - IX	The port will experience severe weather from a storm of very great intensity (Severe Cyclonic Storm with a core of Hurricane winds with surface winds 118 -170 km/h (64 -119 knots)
8	Great Danger Signal - X	The port will experience severe weather from a storm of very great intensity (Severe Cyclonic Storm with a core of Hurricane winds with surface winds 171 km/h and above (120 knots and above))

b. Signal system for Inland River Ports

Sl. No.	Signals	Explanation
1	Local Cautionary signal number -III	Your area is threatened by squally winds of transient nature (Nor'wester squall of wind speed 40-50 km/h (22-27 knots)). Look out for further development
2	Local Warning signal number -IV	A storm (of depression intensity, associated sustained winds 51-61 kph (28-33 knots)) or Nor'wester squalls (of wind speed 51-61 kph (28-33 knots) is likely to strike you (vessels of length 65 feet or less are to seek shelter immediately
3	Danger Signal -VI	A storm of moderate Intensity or Nor'wester squalls, associated sustained winds 62-88 km/h (34-47 knots) may strike you. All vessels are to seek shelter immediately and keep in shelter till further notice.
4	Great Danger Signal - VIII	A violent storm or nor'wester associated sustained wind 89-117 km/h (48-63 knots) may strike you. All marine vessels have to keep in shelter till further notice.
5	Great Danger Signal - IX	A very severe cyclonic storm with very high intensity with sustained wind 118-170 km/h (64-119 knots) may strike you. All marine vessels are to be in shelter till further notice.
6	Great Danger Signal - IX	A very severe cyclonic storm with the intensity of super cyclone with sustained wind of 171 km/h or more (120 knots or more) may strike you. All marine vessels are to be in shelter till further notice.

7. TECHNICAL SUPPORT UNIT (Agenda item 10)

BMD cooperates with TSU regularly.

8. SUPPORT FOR THE PANEL'S PROGRAMME (Agenda item 11)

The payment of contribution to the WMO/ESCAP Panel on Tropical Cyclones Trust Fund since 2004-2008 could not be possible due to the following problems:

a. For the payment of the contribution of WMO/ESCAP Panel on Tropical Cyclones Trust Fund, our Government's Sanction Title is "Technical Support Unit (TSU), Bangkok, Thailand". So the Ministry of Finance sanctioned the necessary fund in favour of Technical Support Unit (TSU) every year to pay the contribution accordingly. But Bangladesh Meteorological Department (BMD) is paying the contribution to the title "WMO/ESCAP Panel on Tropical Cyclone Trust Fund"

b. Now our controlling Ministry has raised the question that the Government's sanction title is "Technical Support Unit (TSU)" but it is deposited to the title "WMO/ESCAP panel on Tropical Cyclone Trust Fund" which are not the same. Due to the difference of the title, our controlling Ministry has stopped the payment of the contribution from 2004.

c. Under the circumstances, we need a letter from WMO to clarify the relation between WMO/ESCAP Panel on Tropical Cyclone Trust Fund and Technical Support Unit (TSU) for satisfying our Administrative Ministry to overcome the problem. This will help Bangladesh Meteorological Department to pay the contribution for the said period.

END.

Country Report of India

5. Review of coordinated technical plan and consideration of the work programme for the next five years (2009-2013)

5.1. Meteorology

a. Surface Instruments

1. IMD has installed 10 sets of High Wind Speed Recording Systems (Ultrasonic type) at East and West coast stations of India as. Also, 10 more systems of HWSR, procured under World Bank Project were installed at West Bengal, Orissa, Andhra Pradesh and Tamil Nadu Coast. It has been experienced that the display and sensor of the systems become defective mainly due to lightning activity at coastal stations. Therefore, new lightning arresters have been erected with proper earthing at all the coastal stations. In addition, a newly designed HWSR system has also been installed at Puri and same will be installed at other places to replace the defective ones

2. One hundred SUTRON make AWS systems and 25 ASTRA make AWS systems were procured during June 2006. All AWS systems have been installed. One receiving Earth Station in redundant mode has been installed in INSAT-AWS Laboratory, Pashan, Pune. AWS data from AWS sites are being received at Pune Receiving Earth Station. From Pune Receiving Earth Station, hourly data is being sent to AMSS Mumbai through dedicated lease line for onward transmission through GTS to different users. Quality of AWS data from new AWS stations is under evaluation. Comparison of AWS data received through kalpana – 1 Satellite with Co-located obsy. data is in progress.

3. The data reception from Moored Buoys over the north Indian Ocean is being monitored on a regular basis.

4. Under the scheme "Up-gradation of standard test facility for barometer and thermometer", various calibration standards were procured. Among them are Stable Ozone Generators for calibration and conditioning of ozonesonde sensors.

5. Procurement action of the following is in progress.

a) Commissioning of new Integrated Airport Meteorological Instruments for 20 airports. (Store received and likely to be installed before Jan.2008 at Mumbai, at other Airports Order placed and stores awaited and likely to be installed before March 2008

b) Commissioning of 550 nos. of automatic weather stations (AWS)

c) Commissioning of automatic raingauge stations (ARS)1350 nos (TEC report sent to HQ. Order likely to be placed shortly for 500 ARS)

6. Augmentation of Radiation Network: State-of-the-art radiation measuring equipment have been received and installation is in progress. Procurement of electronic sunshine sensor is in progress.

7. Establishment of UV Radiation Network: 50 nos of UV A radiometers have been received and are under test and procurement action for UV B and total UV radiometer is in progress.

FUTURE PLANS

1) It is planned to procure 900 AWS & 4000 ARS within the next few years to upgrade all part time observatories by AWS and DRMS stations by ARS.

2) DIWE becomes defective mainly due to malfunctioning of Selsyn motors. These motors are out of market and hence all wind vane systems (54 Nos.) in which Selsyn motors are used, are being replaced with potentiometric windvanes

3) Facilities for calibrating the instruments (anemometers, barometers and barographs) are being upgraded. As this office is calibrating and certifying surface meteorological instruments, this facility will definitely facilitate higher capacity for calibration/certification, which will result in improved revenue.

4) Modernisation of Voluntary Observing Fleets (50 nos). Scheme has been forwarded to HQ for approval.

5) Construction of 'Test and Evaluation laboratory' and Seismo Observatory as Extension of AWS building.

6) Scheme to modernise 45 airports in India has been approved in CMAS - 59. International airports will be equipped with integrated aviation meteorological systems which will include dual base line transmissometers catering to need of CAT–I to CAT–III operations.

7) Lightning detection system.

8) Anemometer array for detection of wind sheer.

9) Microwave radiometer.

10) A project scheme to augment the radiation network with additional sensors and satellite communication of data is under implementation.

11) Action for purchase of 100 Nos. of Digital Barometers and Dead Weight Testers as primary standard is in advanced stage.

b. Upper Air Observatory Network

In I.M.D. upper air observations are made at 39 RS/RW stations twice a day at 00 and 12 UTC. These observations provide Met data i.e. pressure, temperature, humidity & wind at various levels in the atmosphere upto an altitude of 20-25 kms. There are 62 Pilot Balloon observatories spread all over the country conducting upper air wind measurements 2 - 4 times a day providing wind speed and direction up to a maximum altitude of 10 kms employing optical theodolites.

Out of 39 upper air observatories, from which balloons with radiosonde are released twice a day for getting PTU and wind data, the observatories at Kochi and Jaipur provides only RS data and not the wind data.

STATUS OF RADAR NETWORK OF IMD

IMD has a network of 40 radars installed throughout the country which are categorized as follows:

1. CYCLONE DETECTION RADAR

There are 11 S-band CDR stations out of which 6 are using conventional radars, 4 stations viz Chennai, Kolkata, Machilipatnam and Visakhapatnam have DWRs imported from M/s Gematronik, Germany and one station SHAR, Sriharikota has indigenous DWR developed by ISRO.

The conventional radars at Mumbai and Paradip are being replaced by latest state of art S-band imported DWR in first phase of Modernisation Plan of IMD under which 12 Nos. DWRs are to be installed at ; Agartala, Karaikal, Goa, Patna, Lucknow, Patiala, Nagpur, Delhi (HQ), Mohanbari, Mumbai ,Paradeep and Bhopal.

Delivery of 2 S-band DWRs is expected by April, 2009.

The 2 indigenous radars for Bhuj and Kochi are expected to be installed by March , 2010.

2. STORM DETECTION RADAR

There are at present 9 X-band radars working for the purpose of storm detection. Also there are 2 S-band radars working at S-band at Sriganganagar and Jaisalmer for monitoring development of convective clouds and thunderstorm formation and one S-band radar at Mausam Bhavan for testing / training purpose.

IMD is also planning to install 2 C Band dual polarized radars at Delhi and Jaipur during 2009-10 in its weather network and to meet the requirement for Common wealth Games during 2010.

3. WIND FINDING RADAR

There are 9 X-band wind finding radars working in X-Band at Bhubaneswar AirPort, Goa, Mangalore, Visakhapatnam, Bhopal AP, Karaikal, Machilipatnam, Patna AP, and Thiruvananthapuram.

4. WEATHER CUM WIND FINDING

There are 8 X-band radars used for weather cum wind finding purpose.
These are installed at Ahmedabad, Bangalore, Mohanbari, Chennai, Hyderabad airport and Delhi (H.Q.), Patiala and Srinagar.

It has been decided in Annual Cyclone Review Meeting 2009 that DWR offices should prepare bulletins during cyclone season which should be made available to Cyclone Warning Division, New Delhi and ACWCs.

Priority projects

1. Improvement of data quality at 10 existing IMS-1500 stations by deployment of improved quality Radiosonde under Modernization of IMD
2. Establishment of 5 GPS stations for Upper Air Data collection under Modernization of IMD and 5 GPS stations under MFI as mentioned at Enclosure-3.
3. Commissioning of new optical theodolites at all 62 stations.
4. Commissioning of Optical Electronic Theodolite at 5 stations.
5. Development of new generation Radiosonde

c. Telecommunication Network

1. India Met. Deptt. maintains a very extensive Telecommunication Network with Central Hub in its National Meteorological Telecommunication Centre (NMTC) at New Delhi connected with Five State of the art Regional Automatic Messages Switching Systems (AMSS) at Delhi, Kolkata, Chennai, Mumbai and Guwahati AMSS at RTH New Delhi is under the process of upgradation

(replacement) by the latest –state- of the art technology AMSS to be supplied by the M/s MFI. After installation of the new AMSS, RTH New Delhi will become at par with WIS Centre of WMO's GTS . For collection of Meteorological Data from the entire country. and the neighbouring NMTC, various modes of communication viz dedicated leased line circuits, fax, internet, high speed data terminals, VPN connectivity, VHF / Walkie-Talkie have been installed at various locations dispersed throughout the country

2. The Regional Telecom Hub (RTH) New Delhi maintains point to point Global Telecom System (GTS Ten links) and Five circuits through internet connectivity.
3. For public weather informations Interactive Voice Response Systems (IVRS), popularly known as 'Weather on Telephone' have been installed at 26 stations (mainly state capitals) through out the country. One can access current weather and forecasts for major Indian cities by dialing a toll free number 1800 180 1717 or 1717.
4. 28 Stations have been provided VPN Connectivity, which are mainly located at MCs, AMSS Centres, DWR sites Pune and VPN connectivity for another 11 stations under process.
5. 26 Stations have been equipped with 64 kbps high speed data terminals.
6. A network of 26 V-SATs is being installed at selected seismological observatories, Cyclone Detection Radar stations, Cyclone Warning Centres for reception of observational data utilizing communication transponder of INSAT.
7. A Satellite Data Dissemination System (SADIS) (receive only)is in operation at New Delhi to receive aeronautical meteorological information from International Civil Aviation Organization (ICAO) Centres which are routed to four International Airports of India for National and International Flight briefing and for providing data in GRIB/ BUFR format for Wind/ Temperature and Sig. Wx charts. Migration from SADIS 1G to SADIS 2G is under process.

On going project

1. Provision of Toll free facility at M.Cs to collect data from part time /departmental observatories is under process.
2. RTH New Delhi system will be upgraded by MFI and it is in progress.

d. Meteorological Satellites:

(i) INSAT Data Reception and Processing:

At present India Meteorological Department (IMD) is receiving and processing meteorological data from two Indian satellites namely Kalpana-1 and INSAT-3A. Kalpana-1 was launched on 12th September, 2002 and is located at 74^0 E. INSAT-3A was launched on 10th April, 2003 and is located at 93.5^0 E. Kalpana-1 and INSAT-3A both have three channel Very High Resolution Radiometer (VHRR) for

imaging the Earth in Visible (0.55-0.75 um), Infra-Red (10.5-12.5um) and Water vapour (5.7-7.1um) channels having resolution of 2X2 kms. in visible and 8X8 kms. in WV and IR channels. In addition the INSAT-3A has a three channel Charge Coupled Device payload for imaging the earth in Visible (0.62-0.69um), Near Infra Red (0.77-0.86um) and Short Wave Infra Red (1.55-1.77um) bands of Spectrum. The Resolution of CCD payload in all the three channels is 1KmX 1 Km. At present about 48 nos. of satellite images are taken daily from Kalpana-1 which is the main operational satellite and 9 images are taken from INSAT-3A. Imaging from CCD is done 5 times during daytime only. All the received data from the satellite is processed and archived in National Satellite Data Centre (NSDC), New Delhi.

Future Plans:

A new Geostationary Meteorological Satellite INSAT-3D is being designed by ISRO. It will have a six channel imager and a nineteen channel sounder. In addition to satellite imagery in six channels several new derived products will be available after processing the data from INSAT-3D. These products will be useful in NWP and in day-to-day weather forecasting. In addition to ground level products the vertical profiles of atmospheric temperature, moisture and ozone will be available from the satellite data of INSAT-3D. It will provide 1Km resolution imagery in visible band, 4 Km resolutions in IR band and 8 Km. in water vapor channel. This new satellite is scheduled for launch in fourth quarter of 2008 and will provide much improved capabilities to the meteorological community and users.

New ground segment facilities to receive and process data from INSAT-3D is being installed. This will consist of the establishment of an Earth Station & Data Reception and processing systems through M/s Antrix Corp, ISRO, Bangalore.

(ii) INDO-US Co-operation:

An MOU was signed on 16th Dec., 1997 between DST/DOS (India) and NOAA/NASA (USA) for co-operation in Earth Atmospheric Sciences. Under the implementation of this MOU an INDO-US data exchange center was established in Sat. Met. Division of IMD in 1998 for exchange of satellite data with USA. NASA, USA, has provided a dedicated communication link of 512 Kbps with full duplex capability. IMD has been transmitting INSAT cloud imagery data every three hours to USA as per terms of agreement of the above-referred MOU. IMD has been receiving data from GOES satellites of USA in IMD, New Delhi. The exchange of scientific data between the two countries also takes place through the same link. India Meteorological Department has now come under the new ministry named Ministry of Earth Sciences (MoES) formed by Government of India. In order to have better interaction between IMD and NOAA/NASA of USA, a fresh MOU was signed on 16 April 2008 between MoES(India) and NOAA/NASA(USA) for cooperation in Earth Atmospheric Sciences.

(iii) Automatic Picture Transmission (APT) System and other satellite data receiving system:

An APT data reception and processing system has been set up in Satellite Meteorology Division of India Meteorological Department for receiving the data from the operational Polar Orbiting NOAA satellites. The APT images are displayed on IMD website regularly.

Future Plan:

It is planned to install three nos. NOAA/MODIS/Metops Satellite data receiving and processing system at New Delhi, Chennai and Guwahati for obtaining Satellite derived products that are useful in weather forecasting.

(iv) Meteorological Data Dissemination (MDD):

The processed INSAT cloud imageries are broadcast through INSAT-3C, an Indian communication satellite using S band broadcast capability in digital mode every three hours. Meteorological data consisting of satellite cloud imageries, T/P data (conventional Met. Data) and Fax charts (Analysed weather charts) are provided to various field stations through this MDD network. At present there are 37 MDD receiving stations in India. In addition to IMD, IAF and Navy also receive signals. Conventional Met. Data satellite bulletins based on analysis of satellite cloud imageries are transmitted at synoptic hours, heavy rainfall advisories are also sent over MDD. During cyclone situations, actual position of system and its intensity and related forecast are also being transmitted to field stations every hour. The system transmits data in International LRIT/HRIT format through own transmitting station at New Delhi. A DMDD has been installed at Nepal.

Future Plan:

Two DMDD receiving stations will be installed at Maldives and Srilanka by April, 2009.

(v) Cyclone Warning Dissemination System (CWDS):

A scheme, known as Cyclone Warning Dissemination System (CWDS) using INSAT is also in use. Under this scheme the cyclone warning messages are disseminated to the affected areas in their local languages. This communication method is more reliable as it does not use terrestrial links, which generally get disrupted during severe weather conditions. The scheme is very successful and has saved thousands of lives and invaluable property during the cyclone occurrences.

Total numbers of 252 analogue CWDS receivers have been installed in the cyclone prone areas of east and west coasts of India. The cyclone warning messages are broadcast in local languages of the area likely to be affected. Messages for the state of West Bengal and Orissa are broadcast from ACWC Kolkata. Andhra Pradesh, Tamilnadu, Kerala and Karnataka are covered by ACWC Chennai. The broadcast for Maharashtra, Gujarat and Goa states originate from ACWC Mumbai. 100 more

Digital CWDS receivers based on Digital Technology have been deployed in Andhra Pradesh under the World Bank Project in the year 2003.

Future Plan:

It is planned to replace all the 252 Analogue CWDS receivers by Digital CWDS in the current year 2008-09 and increase the network to 400 from 352 at present. Efforts are on to have an agreement with ISRO.

India Meteorological Department has proposed expansion of AWS and ARG network under modernization programme. 549 AWS and 1350 ARG's will be installed all over India under this programme. IMD proposes to have at least one District and one ARG in a Taluka. In this expansion programme action for procurement of these AWS/ ARG is in progress. One AWS and Two ARG has been installed in Pune. The installation work of the AWG/ARG will be completed soon.

(vi) GPS:

IMD has commissioned Five Nos. Global Positioning Stations (GPS) at New Delhi, Chennai, Kolkata, Mumbai and Guwahati along with main processing system at New Delhi in the year 2007 for the measurement of Integrated PrecipitableWater Vapour (IPWV) at these locations.

Future Plan:

It is planned to increase the GPS weather forecasting Network to 55 stations from existing 5 nos.

(vii) Earth Station for Meteorological Application (ESMA) :

During the year 1992 a Earth Station for Meteorological Application (ESMA) was installed / commissioned at Satellite Meteorology Division of India Meteorological Department at Lodi Road, New Delhi in association with Space Application Centre, Ahmedabad to receive cloud imagery and AWS data from INSAT-II series of satellites. This Earth station has served its useful life but its antenna and other front end equipment are still being used for receiving data from Kalpana-1 satellite.

During the year 2003 one more Earth station was installed in Satellite Meteorology Division to receive data from a multi-purpose Satellite INSAT-3A. This Earth Station is at present operational and receives VHRR and CCD data along with AWS data from Indian satellites. The earth station is operational round the clock. It is planned to set up New Satellite Earth station by 2008 for a new Indian Satellite (INSAT-3D).

(viii) Tropical Cyclone Analysis- ADT

Initiation of Cyclone development over the ocean is generally indicated by the presence of curved cumulus lines and their interaction with deep layer convection. Such lines can be better resolved in high-resolution imagery. During the life cycle of a storm, cloud features appear to change in surges and variability in cyclones cloud pattern is better observed. Cloud pictures received from weather satellites are extensively used in locating the movement of cyclones over data sparse oceanic region.

5.2 Hydrology

(i) Rainfall Monitoring Unit (RMU):

IMD has been monitoring district-wise rainfall on real time basis. Over 500 surface observatories of IMD record daily rainfall in addition to about 5,000 rain gauge stations controlled by State Govt: authorities. At present, about 2,900 rain gauge stations of both IMD as well as State Govt. agencies report daily rainfall data on real time under the District-wise rainfall Monitoring Scheme (DRMS), which is a regular operational activity of IMD. Daily station-wise rainfall data is collected, compiled, checked and processed at the Meteorological Centres of IMD. The district-wise processed rainfall data is transmitted to the Hydromet. Division of IMD at New Delhi for preparation of periodical rainfall statistics mainly district/ meteorological sub-divisional/country as whole, rainfall realized and its departure from long term average for week and season. The output is available both in tabular and pictorial form for the benefit of planners, policy makers, agricultural scientists. Civil and irrigation engineers, research scholars etc and is also available on IMD's website.

(ii) Salient features of Rainfall during South West Monsoon (June-Sept. 2008)

The seasonal rainfall over the country as a whole was 98% of its Long Period Average (LPA). Large temporal variation was noticed within the season. For the country as a whole ,the rainfall was 23% above LPA in June and 17% below LPA in July. It was i% above and 5% below LPA respectively during August and September. The spatial distribution of season rainfall was largely uniform with 31 meteorological sub-divisions recording normal rainfall. Only 2 sub-divisions received excess rainfall and 3 deficient rainfall. The seasonal rainfall was 105% of its LPA over Northwest India, 96% each over Central and south peninsula and 97% of its LPA over Northeast India.

HIGHLIGHTS

Out of 36 meteorological subdivisions, 92% of the country's area comprising 32 meteorological sl;lbdivisions received excess/normal rainfall and the remaining 8% received deficient rainfall during the season.

Monsoon rainfall was marked by large temporal variations for the country as a whole, as rainfall was 24% above LPA in June and in July it was 17% below LPA. The rainfall was near normal during August and Sept as it was 3% and 1% below the LPA respectively.

IMD's long range forecast for the seasonal R/F over the country as a whole and over different homogeneous region except Northwest India have been accurate. However, the seasonal over northwest India R/F during July for the country as a whole have not been' accurate. while the prediction overestimated the R/F during July For the country as a whole, it underestimated the seasonal R/F over Northwest India.

(iii) Role of India Meteorological Department (IMD) through Flood Meteorological Offices (FMOs) in Flood Forecasting:

Flood Forecasting in India is jointly carried out by the coordination of two organisation IMD under Ministry of Earth Sciences (MoES) and Central Water Commission (CWC) under Ministry of Water Resources (MoWR). IMD has established 10 FMOs and CWC 20 Central Flood Forecasting Division (CFFD) in flood prone river basins of India. This scheme has an exclusive network of 380 part time rainfall station (FMO Stations) reporting rainfall on real time basis during flood season (generally from 15th May to 15th October) in addition to other rainfall observatories. The main work of FMOs is to issue QPF. 7 FMOs are co-located with the Meteorological Centres (MCs) which are issuing general weather forecast and prepares all related weather charts which are also utilised by FMOs for issuing QPF. 3 FMOs are not co-located with MCs, so prepares all weather charts also in addition to rainfall chart and require more officers / staff. A total of 4085 QPFs were issued by all the ten FMO:S during the flood season of 2008.

Activities of FMOs:

(a) Collection of Rainfall Data:

Each FMO collect rainfall data from FMO stations, IMD departmental station and
other selected state raingauges from where data is received on real time basis. The rainfall data is observed at 0830 as per WMO norms i.e, 03 UTC/0830 hr. 1ST. This data is used to compute daily areal rainfall catchments/sub catchments under the jurisdiction of FMO during Flood season which generally from 15th May to 15th October.

(b)Flood Met Bulletin:

Each FMO during flood season issue daily Hydro-meteorological Bulletin to CFFD for all sub catchments. The Hydrometeorology Bulletin containing the information which are as under:

(i) Quantitative Precipitation Forecast (QPF).

(ii) Prevailing synoptic situation in the region.

(iii) Basin-wise areal rainfall.

(iv) Station-wise significant rainfall during past 24 hrs (>5 cm).

(v) Heavy rainfall warning in the next 24 hrs. QPF when issued and watch round the clock and modify QPF during flood alert.

(c) Quantitative Precipitation Forecast (QPF):

The QPF are to be issued in the following eventualities:

(i)During Flood Alert notified by CFFDs.

(ii) During the weather situation when there is expectation of significant rainfall leading to floods. During the Flood Alert period, FMO keeps watch round the clock.

(iii) The QPF are to be issued sub basin wise and it is valid for next 24-hrs, being revised 12-hrs if situation demands. The QPF are to be issued in the following ranges:

S.No.	Rainfall in mm
1.	1-10
2.	11-25
3.	26-50
4.	51-100
5.	>100 .

(d) During non flood season FMOs carryout the following work.

(i) Inspection

(ii) Data entry

(iii) Preparation of annual Flood Report

(iv) Training

Hydrology Division, New Delhi conducted a training course during 5-9 May 2008 at CTI, Pune for staff posted at each of 10 FMO's. In this training course isohyetal method has been covered and proper training was given.

(iv)Proposal of Integrated Project over Himalayan Region:

A project is being prepared by IMD to improve the meteorological network over Himalayan region with a view to carryout flash flood forecasting and glaciological studies of the glaciated of Himalayan region.

5.3. Disaster prevention and preparedness

5.3.1. Cyclone Warning Services

The extensive coastal belts of India are exposed to cyclonic storms, which originate in the Bay of Bengal and the Arabian Sea every year. These cyclones, which are accompanied with very heavy to extremely heavy rain, gales and storm surges cause heavy loss of human lives and cattle. They also cause extensive damage to standing crops and properties.

It is the endeavour of India Meteorological Department (IMD) to minimise the loss of human lives and damage to properties due to tropical cyclones by providing early warnings against the tropical cyclones. Cyclone warning is one of the most important function of the IMD and it was the first service undertaken by the department in1865. The cyclone warnings are provided by the IMD from the Area Cyclone Warning Centres (ACWCs) at Kolkata, Chennai & Mumbai and Cyclone Warning Centres (CWCs) at Vishakhapatnam, Bhubaneswar and Ahmedabad.

The complete Cyclone Warning Programme in the country is supervised by the Cyclone Warning Division (CWD) at Head Quarter Office of the Director General of Meteorology at New Delhi. The CWD monitors the cyclonic disturbance both in the Bay of Bengal and Arabian Sea and advises the Government of India at the Apex level. Information on cyclone warnings is furnished on a real time basis to the Control Room in the Ministry of Home Affairs, Government of India, besides other Ministries & Departments of the Central Government. This Division provides cyclone warning bulletins to Doordarshan and All India Radio (AIR) station at New Delhi for inclusion in the National broadcast/telecast. Bulletins are also provided to other electronic and print media and concerned state govts. The Deputy Director General of Meteorology (Cyclone Warning) and Deputy Director General of Meteorology (Weather Forecasting) Pune monitor technical aspects and review the standard practices in the area of cyclone forecasting.

5.3.2. Cyclone warning bulletins

The following is the list of bulletins and warnings issued by ACWCs/CWCs for their respective areas of responsibility:

(1) Sea area bulletins for ships plying in High Seas.
(2) Coastal weather bulletins for ships plying in coastal waters.
(3) Bulletins for Global Marine Distress and Safety System (GMDSS). Broadcast through Indian Coastal Earth Stations.
(4) Bulletins for Indian Navy.
(5) Port Warnings.
(6) Fisheries Warnings.

(7) Four stage warnings for Central and State Govt. Officials.
(8) Bulletins for broadcast through AIRs for general public.
(9) Warning for registered users.
(10) Bulletins for press.
(11) Warnings for Aviation (issued by concerned Aviation Meteorological Offices).
(12) Bulletins for ships in the high seas through Navtex Coastal Radio Stations.

The cyclone warnings are issued to state government officials in four stages. The **First Stage** warning known as **"PRE CYCLONE WATCH"** issued 72 hours in advance contains early warning about the development of a cyclonic disturbance in the north Indian Ocean, its likely intensification into a tropical cyclone and the coastal belt likely to experience adverse weather. This early warning bulletin is issued by the Director General of Meteorology himself and is addressed to the Cabinet Secretary and other senior officers of the Government of India including the Chief Secretaries of concerned maritime states.

The **Second Stage** warning known as **"CYCLONE ALERT"** is issued at least 48 hrs in advance of the expected commencement of adverse weather over the coastal areas. It contains information on the location and intensity of the storm likely direction of its movement, intensification, coastal districts likely to experience adverse weather and advice to fishermen, general public, media and disaster managers. This is issued by the concerned ACWCs/CWCs and CWD at HQ.

The **Third Stage** warning known as **"CYCLONE WARNING"** issued at least 24 hours in advance of the expected commencement of adverse weather over the coastal areas. Landfall point is forecast at this stage. These warnings are issued by ACWCs/CWCs/and CWD at HQ at 3 hourly interval giving the latest position of cyclone and its intensity, likely point and time of landfall, associated heavy rainfall, strong wind and storm surge alongwith their impact and advice to general public, media, fishermen and disaster managers.

The **Fourth Stage** of warning known as **"POST LANDFALL OUTLOOK"** is issued by the concerned ACWCs/CWCs/and CWD at HQ at least 12 hours in advance of expected time of landfall. It gives likely direction of movement of the cyclone after its landfall and adverse weather likely to be experienced in the interior areas.

Different colour codes as mentioned below are being used in since post monsoon season of 2006 the different stages of the cyclone warning bulletins as desired by the National Disaster Management.

Stage of warning	**Colour code**

Cyclone Alert		**Yellow.**
Cyclone Warning	**-**	**Orange.**
Post landfall out look		**Red.**

During disturbed weather over the Bay of Bengal and Arabian Sea, the ports likely to be affected are warned by concerned ACWCs/CWCs by advising the port authorities through port warnings to hoist appropriate Storm Warning Signals. The Department also issues **"Fleet Forecast"** for Indian Navy, Coastal Bulletins for Indian coastal areas covering up to 75 km from the coast line and sea area bulletins for the sea areas beyond 75 km. The special warnings are issued for fishermen four times a day in normal weather and every three hourly in accordance with the four stage warning in case of disturbed weather.

The general public, the coastal residents and fishermen are warned through State Government officials and broadcast of warnings through All India Radio and Doordarshan telecast programmes in national and regional hook-up. A system of warning dissemination for fishermen through World Space Digital Based radio receivers is being planned.

Specific objectives

A revised **stages of cyclone warning** (7 stages instead of the present 4 Stages of Warning) has been suggested by NDMA of Govt. of India headed by top officials of the government. The same is being deliberated further and with some modifications will be implemented from the ensuing cyclone season. It is also proposed to modify the format of Cyclone Warning bulletins to make it more comprehensive for the use of Disaster Managers. The possibility of automation in generating the bulletins through a suitable software whereby several different bulletins which are focused towards the needs of specific groups such as fishermen, shipping, AIR, press, port etc. which could be generated from a single bulletin format is being pursued by Cyclone Warning Division at New Delhi.

5.3.3 Cyclone Warning Dissemination

Cyclone warnings are disseminated through a variety of communication media, such as, radio, television, print media, telephones, fax, telex, telegrams, police, wireless network. A specially designed Cyclone Warning Dissemination System (CWDS) which works via the INSAT Satellite provides area-specific service even when there is a failure of conventional communication channels. A set of 250 analog and 100 digital CWDS receivers have been employed in vulnerable coastal areas in the east and west coast. Orders are being placed shortly for 300 new CWDS (Cyclone Warning Dissemination Systems), which are modern and easy to maintain.

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5.3.4 Disaster Management

National Disaster Management Authority (NDMA)

About 8% of the area in the country is prone to cyclone-related disasters. Recurring cyclones account for large number of deaths, loss of livelihood opportunities, loss of public and private property and severe damage to infrastructure, thus seriously reversing developmental gains at regular intervals.

Broad-scale assessment of the population at risk suggests that an estimated 32 crore people, which accounts for almost a third of the country's total population, are vulnerable to cyclone related hazards. Climate change and its resultant sea-level rise can significantly increase the vulnerability of the coastal population.

. As mandated by Disaster Management Act, 2005, the Government of India (GoI) created a multi-tiered institutional system consisting of the National Disaster Management Authority (NDMA) headed by the Prime Minister, the State Disaster Management Authorities (SDMAs) by the respective Chief Ministers and the District Disaster Management Authorities (DDMAs) by the District Collectors and co-chaired by Chairpersons of the local bodies. These bodies have been set up to facilitate a paradigm shift from the hitherto relief centric approach to a more proactive, holistic and integrated approach of strengthening disaster preparedness, mitigation and emergency response.

Guidelines for the Management of Cyclones

The NDMA has prepared Guidelines for the Management of Cyclones to assist ministries and departments of GoI and state governments to prepare their DM plans. The guidelines are presented in nine chapters as detailed below:

i) Chapter 1 provides an introductory overview that reflects the risk and vulnerability of the country to cyclones, including the dimensions and magnitude of the problem.

ii) Chapter 2 discusses the Early Warning Systems (EWS) for cyclones. In this chapter, the present status of EWSs has been discussed and the gaps have been identified. Requirement to bring them up to international standards and making them state-of-the-art systems has been recommended.

iii) Chapter 3 deals with the present status of Warning Communication and Dissemination, its gaps and future improvements required towards making it fail-proof and modern.

iv) Chapter 4 covers structural measures for preparedness and mitigation, covering cyclone shelters, buildings, road links, culverts and bridges, canals, drains, saline embankments surface water tanks, cattle mounds and communication/power transmission networks.

v) In Chapter 5, important aspects of the management of coastal zones and its relevance to CDM, including some other non-structural mitigation options have been presented. This

chapter discusses issues related to coastal zone management, sustainability of coastal resources, bioshields, coastal flood plain management, coastal erosion, natural resources management, etc.

vi) Chapter 6 deals with various aspects of awareness generation related to CDM as an important preparedness measure.

vii) Chapter 7 covers Disaster Risk Management (DRM) issues, risk assessment and vulnerability analysis, hazard zoning and mapping, data generation, including the use of GIS tools, and capacity development.

viii) Chapter 8 deals with CDM-related response and relief strategies. A detailed account of several issues related to effective response such as response platforms, linking risk knowledge with response planning, evolving disaster response capabilities, etc., is brought out in this chapter.

ix) In Chapter 9, guidelines and implementation strategies have been discussed.

Salient initiatives recommended for implementation as part of the National Guidelines for Management of Cyclones are listed for undertaking action by various relevant Departments. The detail Guideline is hoisted in the NDMA website.

5.4. Training

- From Maldives, two official have are undergoing training in Advance Course in General Meteorology at RMTC, Pune under WMO Fellowship since November2008.
- From Mauritius, one official has undergone training in Advanced Course in General Meteorology at RMTC, Pune under Bilateral Cooperation Sept 2007 to July 2008. One more official is currently undergoing training in Advanced Course in General Meteorology since November 2008 at RMTC, Pune. Another 3 officials have also been accepted for Advanced training in General Meteorology (condense course six months duration) w.e.f. 9 March 2009.
- From Maldives one official has undergone familiarization training on tropical cyclones monitoring at RSMC New Delhi during 09-20 February, 2009.
- From Vanuatu one official has undergone training in Advanced Course in General Meteorological at RMTC, Pune from September 2007 to July, 2008 under WMO Fellowship.

Familiarization training on tropical cyclones monitoring at RSMC New Delhi

- One official each from Sri Lanka and Thailand had received familiarization training on tropical cyclones monitoring at RSMC New Delhi during 14-25 January, 2008.

- One official each from Maldives and Bangladesh has undergone familiarization training on tropical cyclones monitoring at RSMC New Delhi during 09-20 February, 2009.

Future Plan:

1. Attachment of cyclone forecasters training in RSMC, New Delhi has been completed for the year 2009 and same will be conducted in 2010.
2. The seminars/workshops will be conducted for the cyclone forecasters in India during March and September 2009-10 as pre-cyclone exercise.
3. A refreshers course in cyclone monitoring & prediction will be conducted in March 2009.
4. A workshop on FDP- Cyclone (pre-pilot phase) will be conducted in May 2009 and for the pilot phase will be conducted in year 2010.
5. A special training may be provided by RSMC, New Delhi to the forecasters to Myanmar if proposed by WMO.

5.5 Research:

5.5.1. Papers published in Mausam

The research paper(s) published in the journal, **'Mausam'** Vol. 59, during the year 2008 are as follows

Simulation of mesoscale structure of thunderstorm using ARPS Model, Kuldeep Srivastava, S. K. Roy Bhowmik, H. R. Hatwar. Ananda K. Das and Awadhesh Kumar, 1-14

Relation between southern oscillation index and Indian northeast monsoon as revealed in antecedent and concurrent modes, Y. E. A. Raj and B. Geetha, 15-34

Daily summer monsoon rainfall over northeast India due to synoptic scale systems, M. Mohapatra, H. R. Biswas and G. K. Sawaisarje, 35-50

Intensification and movement of cyclonic storm in the Bay of Bengal during post monsoon season, A. Muthuchami and S. Sridharan, 51-68

Diurnal variation of atmospheric stability at Qena (Upper Egypt), M. El- Nouby Adam and Sayed M. El. Shazly, 69-76

Seasonal forecasts of Indian summer monsoon rainfall using local polynomial based non-parametric regression model, Anil Kumar Rohilia, M. Rajeevan and D. S. Pai, 77-86

Evolutions of sea level high and warm pool in the southeastern Arabian Sea and their association with Asian monsoons: study on cause-and-effect relationships, O. P. Singh, 87-94

An indigenous design of Integrated Automated Current Weather Instruments System (IACWIS) for aeronautical meteorological observations, *P.S. Biju, R.R. Mali* and *R.D. Vashistha,* 503

5.5.2 Specific objectives

(i) Forecast Demonstration Project (FDP) on Landfalling Tropical Cyclones over the Bay of Bengal

A Forecast Demonstration Project (FDP) on landfalling tropical cyclones over the Bay of Bengal has been taken up. It will help us in minimizing the error in prediction of tropical cyclone track and intensity forecasts. The programme has been divided into three phases

(i) Pre- pilot phase : Oct-Nov. 2008

(ii) Pilot phase : Oct-Nov. 2009, 2010

(iii) Final phase : Oct-Nov 2011

During pre-pilot phase **(15 Oct-30 Nov 2008),** several national institutions participated for joint observational, communicational & NWP activities.

(ii) Electronic version of IMD's Storm Track Atlas (e-Atlas):

This is a project undertaken at CWRC, RMC Chennai with an objective to bring out an electronic version of IMD's Storm Track Atlas. Development of the software is completed. Digital database of the tracks of cyclones and depressions that formed over Indian seas during the period 1891-2006 has been generated in-house. Tracks of these cyclones and depressions, given various types of inputs such as year, month, intensity, basin of formation and dissipation, coastal crossing etc., can be generated instantaneously by using the software. In addition, several types of tabular outputs and maps depicting spatial variation of features such as formation, dissipation, movement vector, direction of movement, recurvature, coastal crossing can be generatred. The e-Atlas software will be made available to the countries of WMO/ESCAP Panel members on payment of US $100. The e-Atlas should give substantial boost to the cyclone warning capabilities of India as well as other WMO/ ESCAP Panel countries. WMO/ ESCAP Panel in its 33rd session appreciated the efforts made by India to digitize the IMD's storm track atlas. It is also recommended by ACR-2009 to redevelop the Cyclone e-Atlas for web based accessing.

(iii) Meteorological Monograph

The Meteorological Monograph on cyclone **'Ogni'** has been published.

Met Mongraph on Super Cyclonic Storm **Gonu** over the Arabian Sea (1 – 7 June 2007) and Very Severe Cyclonic Strom **Sidr** over the Bay of Bengal (11-16 Nov. 2007) is being brought out by IMD.

(iv) Updated RADAR Manual

Updated RADAR Manual - I will be brought out by mid -2009.

(v) Dvorak's T classification of storms over north Indian Ocean

A report on the inter-comparison of the T- number derived by various agencies using ADT is being prepared for north Indian Ocean.

(vi) Forecasting Manual on "Tropical Cyclones" is under preparation.

Cyclone warning is one of the most important functions of the India Meteorological Department and it was the first service undertaken by the Department as early as in 1865 and thus the service started before the establishment of the department in 1875. The historical development of the cyclone warning system leading to the organization as it is today is well known to you. In view of the developments in observational tools and analysis and prediction techniques, the monitoring and prediction methodology w.r.t cyclones over north Indian Ocean has undergone several changes. All these above facts have been documented as forecasting manual or cyclone manual. These manuals have undergone several changes in the past considering the requirements of forecasters and disaster managers. The last review of the cyclone manual was carried out and published by IMD during 2003.

In the recent years, there have been many developments in observational and prediction aspects including deployment of DWR. automatic weather station (AWS) and meteorological satellites and development of prediction models including QLM, WRF, HWRF models etc. in addition to various synoptic and statistical methods. Hence, the review of the cyclone manual has been taken up with special emphasis on forecasting aspects.

5.5.3. Exchange of research information

(i) RSMC, New Delhi solicit support from other RSMCs and forecast agencies to develop a probabilistic track forecast with specification of probability ellipse.

(ii) RSMC, New Delhi needs to run IIT Delhi storm surge model so that it can provide storm surge guidance to different member countries.

5.6. New joint initiatives

5.6.1. Multi-hazard early warning system and Integrated hazard awareness display (IHAD) system

The information on different hazards are uploaded in IMD's website. It includes information on cyclone, heavy rain, heat wave, cold wave, earthquake, thunder squall etc. However a separate web page integrating all these information will be hoisted in the IMD's website.

5.6.2. Video conferencing and hot line facility

(i) There has been a demand from some of the member countries to make arrangement for video conferencing between RSMC New Delhi and other member countries. WMO may consider support for such an arrangement.

(ii)RSMC New Delhi solicits support from the member countries for its FDP- Cyclone project over the Bay of Bengal during 2009-2011.

5.7. Publication:

Annual Review of Tropical Cyclones

The Annual Review for the year 2007 is in its final stage of completion. The review will be sent to WMO for publication by the end of March 2009. It has been delayed due to delay in reception of final report of PTC-35. Dr. M. Mohapatra will work as national editor and Mr. B.K. Bandyopadhyay will work as chief editor for publication of Annual Review for the year 2008.

6. Review of Tropical Cyclone Operational Plan

(i) Tropical Cyclone Plan for 2008 has been published by WMO. India was rapporteur for this purpose. India would like to continue to act a rapporteur for the year 2009.

(ii) A proposal is submitted herewith for change of format of tropical weather outlook and tropical cyclone advisory issued by RSMC New Delhi. (Appendix –I)

7. Technical Support Unit

No action from RSMC, New Delhi

8. Support for the Panel's Programme

India has paid its annual contribution US $ 2000 to WMO/ESCAP Panel on Tropical Cyclones Fund for the year 2007. Contribution for the year 2008 is likely to be paid by March 2009.

VCP India has been providing training facilities at its RMTC to foreign candidates under various programme including VCP of WMO Fellowship.

Bilateral Assistance INSAT Meteorological Data Dissemination System (MDD) at Male, Maldives is being upgraded by a new digital Meteorological Data Dissemination system on gratis basis by Govt. of India. The new digital MDD system will be installed in Maldives by IMD by end of March 2009. At present Male is receiving INSAT picture through internet till Digital MDD system is installed. .

Govt. of India / IMD is also in the process of installation of Digital MDD system in Sri Lanka in 2009 on priority basis. The supply for Radiosonde equipment was extended to Sri Lanka for period of 3 years from 2006-2009 under bilateral cooperation in Science & Technology.

No activity took place during 2007-2008 under TCDC programme. We could consider the training requirements of the Panel countries. Under this programme, financial support is either provided by WMO or by the country concerned and at our end, we provide the training facilities free of cost.

Maldives' Report for the WMO/ESCAP Panel on Tropical Cyclones

Thirty-Sixth Session

Muscat – Oman, 2 – 6 March 2009

Review of the 2008 Cyclone Season – Maldives

January

Trough of low pressure prevailed over the Maldives from 7th till 28th January. It became active and was well marked from 22ndJanuary. This system caused flooding over southern atolls affecting many people living in the area. Heaviest rainfall recorded with in 24 hours was 92 millimeters in Kaadedhdhoo of south Huvadhu atoll on 23rd followed by 77 millimeters in Gan of Southern-most atoll on 26th and 60 millimeters in Fuvahmulaku on 28th. Apart from heavy rain, gust winds were also reported from the area with maximum speed of 44 miles per hour in Gan on 28th of January.

March

Under the influence of Low pressure system formed over the Maldives on 9th March, heavy showers occurred with 47 millimeters recorded in 45 minutes in Male' and a total of 91 millimeters causing floods. Schools in the Capital, Male' had to be closed due to heavy rain. This system still remained active over the country and strengthened further on 14th March. Heavy rain recorded in Kela of Northern-most atoll which caused flooding and more than 20 residential houses been affected.

May

Monsoon activities started over southern Maldives on 7th May. It was stronger over southern atolls and moderate over the rest. As a result, widespread rain, occasional heavy with isolated thunderstorms were experienced in southern atolls. Rainfall of 74 millimeters recorded in Kaadedhdhoo and average strong winds of 22 – 31 miles per hour sustained in southern-most atolls with maximum gust wind speed of 43 miles per hour in Seenu Gan.

The combine effect of the active monsoon and the trough in the Arabian Sea, violent showers were reported in Hanimaadhoo measuring 63 millimeters within 3 hours. Total rainfall of 147 millimeters registered at that station on 30th May.

July

A man killed and two other fishermen were struck by lightning due to a very severe thunderstorm that occurred in Hadhdhunmathi on 7th July. Another incident of severe thunder and lightning reported in South Huvadhu atoll Fiyori, on the next morning. Residential house and a coconut palm tree had been damage by this thunderstorm.

A Fresh low pressure area formed over the Maldives on 12th July. Under the influence this system, gust winds of 45 and 43 miles per hour were recorded in Kaadehdhoo and Kadhdhoo respectively. The low pressure area became stronger on 14th July and this system brought thunderstorms and violent showers measuring 40 millimeters in 3 hours. Total rainfall of 136 millimeters registered in Hanimadhoo and average strong wind speed of 15 – 25 miles per hour sustained in central and northern atolls.

Heavy showers were continued over the country with a rainfall of 100 millimeters in Hanimaadhoo. Average strong winds of 15 – 25 miles per hour recorded in central and northern atolls. Continuous rain in northern atolls caused severe flooding in some islands. Kulhduffushi reported 25 houses being flooded. The active low pressure became stronger on 20th July and brought occasional heavy showers and thunderstorms in southern atolls with strong wind speed of 20 -30 miles per hour sustained in central atolls for nearly 12 hours. Gust wind speed of 55 miles per hour recorded in Male'. Gusts of 44 - 47 miles per hour were recorded elsewhere in the country. Further strengthening of the active low-pressure trough over the Maldives, gale force winds of 30 – 39 miles per hour sustained over Male' area for about 5 hours on 22 July. Maximum gust wind speed of 62 miles per hour was registered in Male'. Other than this, 56, 51 and 45 miles per hour were also recorded in Hanimaadhoo, Kadhdhoo and Kaadedhdhoo respectively. This stormy winds and rough seas gave rise to several maritime incidents throughout the country. Three fishing vessels crashed into Hulhule' breakwater and another cargo ship carrying 15 crews and loads of cargo had also crashed.

The bad weather and unusually strong winds being experienced across the country has left awake of destruction in several islands of the Maldives. Strong wind caused serious damages like blown off roofs, damaging many homes, fallen and uprooted trees and many public properties had been left destroyed. In Kulhdhufushi alone, huge breadfruit tree was uprooted and fell on top of the Cable TV service antenna disconnecting the service. Apart from this, high swell waves smashed in these low lying islands. Several farms in southern atolls had either being damaged or completely destroyed.

October

The upper level cyclonic circulation persisted over the southwest Bay of Bengal and caused strengthened winds mostly over the southern Maldives with an average speed of 20 - 26 miles per hour sustaining over Hadhunmathi for about 10 hours on the night of October 12th. Gusty winds ranging from 45 – 51 miles per hour was recorded across the country for next two days.

November

A trough of low pressure over the Maldives brought strong winds again in November. Heavy rain associated with strong winds of 20 – 25 miles per hour maintained for more than 12 hours on the 26th. On the same day, Tropical Cyclone "NISHA" which was originated few days ago in the Bay of Bengal has made landfall through Tamil Nadu coast.

December

As usual, December happened to be very wet; the highest annual rainfall was recorded in Gdh. Kaadedhdhoo totaling 2151 millimeters.

5. 1 Meteorological Component

Upper air Observation

Making of Radio-sonde observation were continued at the Meteorological Office, Gan (WMO # 43599) in 2008 under the Global Upper-Air Network (GUAN). TEMP message (at 12UTC) is transmitted daily through GTS from this station.

Like last several years, no upper-air observations were made at Male' (WMO # 43555) in 2008. The WF100 wind finding radar with the hydrogen generator remained unserviceable for many years.

The location of Maldives in the Indian Ocean happens to be a data sparse area, upper air observations from the south and central Maldives are very important to us as well as the entire meteorological community in the region. Hence, Maldives urge assistance from WMO/ ESCAP and Panel members to consider rebuilding of our upper air network.

Surface Observations

Maldives has 5 meteorological stations all are manned 24 hours, both synoptic and aviation reports are made on all five stations. Only one of them is categorized additionally as upper-air station.

- Hanimaadhoo (43533) surface
- Male' (43555) surface
- Kadhdhoo (43577) surface
- Kaadehdhoo (43588) surface
- Gan (43599) surface + radiosonde

Ten Automatic Weather Stations (AWS) were installed in mid/ late 2008. Ten additional AWS stations are planned for 2009.

- Uligam
- Makunudhoo
- Feevak
- Dharavandhoo
- Male'
- Fulidhoo
- Nilandhoo
- HulhUdheli
- Hirilandhoo
- Gan

Rainfall Stations

Across the country, Maldives has 7 rainfall stations which measure only accumulated rainfall for 24 hours and reading are collected at 0300UTC for national use.

- HA. Kela
- Sh. Funadhoo
- B. Dharavandhoo
- M. Muli
- Dh. Kudahuvadhoo
- Th. Veymandoo
- Gn. Fuvanmulah

Meteorological Satellites and Doppler Weather Radar

The INSAT receiving system remains unserviceable since 2003. When efforts had been made to repair the system eventually failed, the India Meteorological Department has agreed upon replacing the old analogue MDD system with a new digital system. Hence, we urge India to accomplish this task in 2009.

As a part of Multi-hazard Early Warning System, Department of Meteorology (now Maldives Meteorological Service) received a High Resolution Satellite Image Receiving System and a Doppler Weather Radar. They are in operation now.

Numerical Weather Prediction

Maldives Meteorological Services also runs WRF model as a trial basis and plan to expand this service in 2009.

Telecommunications

The computer based telecommunication system between the local Meteorological Offices and the National Meteorological Centre (NMC), functioned very well during 2008. Maldives Meteorological Service upgraded its internet service from 5mbps to 10mbps and a redundant VSAT internet service is also in place to collect firsthand information from various international organizations easily in time.

NMC's Global Telecommunications System and Message Switching System

The National Meteorological Centre's GTS has been upgraded using COROBOR's MESSIR-COMM message switching systems during 2007. The National Weather Service (NWS) of the United States in collaboration with the WMO generously aided Maldives for this program. This link is a TCP/IP based multi-channel communication link that is capable of handling vast amount of data. In addition to RTH New Delhi, Male' is also connected to Colombo and Melbourne through this link. In the year 2008, GTS was working smoothly.

Forecasters' Workstation

After a long time, the **A**nalyzing, **F**orecasting, **D**ata-processing and **O**perating **S**ystem (AFDOS) of became operational in late 2008. The new system called **M**eteorological **I**nformation **C**omprehensive **A**nalysis and **P**rocess **S**ystem (MICAPS) also donated by China Meteorological Administration (CMA). Expert team from CMA conducted a training program for forecasters at NMC just after the installation.

Meteorological information through internet

The official website of the Maldives Meteorological Service www.meteorology.gov.mv and http://www.met.gov.mv have served its users very well. Users can have easy access to weather forecasts, warnings, meteorological reports and aviation weather charts. This website has been upgraded during 2008.

5. 2 Hydrological Component

There are no much hydrological issues in the Maldives; only a few lakes or swamps exist here.

5. 3 Disaster Prevention and Preparedness Component

To establish multi-hazard early warning system in the country, the Department of Meteorology (now MMS) in collaboration with UNDP had started in 2005, a nation-wide project categorized to 3 Phases. At the end of 2007, Phase-I was completed; upgrading of communication system (GTS), installation of Doppler Weather Radar and Satellite Receiving System at the National Meteorological Centre. Two Automatic Weather Stations were installed at Daravandoo of Baa Atoll and Nilandoo of Faafu Atoll. One short-period seismometer was installed in Gan Island - Addu Atoll. The main activities of Phase II were completed in 2008 by installing 2 Broadband Seismometers in North and South of the country.

Warnings and advisories

The Maldives Meteorological Service issued timely and accurate severe weather warnings and disseminated them to the public through mass media and through its website.
Apart from severe weather or tropical cyclone warnings, tsunami warning reports received from PTWC, JMA through GTS and internet were also disseminated to public satisfactorily in time.

Under the Standard Operating Procedures (SOP) of the Department, the warnings were additionally dispatched through cooperate SMS and Hotlines to designated authorities.

5. 4 Training

In the year 2008, the department has given training in various sectors. Following are the details of the short term training given.

	Name of the Training Program	Country	Duration	Participants
1	Preliminary Meteorology Course	Pakistan	Feb 22 – Jun 28	2
2	Certification Program in Tsunami Science & Preparedness	Thailand	10 – 26 March	2
3	GIS and inundation Mapping Training Course	Germany	April 22 – May 6	1
4	UNESCO-IOC Modeling and Remote Sensing Training Course	India	Oct 27 – Nov 27	1
5	Advanced Training Course in General Meteorology	India	Nov 10 – 4 Sep '09	2
6	MESSIR- COMM Training	France	Nov 9 – 16	4
7	WMO GURME Training Course on Air Quality Forecasting for India and South Asia	India	Dec 8 – 12	1
8	Doppler Weather Radar Training	USA	Dec 1 – 23	2

These trainings were funded by the WMO, IOC, UNDP (Maldives) and the Maldives government.

In addition to these, the department participated in workshops and seminars held at national and international levels.
Ongoing Graduate level and Post-Graduate level programs funded by the department's regular budget.

	Name of Training Program	Country	Duration	Participants
1	Master of Science in Communication Engineering	Malaysia	2007-2009	1
2	Bachelor of Science in Physics	India	2006-09/10	2
3	Bachelor of Science in Geological Sciences	India	2006-09/10	2
4	Bachelor of Science in Chemistry	India	2007-2010	1

With the recent introduction of 2 other disciplines; Oceanography and Seismology, the department is expanding its network by introducing various equipments in these fields and as well as Meteorology. To fully utilize these equipments we urgently need to train staffs in these areas.

Qty	Name of Training Programmes	Country	Duration
2	Bachelor of Science in Meteorology	Any	3 Years
2	Advance Training course in General Meteorology	India	10 months
1	Bachelor of Geological Sciences	India	3 Years
1	Training Course on Meteorological Instrumentation	India	10 months
	Bachelor of Climatology	Any	3 Years
3	Training Course on Radar Meteorology	Any	1-2 months
2	Training course on Data Processing and Analysis	Any	Any

Assistance is required in the following areas:

NWP
- WRF / WAM
- Storm Surge Modeling
- Tsunami Propagation Modeling
- Climate Modeling

5. 5 Research

Research projects on air-pollution were carried-out in the Climate Observatory of Hanimaadhoo.

Maldives Climate Observatory

Location in an Island called Hanimaadhoo (≈ 6N, ≈ 73 E)

Major purpose Monitoring Transboundary Air pollution

Measurement Techniques Remote sensing mainly Passive, In situ Technique Passive

Equipments Microtops and Cimel Sun photometer for Aerosol optical depth and for Ozone, Condensation Particle Counter (CPC) to measure number of particles, Sample mobility Particle Seizer (SMPS) to measure particle size, Aethelometer for Black carbon, Nephelometer for Scattering and pyranometers with sun tracer, for direct , diffusive radiation, Wet only collectors for collecting rain water for pH , EC, and ion analysis.

DATA shows the country experience high concentration of Aerosols in North east Monsoon compare to South West Monsoon and also rain analysis DATA shows increased acidity (pH<5) in rain water in some months in the north east monsoon.

5. 6 New Joint Initiatives

In the wake of Indian Tsunami Early Warning Centre (ITEWC) coming to existence in late 2007, DoM started negotiations with that centre in early 2008 for possible exchange of data between the two organizations in regular and timely basis. We now receive tsunami/ earthquake information from ITEWC/ INCOIS.

5. 7 Publications

(A) Maldives contributed information on significant weather events and developments in the meteorological service to Panel News Letter.

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Country Report of Myanmar

METEOROLOGICAL COMPONENTS

Some improvement in Instrumentation and Communication Systems

The main improvement in Communication Network In DMH for the last three years are (1) installation of PCVSAT in 2005 (WMO/VCP from China), (2) Fengyuncast Satellite Receiver in 2008 at Nay Pyi Taw (WMO/VCP from China), (3) Upgrading of GTS system in 2008 at Yangon (WMO/VCP), (4) UHF Radio Communication (Yangon), (5) AWOS (Yangon, Sittwe, Dawei), (6) GPS (Yangon, Sittwe, Dawei), (7) Automatic Raingauge (6 stations), (8) 40 sets of HF Transceivers in 2009 (Mitsubishi Co., Yangon), (9) Internet Facilities in 2008-2009 (National Resources).

GTS circuits

Data from RTHs of New Delhi, Bangkok and 27 WWW stations of DMH are exchanged on routine basis through WMO's GTS. Initially, National Meteorological Center (NMC) of Myanmar (Yangon) is linked with RTHs of New Delhi and Bangkok through a circuit of speed of 50bps. The circuit is now upgraded up to128kbs funding by WMO/UNISDR on year 2006 with assist of Netsys International Company, Southern Africa.

- Another area of upgrading the monitoring service on meteorological and hydrological, geological related disasters are the new establishment of more 24x7 centres. During Nargis(May,2008), the DMH has five 24x7 centres as (1) National Multi-hazard Early Warning Centre in Yangon, (2) The National Meteorological Centre, (3) The National Aviation Meteorological Forecasting Centre, (4) National Meteorological Centre at New Capital Naypyitaw, and (5) the observation stations at along the coast.

Chinese Feng Yun-series of geostationary satellite over about 110˚E longitude is covered the Bay of Bengal and Myanmar area and so its imageries are obviously of better use for DMH. This FY satellite receiving system was installed at DMH from China under VCP Program on 2001.DMH has also received PCVSAT system from China under VCP Program on 2005.

Projects to be accomplished: Followings are projects to be accomplished.

No	Description	Remarks
1.	**Kyaukphyu Radar Project**	**JICA/MISUBISHI**
2.	**Sea Level Gauge**	**UNESCO/ IOC**
3.	**Installation of Broadband Digital Seismograph with VSAT**	**National Budget**
4.	**Installation of Broadband Digital Seismograph with VSAT**	**ADPC**
5.	**Installation of Broadband Digital Seismograph with VSAT**	**CEA**
6.	**Data Center**	**CEA**

Future Plans of DMH

Mostly conventional instruments are still used and all the analysis done by by manually. DMH needs to equip with the latest technicalities and achieve advancement in forecasting as well as other relevant fields of Meteorology. Therefore, a number of future plans need to consider.

* To establish of Numerical weather Prediction System.
*To Substitute conventional instruments to advanced instruments.
*To install modernize weather radars to cover the coastal regions.
*To upgrade DMH's Data collection and processing system with automation.
*To built up Human Capacity with higher training/degree in Meteorology on operational weather analysis, forecasting and other relevant meteorological field.

HYDROLOGICAL COMPONENT

Floods in 2008

During 2008, no flood occurred along Ayeyarwady except just exceeding danger level in one middle and one lowermost station due to flood of Chinwin, which is the major tributary to Ayeyarwady confluent at its middle part. Due to 27 inches of accumulated rainfall during the first week of July in Hkamti, the upstream station of Chindwin, flood occurred along the river with exceeding about 3m above danger level in middle and lower potion of the river. Flood affected 772 household and cause 3000 acres paddy field inundation at Kalewa, downstream of Chindwin. Though the second highest ever recorded flood was experienced in lowermost station in downstream of Chindwin, Monywa, commercial city with dense population, there was no remarkable destruction due to flood since the existing embankment can hold 1165 cm level of the river, while flood peak was 1094 cm in Monywa. Flood peak in Bago was also noted as second highest ever recorded and evacuation was taken placed in 9 wards of the town. On the other hand, Thanlwin river flood in 2008 was remarkable for lasting 46 days above danger level in Hpa-an. DMH has issued (28) flood warnings and (80) flood bulletins during 2008 flood season. Compared to previous severe floods, 2008 floods can be categorized as normal flood.

During 2008, discharge measurements were accomplished at Maubin (Toe river), Yeni (Sittaung river) and Sagiang (Ayeyarwady river). Hydrological data of full-time stations are checked, processed and published annually as Hydrologic Annual Volume I and II by Hydrological Division. Volume I comprise of river stage data from 67 stations, discharge data from 37 stations and sediment discharge data from 21 stations. In Volume II, rainfall data from 111 stations, water temperature data from 39 stations and evaporation data from 41 stations are composed.

Acid Deposition Monitoring

Laboratory under Hydrological Division has started river water quality monitoring since 1999 by the use of portable photometer at some chosen site. Regarding acid deposition monitoring, DMH has initiated rain water collection and measuring its pH and EC since the year 2003. It can be generally concluded that acid deposition is still less in Yangon area. Japan government will provide Ion-chromatograph, the instrument for ion analysis in 2009 through JICA.

Regarding Public Awareness on acid deposition, DMH has had an opportunity to compile the Myanmar brochure on acid deposition problem with financial support from Japan Fund for Global Environment in 2006-2007. Moreover, under the public education programme of Myanmar television, a

Talk on the cause and impact of acid deposition is disseminated frequently through MRTV 4 channel. So, this message is penetrated to the audiences from authorities to grass root level.

GIS application in Hydrology

GIS application in meteorology and hydrology is initial stage at the present. The government has invested about 100 million Kyats for establishment of GIS application in DMH. During February 2008, DMH has had an opportunity to implement joint mini-project on production of flood map in Deltaic area with AIT (Asian Institute of Technology) by the support of JAXA. Development of inundation maps during the landfall of cyclone Nargis in the affected areas are now in processing. Moreover, DMH is also involve in implementation of the Demonstration Project on Shwegyin Basin aiming to support in flood forecasting, organized by AWCI (Asia Water Cycle Initiative) under Japan based GEOSS (Global Earth Observation System of System).

Myanmar National Committee for International Hydrological Programme

By the organization of DMH, Myanmar National Committee for International Hydrological Programme has formed in 2003 and the government assigned the Minister for Transport as Chairman, Deputy Minister for Transport as Vice Chairman and Director General of DMH as the Secretary of the National Committee. Chairmen of Yangon and Mandalay City Development Committees and Heads of Departments related to hydrology are members of the committee. Under the National Committee, five Working Groups are formed to implement research and task according to the guideline of International Hydrological Programme and also to participate and contribute in the meeting conducted by National Committee. Up to 2008, Myanmar National Committee for International Hydrological Programme had conducted four meetings, including paper reading session.

DPP COMPONENT

The main DPP measures of DMH are on two main components (1) Early Warning System, and (2) Public Education and Awareness Program. Since Myanmar experienced from the impact of Tsunami in December 2004, DMH had laid out plans and actions for the upgrading of Early Warning System since DMH is the only government agency responsible for the monitoring and issuing of warnings to public relating to meteorological, hydrological and geological hazards except for the urban fire.
In upgrading the early warning system, the following actions has been taken:

(1) A new Multi-hazard Early Warning Centre was established in 2006.
(2) Many efforts has been already made through international cooperation with agencies like TICA, JICA, WMO, UNESCAP, UNDP, ADPC in upgrading the early warning system to end-to-end early warning system.
(3) 40 sets of HF Transceivers are now donated to DMH by Mitsubishi Co. in Yangon for the better service of data exchange between NMC and remote stations.
(4) With the assistance from IIT and TMD, storm surge numerical models were installed and staffs of DMH were trained under fact finding programme headed by WMO
(5) Two officials are undertaking a secondment training in Regional Centre of RIMES, which is scheduled to continue beyond 2010 after the current funding from UNESCAP is terminated.
(6) For the preparation of better monitoring service on natural disasters, five 24x7 monitoring and forecasting centres are established and upgraded in DMH.
(7) DG of DMH is working as a committee member in the National News Committee on Natural Disasters.

(8) DG of DMH is now serving as a member in the Construction Committee on Shelters in the Ayeyarwady Division.

As for the Public Education and Awareness Program, the Director-General of DMH is a national WMO Focal Point for Public Information. The DG has been undertaking educational works such as interviewing the various journals, writing articles in national newspapaers, periodical journal. The DG has published a book entitled " A Girl Named La Nina" by the Association of Writers and Literature. It is recollection of all of his articles which the has been written during the last 35 years. The book was awarded first prize for category of "Knowledgeable Science".

Moreover, DMH in collaboration with ADPC has published a in depth report on Rapid Response System to Nargis. This report is the first of its kind and has explained explicitly the state of the art of the main eight components of Disaster Management works in Myanmar.

Another major area that DMH is working hard is the field of earthquake and tsunami. Myanmar is currently living under the threat of the possibility of large earthquake along the Rakhine (the western) coast of Myanmar. DMH is currently implementing in the installation of new real-time seismometers, GLOSS tide gauges, the GPS Network for monitoring on earthquakes, the system for issuance of early warnings.

DMH has initiated collaborative works IOC/UNESCO, INCOIS(India), PTWC, JMA, TMD, etc.

TRAINING COMPONENT

Training programs were undertaken on Storm Surge Modeling, Tsunami Modeling, Acid Deposition, Earthquake Engineering, etc. DMH has sent approximately 17 officials for foreign training, and around 90 officials for workshops and meetings during the fiscal year of 2008-2009.

At present, one staff is currently working for his Ph.D. degree in Yunan, China in the field of seismology. Another staff is also undertaking a long-term training on earthquake in Japan. Two candidates are now undertaking a post-graduate training courses in University of Philippines under the WMO/VCP Programmes. Two of DMH Staffs are now undertaking post graduate study on Hydrology at the Roorkee University in India under the WMO/VCP.

A degree offering program has been carried out in DMH since 1997 with the collaboration of the Yangon and Dagon Universities. For the fiscal year of 2008-2009, eight students are attending for the final year for achieving the degree of B.Sc.(Honors) majoring in Meteorology. For the fiscal year of 2009-2010, DMH has received 14 new first year students.

Instructors from DMH has been conducting six training courses in collaboration with the Social, Relief and Resettlement Department on Disaster Management Courses for Disaster Managers.

RESEARCH COMPONENT

DMH has laid out several programmes on research and development. DMH has run the IPCC Models on climate scenarios for Myanmar for the year 2020 and 2050. DMH was able to send two officials to Regional Centre affiliated by ADPC. Research works on climate change and Earthquake Potentials were carried out recently by these two officials at the regional centre. Some research work on climate change has carried by the DG and his team. The research work reveals that the climatology relating to storm formation and movement has changed dramatically near the sea waters of Myanmar after 1978.

By using a 50 years record of climate data, DMH has carried out the study on the changes in Monsoon Climatology of Myanmar. The findings are observed as quite relevant to the current situation experiencing in the monsoon climatology of Myanmar.

Other works such as Study on the tectonic movement around Myanmar and the Flood Risk Mapping by using the GIS Technology, etc. are also done. The most striking study was the study on the Palaeosesmicity of Myanmar. This work was carried out in collaboration with the JGS(Japan Geological Survey), MES(Myanmar Engineering Society), MEC(Myanmar Earthquake Committee) and the DMH(Department of Meteorology and Hydrology).The results revealed that there had been three incidences of flooding happened along the Rakine Coast during the last 3000 years, with a periodicity of about 1000-1200 years. Since the last flooding was occurred in some 250 years ago (in 1762), it could be considered that the potential of next tsunami event along Myanmar and Bangladesh coasts are not likely in near future. However, based on other leading seismologists, the threat of next big earthquake in Myanmar is still going high.

Government of Sultanate of Oman
Ministry of Transport and Communication
Directorate General of Meteorology and Air Navigation
Muscat

National Report
To

Panel on Tropical Cyclones in the Bay of Bengal
And
Arabian Sea

36th Session, Muscat, Sultanate of Oman
2nd March to 6th March, 2009

Directorate General of Meteorology and Air Navigation
Muscat, Sultanate of Oman

Annual Report on Activities in Meteorology In the Sultanate of Oman During the year 2008

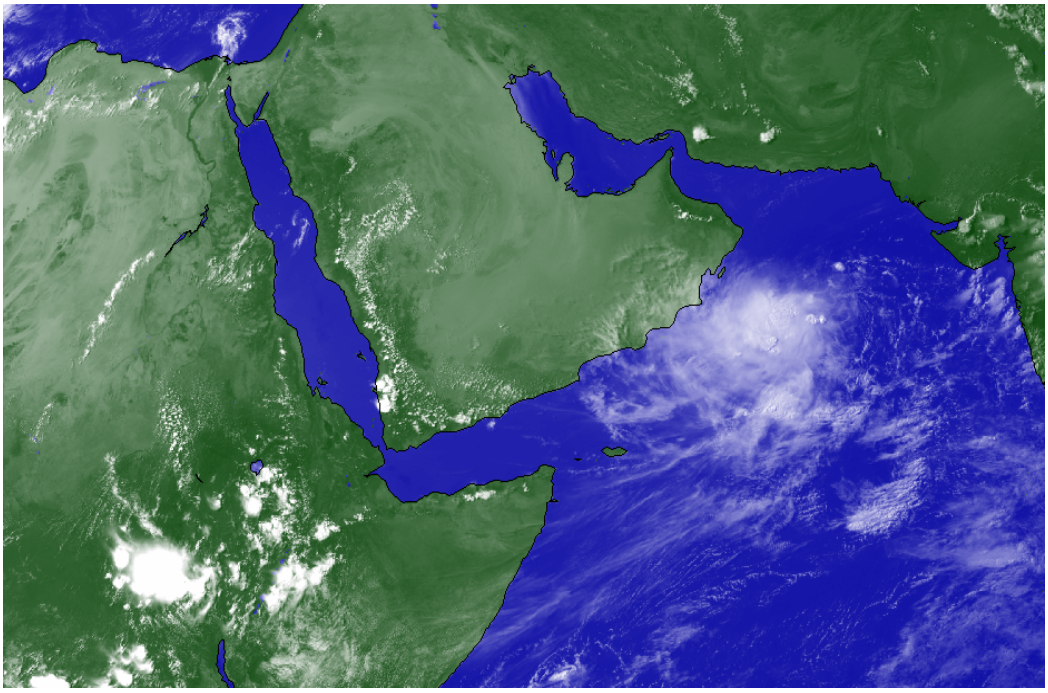
Review of the 2008 Cyclone Season

1. Meteorological Events

1.1. Cyclones

The most notable storm of the 2008 cyclone season was Cyclone Nargis that caused a majority of the damages and deaths which can be the worst natural disaster in Myanmar's history.

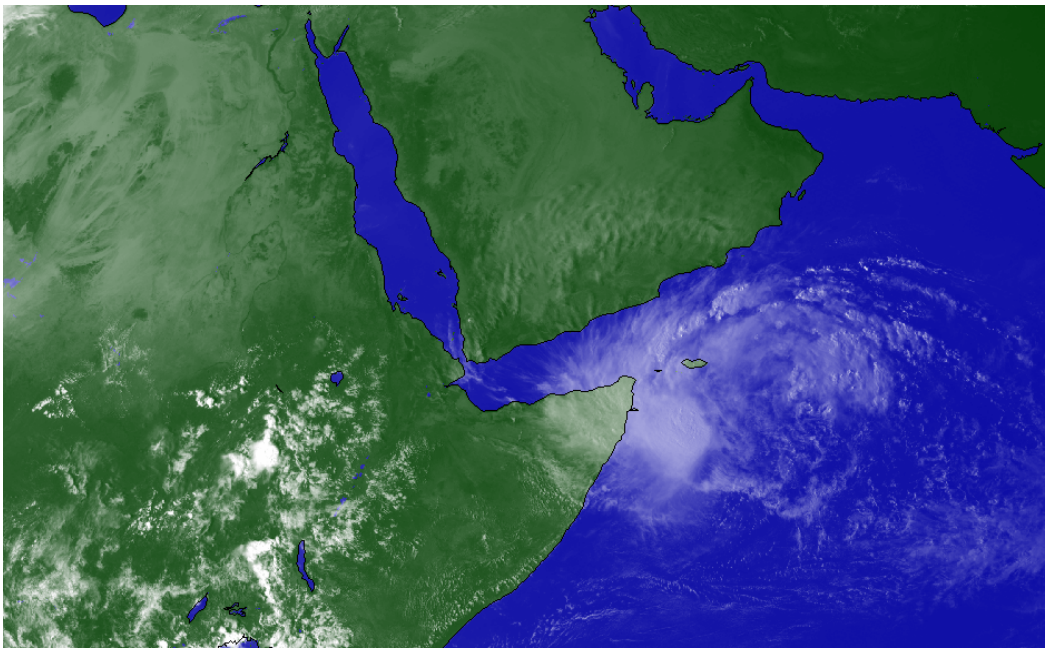
A mass of convective clouds observed over North West of India on 4th of June associated with low pressure area. Regional Specialized Meteorological Centre RSMC New Delhi designated it as Depression ARB 01 on the 5th June. Although it was forecast to intensify further, it did not develop as it turned away from the coast. The RSMC downgraded it to an active area of low pressure on 7th of June as it weakened and dissipating over the Arabian Sea.



Meteosat image 05 June 2008 at 1200

On 19th October a mass of convective clouds observed over central Arabian Sea associated with an area of low pressure. On the 20th the low pressure area had intensified in to a tropical depression. On October 21st Regional Specialized Meteorological Centre RSMC New Delhi updated the system to a Deep Depression (25-30 kt) while it was near the east coast of Somalia and around 600 km a way from the southern coast of Oman. The D. Depression tracked west wards to the northwestern quadrant of Arabian Sea near Somalia coast. As the D. Depression continued to move slowly in westerly direction moderate to heavy rain was reported along the southeastern coast of Oman for almost 4 continues days starting from 20th Oct.

It lost its strength while crossing the Gulf of Aden due to entry of dry northeasterly winds and land interaction. RSMC New Delhi downgraded it to a Depression. It made landfall on 24th October on the south-eastern coast of Yemen, produced heavy rainfall which prompted floods.



Meteosat image: 20 Oct 2008 at 1200

1.2. Flash flood:

Several flash flood cases were reported over the country during 2008 winter season due to heavy rainfall. However there were no economical or social damages reported. The worse case was during the period from 15 to 23 January when Kasab station reported 37.6mm on the 15th and Mina Sultan Qaboos station reported 45.4mm on the 23rd. Due to wide broad trough at mid-troposphere associated with good moisture at low levels brought thick clouds and heavy thundershowers with fresh gusty winds.

Review of the Coordinated Technical Plan

2 Meteorological Facilities

2.1 Upper Air Observation

The Sultanate of Oman operates two upper air-observing stations, viz. Muscat (41256) and Salalah (41316). Both these are equipped with Vaisala's Digicora GPS wind finding system. The radiosonde was up graded to Visalla RS92 equipment. One flight is launched from each of these stations in a day.

2.2 Ship Weather Reports

Weather Reports from Ships are received through GTS as well as from Muscat Coastal Radio Station. In addition Ship reports are also received from the Royal Oman Navy.

2.3 Wave Measurements

One wave radar measurement station was installed offshore of Qalhat (Sur)- Oman liquid Gas Company- an other wave measurement station located offshore of Sohar Station and the

collected data is inserted on the GTS every three hours. Two more stations will be repaired and or replaced at Muscat and Salalah.

2.4 Synoptic Land Stations

The number of Synoptic Land Stations being inserted into the GTS still remained at 32 stations. Additional station will soon be included in the RBSN also.

2.5 Telecommunication

All the meteorological stations operated by the Meteorological Department are connected to the MSS computer located at the Central Forecasting Office at Muscat International Airport by a reliable dial-up telephone link (Telephone lines and GSM Network).

The MSS is connected to the RTH Jeddah by a dedicated link at 64 kbps based on TCP/IP protocol.

In addition a 512 kbs Internet leased line has been established as well as for transmitting and receiving meteorological data with different meteorological centers as New Delhi and Abu Dhabi.

A bilateral Internet Circuit, which was established between New these centers and Muscat for the exchange of meteorological data, has proved to be very effective, useful and most stable.

Beside that this connection is used to receive the boundary data initiated from the German weather service to be used for the Omani model. This connection have in it's structure different servers as ftp server which is used for serving different users with special meteorological data. All these servers are protected by a firewall.

2.6 Satellite reception

2.6.1 The Department installed Second Generation Satellite ground receiving station and the ground-receiving stations for intercepting High Resolution images from Polar Orbiting satellites operated by NOAA as well as from geostationary satellites operated by EUMETSAT. Also meteorological data are being received through Satellite distribution (SADIS) receiver.

2.6.2 After the forth EUMETSAT Satellite Application course Feb 2008 and the opening Ceremony of the Centre of Excellence for training satellite meteorology in Muscat Oman during February 2006. The Panel Members are invited to attained the fifth EUMETSAT Satellite Application course which is planned to during March 2009.

2.7 Data Visualization

2.7.1 The department is using a visual weather application for visualizing the meteorological data and GRIB format coded data. It is proved to be a useful tool for visualization, analyzing and forecasting the weather.

2.8 Computer Workstations:

2.8.1 Data Processing System

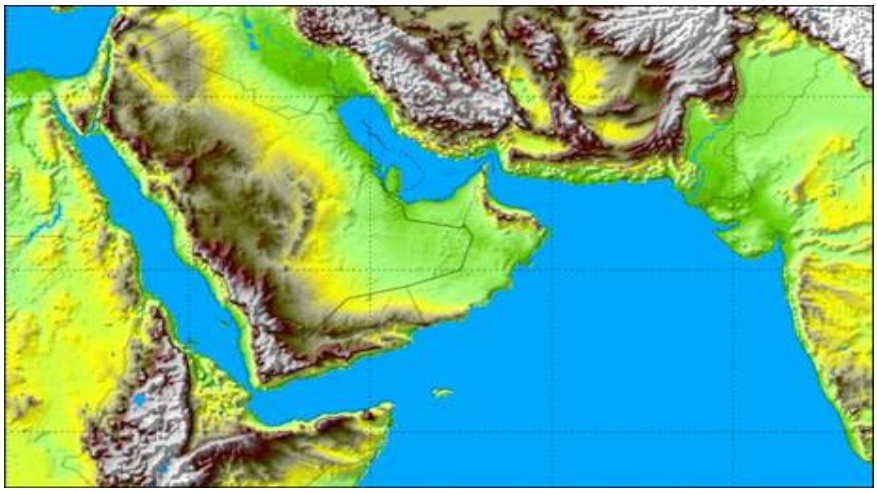
Global Numerical Weather Prediction NWP products are received via Internet, GTS, DWD Sat. We receive products from MDD, ECMWF, UK met office and German Weather Service DWD.

Current processing capabilities consist of a PC Cluster of 20 nodes with total of 40 processors. Dual AMD Opteron 3.0 is used for each node. All nodes are connected via very fast Interconnection network using 24 Infiniband switch with guarantees 3Gbps full duplex.

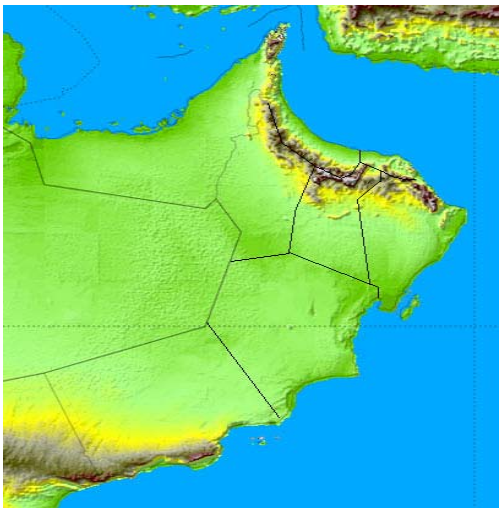
Local Oman Regional Model ORM was established with the kind cooperation of National Weather Service of Germany DWD. The details of the model versions as follow:

A] High Resolution Model HRM is Hydrostatic limited-area numerical weather prediction model for meso-α and meso-β. Main prognostic variables are: Surface pressure (ps), Temperature (T), Water vapour (qv) Cloud water (qc), Cloud ice (qi), Ozone (optional), Horizontal wind (u,

v) and Several surface/soil parameters. More details are available on the model website (http://www.met.gov.om/hrm/index.php).
DGMAN runs HRM with two model resolutions:
ORM_28: 28x28 km resolution. It covers the area between 30.0 E, 7.0 N (lower left corner) to 78.0E, 35.25 N (Upper right corner) with mesh size of 0.25 degree. There are 193x114 grid points and 40 vertical layers. The model is running on 20 nodes from the PC Cluster. It produces up to 78-h forecast at 00 and 12 UTC. The following figure shows the domain area.



ORM_07: 7x7 km resolution. It covers the area between 48.5.0 E, 14.0 N (lower left corner) to 63.5E, 29.0 N (Upper right corner) with mesh size of 0.0625 degree. There are 241x241 grid points and 40 vertical layers. The model is running on 20 nodes from the PC Cluster. It produces up to 78-h forecast at 00 and 12 UTC. The following figure shows the domain area.



- B] Consortium for Small-scale Modeling COSMO is a non-Hydrostatic limited-area numerical weather prediction model for meso-α and meso-β. Main prognostic variables are: pressure perturbation (p`), Temperature (T), specific humidity (qv) Cloud water (qc), Cloud ice (qi), Horizontal/virtical wind (u, v) and Several surface/soil parameters. More details are available on the model website (http://cosmo-model.cscs.ch)

  DGMAN run a research evaluation version of COSMO model with kind cooperation with DWD. It runs on 7x7 km covers the same domain of ORM_07. COSMO was **introduced to** enhance

the accuracy of predicting local rainfall over Hajar Mountains and adjoining area during summer and to compare the forecast with the forecast of ORM_07.

- C] A WAM based wave model was established with the kind cooperation of GKSS of Germany, which covers the Arabian Sea, gulf of Oman and Arabian gulf. WAM model run of 28km resolution and it runs on a single processor on the PC cluster.
- D] A Swan Wave model for sallow water and at higher resolution.
- E] Tsunami Model for the Gulf of Oman and India Ocean: Comit Model from IOC is used to develop some hypothetical experiments to simulate tsunami waves propagation and indentation.

2.8.2 Module Output Statistics (MOS)

The Department successfully established a MOS based on ORM_28. MOS output is generated with each Model run. MOS is an approach to incorporate NWP forecasts information into statistical weather forecast. After installing MOS we noted improvement in Temperature and wind forecast. In addition we were able to get a probability forecast for thunderstorms and fog.

2.8.3 Verification Package

The Department managed successfully to develop its own verification package which was led by Sultan Al Yahyai (Chief of NWP Section). The developed system verifies the continuous weather parameters such as T_2m, TD_2m and for the categorical weather parameters such as Total precipitation. The system generates different statistical scores such as Hit rate with a margin of error, Bias, Root Mean Squared Error (RMSE). The package provides a friendly UGI to allow the user to select different choices (Model type, stations list, observation time, weather element and statistical score) to be verified. This system will help find the systematic errors in the Model output, which can be tuned.

The package is being in several countries such as UAE, Brazil, Jordan, Malaysia, Hungary, Vietnam, Iran, University of Berlin, Kenya and Madagascar. Panel Members may get a copy also if they request Oman's P.R.

2 Aeronautical Services

In order to meet ICAO recommended practices and to fulfill the requirements for Aviation the Department installed a SADIS workstation as early as 1996. Effective Last year the Department started to pay to the UK Met Office the annual contributions for obtaining SADIS data and Products. In addition all the SADIS data and products are also received thru an FTP Server from UK as a back up.

A new service was also established for the provision of en-route flight folders for all Airlines operating in the Sultanate to be accessed on our web site.

Training

3 Training

Workshops, Seminars and Training Courses attended by the Met personnel during the year 2008 were as follows:-

Workshop/Seminar/Training Course	Country	No. of Persons
Master in NWP	UK	1
Master in wave Modeling	UK	1

Master in Seasonal Forecast	UK	1
Master in Computer Network	Germany	1
Master in Statistics	Oman	1
WMO Class II	Egypt	6
WMO Class III	Egypt	1
EUMETSAT Satellite Application Course VI	Oman	3
Satellite Meteorology	Oman	3
Aviation Seminar	Oman	8
Local Computer short courses	Oman	2
Fundamental Meteorological Courses for two government Agencies	Oman	21
Total		49

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Country Report of Pakistan

(2008-2009)

for

36th Session of WMO/ESCAP
Panel on Tropical Cyclones for the Bay of Bengal
& the Arabian Sea
(Muscat, Oman from 2 - 6 March, 2009)

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1. Tropical Cyclone activity: Nil

2. Meteorological Component

(i) Improvement of facilities:

- China has donated various Meteorological equipments through World Meteorological Organization, Voluntary Cooperation Programme (WMO VCP) in order to assist Pakistan Meteorological Department (PMD) for the restoration of various meteorological observatories situated along Balochistan coast. These observatories which were damaged due to the destruction and flooding caused by the Tropical Cyclone "Yemyin" that struck Sindh Makran Coast during the last week of June 2007 has been strengthened again.

(ii) Significant Weather Events

PRE-MONSOON SEASON (APRIL – JUNE 2008):

TEMPERATURE:

The highest monthly temperatures recorded in the months of April, May and June were 46°C at Nawabshah (on 28th April), 50°C at Sibbi (on 18th May) and again 50°C at Dalbandin (on 25th June) respectively.

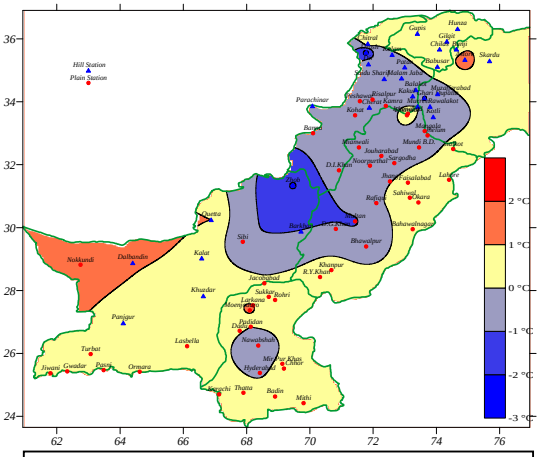


FIG.1 Spatial distribution of anomalies of temperature (°C) during April 2008 from normal (1971-2000).

While the coldest places during these months were Drosh (-3°C), Skardu (3.3°C) and Babusar (9.4°C) on 6th April, 18th May and 30th June respectively. Figures 1 to 3 illustrate the

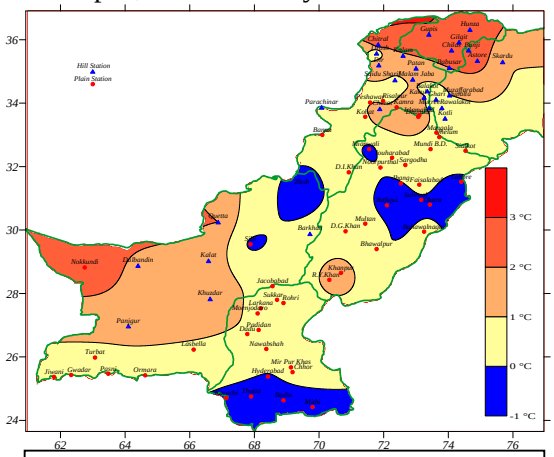


FIG 2: Spatial distribution of anomalies of temperature (°C) in May 2008 from normal (1971-2000).

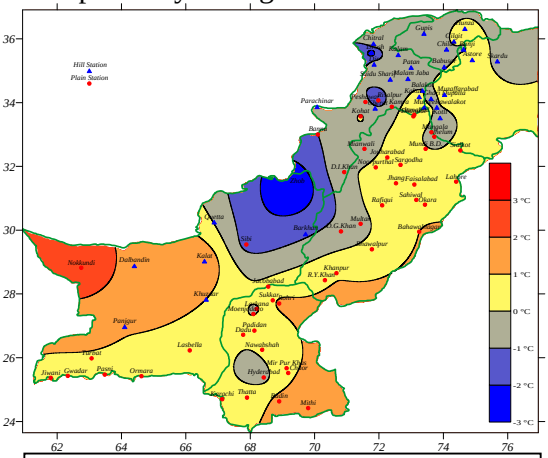


FIG 3: Spatial distribution of anomalies of temperature (°C) in June 2008 from normal (1971-2000).

anomalies of Air Temperature (°C) from normal (1971-2000) during the months from April to June 2008 respectively.

***RAINFALL*:**

During the 2008 pre-monsoon period (April-June) Pakistan received 81.0% above normal rainfall. The distribution of monthly rainfall was 71.5%, 11.6% & 160.1% above normal for the months of April, May & June 2008 respectively. The provinces of Punjab and NWFP received largely above normal rainfall of 132.6% and 73.8% respectively. Whereas, Balochistan province experienced slightly above normal rainfall (38.4 %) and province of Sindh received close to normal rainfall (-6.9 %). The heaviest rainfall recorded in the months of April, May and June were 210mm at Kamra (on 5th April), 64mm at Gilgit (on 26th May) and 123.7mm at Muzaffarabad (on 15th June) respectively. Fig-4 shows the distribution of area weighted rainfall (mm) during the season.

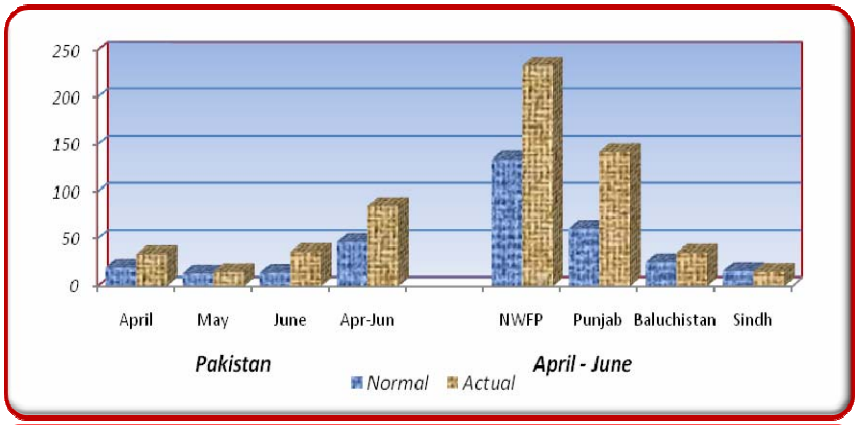


FIG 4: Area weighted rainfall both actual and normal during the Pre-Monsoon Season (April-June)

MONSOON SEASON (JULY – SEPTEMBER 2008):

***TEMPERATURE*:**

The highest monthly temperatures recorded in the months of July, August and September, 2008 were 47.8°C at Nokkundi (on 7th July), 45°C again at Nokkundi (on 1st and 9th August) and 44.5°C at Turbat (on 14th and 16th September) respectively. Figures 5 to 7 illustrate the Anomalies of Air Temperature (°C) from normal (1971-2000) during these months.

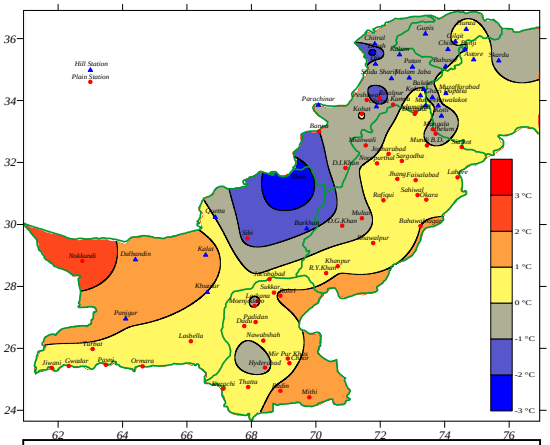


FIG 5: Spatial distribution of anomalies of temperature (°C) in July 2008 from normal (1971-2000).

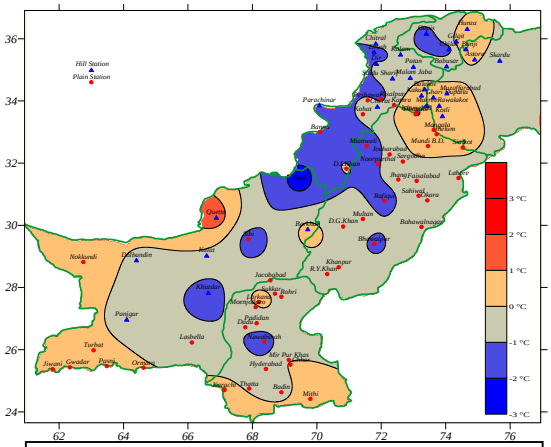


FIG 6: Spatial distribution of anomalies of temperature (°C) in August 2008 from normal (1971-2000)

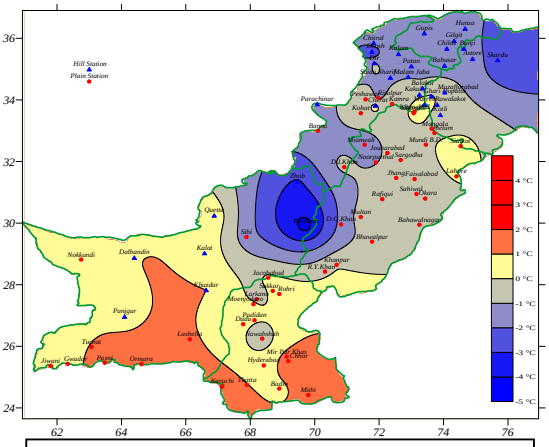


FIG 7: Spatial distribution of anomalies of temperature (°C) in September 2008 from normal (1971-2000)

RAINFALL:

During the 2008 monsoon period (July-September) Pakistan received normal rainfall. The distribution of monthly rainfall was -14.8%, 32.5% & -11.9% above normal for the months of July, August and September 2008 respectively. The provinces of Punjab and NWFP received slightly above normal rainfall of 14.9% and 18.2% respectively. During the season, Balochistan province experienced slightly below normal rainfall (-10.9%) and Sindh province received moderately below normal rainfall (-30.8%). The heaviest rainfall recorded in the months of July, August and September were 125mm at Islamabad (on 6th July), 221mm at Lahore (on 13th August) and 95.0mm at Muzaffarabad (on 7th September) respectively. While the total monthly highest rainfall were recorded to be 525mm (at Islamabad), 439mm (at Lahore) and 132.8mm (at Muzaffarabad) for the months of July, August and September respectively. Fig-8 shows the distribution of area weighted rainfall (mm) during the season.

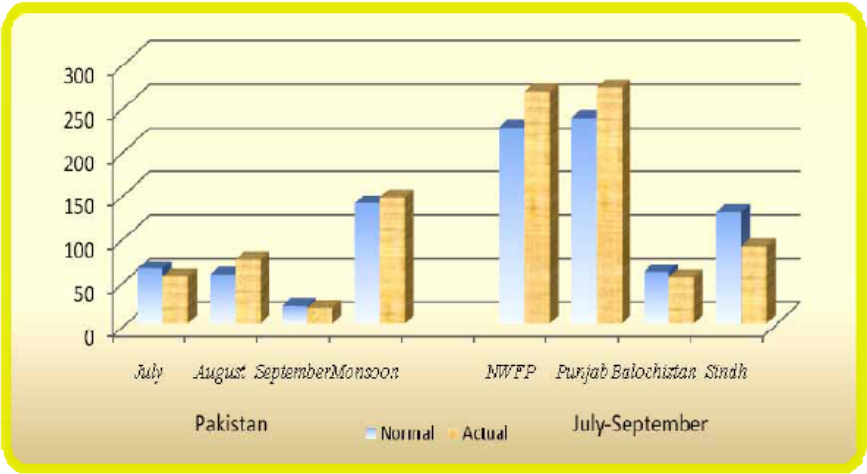


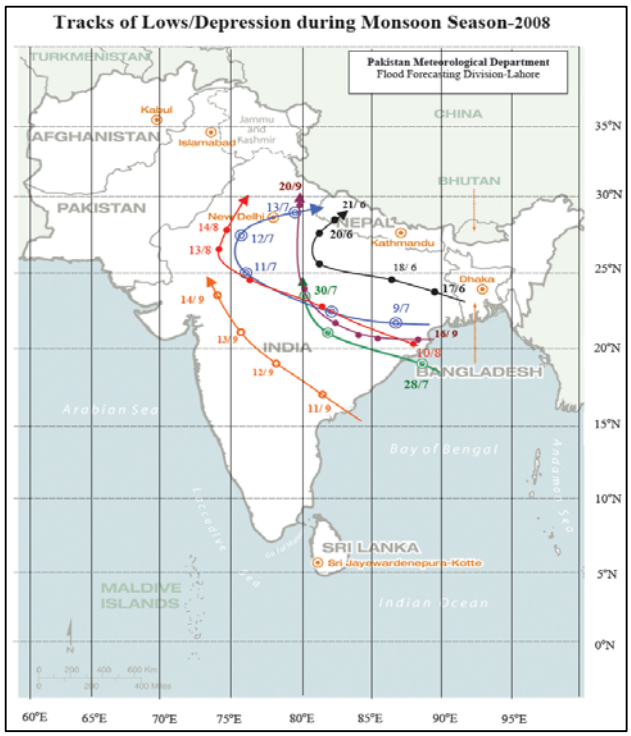
FIG 8 : Area weighted rainfall both actual and normal during the Monsoon Season (July-September)

3. Hydrological Component

3.1 Flood Season 2008

During the Flood Season 2008, six Monsoon lows originated from the Bay of Bengal, however none of these was able to reach in the vicinity of Pakistan. Figure shows the track of monsoon lows / depressions during Monsoon Season-2008.

June, 2008:
First monsoon low was developed over north Bay of Bengal on 16th June, 2008 and dissipated on 21st June 2008 over Uttar Pradesh. Rainfall which occurred over Pakistan during the month of June was due to the accentuation of seasonal low, passing of westerly waves in the north of the country and influx of monsoon current from Arabian Sea. Three wet spells occurred during the period. A peak of high flood magnitude was registered only in river Kabul at Nowshera.



July, 2008:
Second Monsoon low developed in the Bay of Bengal on 9th July, 2008. Initially it took west-northwest course and after crossing Madhya Pradesh (India) it finally reached over Southeastern parts of Rajasthan on 11th July and then it recurved to northeastwards and dissipated over northern parts of Madhya Pradesh on 13th July. No significant rainfall was reported in Pakistan. Rainfall recorded during July was only

due to the passing of westerly waves & accentuation of seasonal low. Four rainfall spells were observed during the month. River Chenab at Marala & Khanki recorded one high flood peak during the month of July. Low flood peaks were also observed in rivers.

August, 2008:

Only one monsoon low developed in the Bay of Bengal on 10th August which initially moved rapidly in a northwesterly direction and reached over southeast Madhya Pradesh India on 11-08-2008 and moving west northwestwards reached Rajasthan on 13th August. After recurving in northeast direction 0n 14th August and moved over Indian Punjab and Himachal Pradesh where it gave very heavy rain over the plains of Sutlej and Beas rivers in India. Areas of Kasur, Kanganpur, & several villages in Okara were affected by the flood. According to news media about 250 villages were inundated in Kasur districts due to increase inflow in Sutlej river from Ganda singh Wala.

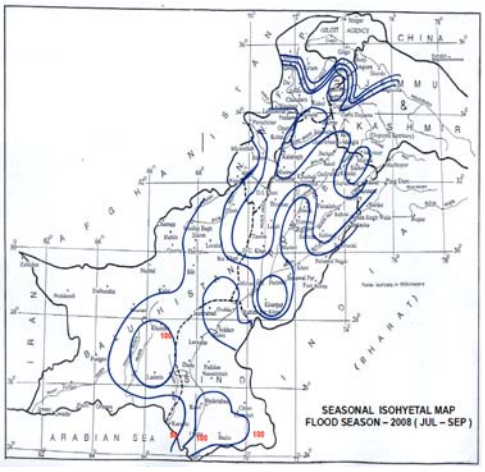
A strong westerly wave accentuated the seasonal low causing currents influx from Bay of Bengal & Arabian Sea into the areas of Punjab and surroundings cause to a heavy downpour over Suleman range & hill torrents in DG Khan & Rajanpur districts. Press reported that six people were died & dozens of villages submerged, and over 100,000 people displaced due to this. One rainfall maxima exceeding 400 mm in the month of August 2008 were located around Lahore, Sialkot, Narowal. One lesser maxima exceeding 300 mm were located around Islamabad Two maxima exceeding 100mm were observed one around Hyderabad, second around Khanpur.

September, 2008:

During this month two monsoon lows / depressions originated from the Bay of Bengal, one on 11th September and second on 16th September. First low which was developed near Andhra coast, took a northwesterly course till it reached over Rajistan on 14th September and dissipated there. Second monsoon low which developed around Orissa coast took almost westerly track and reached Western Orissa on 18th September and then moving in a northwesterly course and dissipated over Uttar Pradesh 20th September. However the second of these Weather systems was quite strong and more than 60 people were reported dead. The rainfall activity during the month was mostly confined to Kashmir & upper catchments of river Indus & northeastern parts of Punjab. Two rainfall spells were recorded during the month of September 2008. The four rainfall maxima were observed during the month of September 2008, exceeding 100 mm, one occurred over Kashmir, second over Sialkot, third over Barkhan & fourth around southeastern Sindh.

Seasonal Isohyetal Map (July to September 2008)

The main belt of maximum precipitation can be seen along the sub-mountainous area of Punjab, parts of Kashmir. One rainfall maximum exceeding 700 mm, which took place during the monsoon season, is located in north Punjab. Two lesser rainfall maximum exceeding 600 mm one is located over Northeast Punjab around Sialkot & second is located in Kashmir as shown in map.



The seasonal precipitation (July to September) was remained above normal rainfall over lower Sindh whereas slightly above normal rainfall is experienced over northeast Balochistan and Kashmir. Western Balochistan remained almost dry during the monsoon season 2008. During August 2008, unprecedented torrential rainfall over the Suleman range & hill torrents of DG

Khan Divisions caused heavy flooding in DG Khan, Rajanpur districts

3.2 Up-gradation & Installation of Radars

In order to strengthen the capabilities of flood mitigation in Pakistan, up-gradation of the existing radar network is under process. In order to cover the western parts of the country from the possible flood situation, proposal of installation of a Weather Surveillance Radar has been prepared and submitted to the government for approval.

3.3 Strengthening of Flood Risk Management in Lai Nullah Basin (twin cities of Rawalpindi and Islamabad)

Lai Nullah has frequently caused devastating floods leading to serious economic damage as well as loss of the lives in the twin cities of Rawalpindi and Islamabad. As a result, the establishment of flood forecasting and early warning system for Lai Nullah Basin was considered utmost necessary. Therefore, PMD under Japanese grant-in-assistance and with the collaboration of other government agencies initiated the the project of establishment of Flood Forecasting and Warning System for Lai Nullah Basin. The project was completed in March, 2007. Under this project six (06) telemetry rain gauges stations and two (02) telemetry water level gauges at various sites have been installed/constructed. There are ten warning posts which are connected to the main control room at PMD Headquarters Islamabad. All rainfall and water level data are received and processed at the main control room which send the signal to Warning Posts, as and when required to blow warning siren to the residents. The flood forecasting and warning system has been fully operational since March, 2007.

In late December, 2007, again under Japanese grant-in-assistance and with the collaboration of other government agencies like Federal Flood Commission (FFC), City District Government Rawalpindi (CDGR) and Rescue Department a project for Strengthening of Flood Risk management in Lai Nullah Basin was initiated. It was meant for mitigation of victims due to flood damage in the Nullah Lai Basin area with the purpose to develop a flood early warning system and structure which enables mass evacuation during flood in the affected area. The above target was to be obtained by strengthening the existing capabilities of Pakistan Meteorological Department (PMD) to utilize flood early warning system effectively and issue warning properly. This would also be done by capacity building of local authorities, to promote people's awareness, preparedness for the floods and to mitigate flood damages.

The project has been divided into two phases
Phase I: Twelve months from Dec.2007 to Nov.2008 (Completed)
Phase II: Twelve months from Dec.2008 to Nov. 2009 (In-Progress)

4. Disaster Prevention and Preparedness Component

4.1 National Seismic Monitoring & Tsunami Warning Centre (NSMC)

In post December-2004 tsunami scenario and after the disastrous Kashmir Earthquake-2005, PMD started up-gradation and strengthening of its existing seismic network for providing in time source parameters of earthquakes especially having tsunami generation potential within minutes of their occurrence which is pre-requisite for the establishment of Tsunami Early Warning System. The project was implemented during 2005-2008. Now a state-of-the-art National Seismic Monitoring & Tsunami Warning Centre has been established in Karachi and a backup centre in Islamabad. The centre is supported by eleven (11) broadband highly sensitive seismic stations which have been established on

various sites. These stations are capable of recording any activity in Asia and the pacific and are connected with National Centre through "Pak-Sat" satellite for real-time communication. National Seismic Centre Karachi is also connected with Global Seismic Network and real-time earthquake data of various 60-seismic stations of the world are being received regularly. Thirty (30) local short period seismic stations have also been established to record local micro-seismicity in the country. These local stations have been equipped with strong ground motion recorders for the measurement of earth shaking during earthquakes.

4.2 Tropical Cyclone Warning Centre (TCWC)

Tropical Cyclones Warning Centre (TCWC) is also being established by PMD with the financial assistance by the Government of Pakistan. Ten (10) Automatic Weather Stations (AWS) with five (05) High Gust Anemometers, Data Collection Platform and satellite transmitters for communication of data would be installed along the coastal areas of Pakistan (Sindh-Makaran Coast) for recording and transmission of real time weather data. TCWC will also facilitate the NMHSs of neighbouring countries by covering North Arabian Sea, Gulf of Oman, Central North Arabian Sea and Gulf of Aden.

5. Training / Education:

5.1 Training of Met. Personnel from neighbouring countries at IMG, Karachi

Pakistan Meteorological Department (PMD) conducted a special Preliminary Meteorology Course (BIP–MT Programme) for the participants from the National Meteorological Services and Hydrological (NMHSs) of the neighbouring countries for their capacity building through WMO Voluntary Cooperation Programme (VCP). Ten (10) trainees with two from each of Bangladesh, Bhutan, Maldives, Nepal and Sri Lanka participated in this training programme. PMD provided complete financial support to the participants in lieu of travel and per diem. The total duration of the course was six (06) months which include 18 weeks of study work and 8 weeks of on-the-job-training (OJT). The study work was conduced at PMD's Institute of Meteorology and Geophysics (IMG), Karachi from 25th February to 28th June, 2008, while the OJT was completed by the participants in their home countries. The participants were awarded certificates in the successful completion of both study work and OJT.

The second such training course has tentatively been scheduled from 9th March, 2009. In this course which is also being conducted at IMG, Karachi, nine (11) participants from NMHSs of the neighbouring countries with one from Afghanistan and two from each of Bangladesh, Bhutan, Myanmar, Nepal and Sri Lanka are expected to attend. For this course too, PMD is providing complete financial support to the participants in lieu of travel and per diem.

5.2 Training of Met. Personnel of PMD at IMG, Karachi

Various regular and specialized meteorological courses were conducted at IMG, Karachi for met. personnel of PMD as well as for officials of Met. branch of Pakistan Air and Naval Forces during 2008-2009 These courses include Initial and Preliminary Meteorology Courses (BIP–MT), Basic Forecasting Course(BIP–M) etc.

5.3 Extension of Memorandum of Understanding (MoU) between Pakistan Meteorological Department (PMD) and the COMSATS Institute of Information Technology (CIIT) Islamabad.

Both PMD and CIIT extended their MoU for cooperation and collaboration in research and development activities and human resource development up till June, 2010. The MoU was first signed in July, 2004. Under this MoU, MS (Meteorology) programme has been regularly conducted at CIIT,

Islamabad. PMD is providing Lab. Facilities and supervision of research projects to the students and faculty members of CIIT whereas CIIT has been providing education and research facilities to the scientists and researchers of PMD. A number of scientists have completed their MS (Meteorology) under this programme.

5.4 Training Abroad in Meteorology

For the capacity building of PMD's scientists, PMD has been providing scholarships to the potential scientists for MS and Ph.D in the fields of meteorology and related sciences. Presently, three (03) officers have been doing Ph.D in Sweden, Germany and Canada. While three (03) scientists have been doing their MS in Norway, China and Thailand. Three (03) students, who were sent to Reading University, UK for their MS (Meteorology) in 2006, have returned home and joined PMD in December, 2008. During the next year, some more scientists are also expected to proceed abroad for their MS and PhD.

6. Research:

6.1 Wind Mapping of Northern Areas of Pakistan (Phase-II):

In the First phase, PMD has already completed the wind power potential of the coastal areas (Sindh-Makaran) of Pakistan. On the basis of the wind data analysis, a wind corridor in Gharo has been identified in Sindh, which covers an area of about 9,700 Square Kilometers and which has the exploitable Electric Power Generation Potential of 11000 Mega Watt.

In the Phase-II, PMD is carrying out similar type of study in Northern Areas of Pakistan for determining the assessment of Wind Power Potential of these areas. The results of this study will ultimately provide a platform for the probable establishment of Wind Mills / Farms for power generation. The project was initiated in 2005 and would be completed in 2009.

A number of Research work / small projects related to forecasting Techniques, Climate Change, Climate modeling, Downscaling for Seasonal and Monthly Prediction, Verification of High resolution Regional Model (HRM), were also carried out by PMD Scientists at the Research & Development (R&D) Division of PMD and they presented their research work at various conferences/ symposium / workshops at national and international levels during 2007-2008.

7. Publications:

- Two Issues of "Pakistan Journal of Meteorology" (Issue No. 9 & 10) have been published by PMD during 2008-2009. These issues contain research papers contributed by PMD scientists and also of international scholars.

- In addition to this, PMD Scientists also contributed (both as lead authors and co authors) in some research papers which have been published in various international journals or presented in International conferences / symposia.

Thirty-sixth Session of the WMO/ESCAP Panel on Tropical Cyclones
02- 06 March 2009, Oman

COUNTRY REPORT - SRI LANKA

1. REVIEW OF THE 2008 TROPICAL CYCLONE SEASON (Agenda No. 3.2)

Although the number of cyclonic circulations during 2008 was not very much, those few and other depressions brought considerable rain to certain parts of the island.

A low pressure area appeared in the South Bay of Bengal on 24th April and deepened in to a depression by 26th. Deepening further in to a tropical cyclone and named as "Nargis" by 28th, the system moved slowly northwestward and was about 600km northeast of Jaffna on 28th. This storm caused temporarily active southwest monsoon conditions resulting very heavy rain during 27 and 28th mainly in the Western, Sabaragamuwa and Southern provinces and in the western slopes of central hills. Weather over the island improved suddenly on the 29th with dry northwesterly winds feeding into the system. The severe cyclone "Nargis" crossed the coast of Myanmar on 02nd May.

Another significant feature was the strong winds that experienced over the island on the 11th of November due to a cyclone near Taiwan, far away.

Tropical cyclone (KHAI-MUK) in the west-central Bay of Bengal caused sea area around Sri-Lanka was rough on the 15th night and on the 16th due to its landfall in Andra Pradesh.

On 21st November, another low pressure area has developed to the east of Sri-Lanka and moved over eastern parts of the island causing heavy rain in the East on 22nd and 23rd. System intensified in to a depression and located over Jaffna peninsula on the 24th. It was practically stationary but intensified in to a tropical cyclone (Nisha) on the 25th locating just off the north coast. Extremely heavy rain and strong winds occurred over Jaffna peninsula on the 25th night causing floods and damages to property creating a disastrous situation in the Northern and Eastern provinces.

At the beginning of the month of December, yet another low pressure area formed in the South-East Bay of Bengal and moved towards Sri-Lankan area and it intensified into a depression on the 04th and then into a deep depression on the 05th, but then weakened into a low pressure area on 05th night. It crossed Sri-Lanka near Trincomalee coast and then through Anuradhapura and emerged from Mannar in the northwest coast during the 07th afternoon. As a result, Northern, North Central and Eastern parts of the country were kept under bad weather alert. However, north-central parts of Sri-Lanka experienced heavy rain and fairly strong winds. Showers or thundershowers were fairly widespread over other areas too.

Another disturbance formed in the southeast of Sri-Lanka on the 08th but it moved very fast and merged with the low pressure area which crossed Sri-lanka, and was located to the west of the island. Hambantota and Deniyaya areas received fairly heavy rain falls due to this system.

Over-all most of the Northcentral and Central parts of the island received below normal rainfall and the year has not been favourable as far as the rainfall distribution is concerned. However many parts of the island, especially the Southwestern parts experienced heavy precipitation.

3. METEOROLOGICAL COMPONENT (Agenda No. 5.1)

Telecommunications: New upgraded GTS system (256kbps) operates perfectly to exchange information with RTH New Delhi.

JICA sponsored Improvement of Meteorological Disaster Information Network (both AWS and communication) commenced the installation of 38 AWSs with one at Katugastota Meteorological Station fully installed except the communication system. Although the project is scheduled to be completed by end of March, due to various difficulties regarding importation of VSAT related components by the Contractor this is delayed.

Synoptic Observations: Data reception from 20 operational stations was very good except during few occasions due to security reasons in some Northern stations. Observations at Trincomalee (43419) are still operated by Lanka Navy. Out of five RBCN stations, a silent station for CLIMAT TEMP data, Colombo (43466), due to non-availability of continuous data is pending re-activation (no replacement station is available). Nine RBSN stations are operational with some restrictions in Northern stations due to security reasons.

Upper-air Observations: Radar wind observations in Colombo (43466) were carried out throughout except for few isolated incidents. Pilot balloon observations at Hambantota (43497) and Puttalam (43424) were done satisfactorily at 0000, 0600 and 1200 UTC. New pilot balloon observations at Anuradhapura (43421) had some disruption due to human resource deficiency. Radiosonde observations using new GPS based equipment was carried out sparingly once a week due to the high cost of consumables.

Meteorological Satellites: As there are no equipment for direct reception of satellite imageries, the NMC heavily depend upon internet on this aspect. The FENGYUNCast satellite receiving system could not be explicitly used due to failure of software/hardware.

Ships and Aircraft Reports: Ship Reports and AIREPs are received from vessels and aircrafts but rarely. However, much information are directly sent by Aviation Authorities directly.

(a) Improvement of Facilities/ Technical Advancements

Setting up of 20 telemeter rain gauges, with solar panels at locations vulnerable to landslides, are in progress but delayed due to a software development issue.

Procurement of Doppler radar with MOU signed between WMO and the Ministry, technical evaluation completed but as the proposed system is somewhat basic, DOM requested options mutually with WMO. The product is expected in Sri Lanka by 2010.

About 75% of construction work at two new meteorological stations, Polonnaruwa in the North-central province and Monaragala in the East, completed and Observers stationed with AWS installed by February, the official commencement is scheduled in March 2009.

4. HYDROLOGICAL COMPONENT (Agenda No. 5.2)

The Hydrology Division of the Irrigation Department collects hydrological data that enables quantification of surface water hydrology analyse and archive the data as the only such institution concerned with surface water measurements in the island.

Hourly surface water levels at 69 Hydrometric stations are collected and daily average river discharges from 40 stream gauging stations located at 17 major river basins which covers over 60% of the total basin area of the island are calculated at present. The Hydrological data thus collected is made available for water resources development, planning and research work. In addition to the above work Hydrological Division collects daily rainfall records from 35 rain gauges, out of which 30 gauges are established in stream gauging stations. This division maintains 10 evaporation pans also to collect daily evaporation records and maintains two weather stations.

Improvement of Facilities and Technical Advancements, Flood Forecasting and Warning

The following computer packages are used for water resources planning, Hydrological Modelling and data processing.

1. MIKE II Hydraulic Model
2. HEC HMS
3. HEC RAS
4. HEC DSS Vue
5 .MIKE BASIN

In addition to above, monitoring and measuring high flood levels, discharge measurements during floods and flood mapping of most of the main river basins are carried out by this division.

5. DISASTER PREVENTION AND PREPAREDNESS (DPP) COMPONENT (Agenda No. 5.3)

Both the SLMD and Disaster Management Centre (DMC) have continued collaborative work on Hazard Mapping and Risk Assessment, Long-term Disaster Mitigation, Preparedness to respond to disasters when they occur, and Emergency Operations Management.

A sessions with the Media personnel pre-cyclone season and pre-monsoon season boosted awareness among journalists and general public. Signal number colour system was introduced for Cyclones, just prior to the October- December Cyclone season by SLMD. Early warnings were issued to DMC and other relevant authorities with lead-time to facilitate disaster managers to act expeditiously.

Disaster Events in Brief

Heavy rain caused flooding and minor earth slips and they accounted for largest damages among natural disasters during the year. These events claimed some 35 lives and over 400,000 persons from Northern and Eastern parts and over 300,000 persons from other areas were either displaced or affected. Lightning and strong winds claimed 19 and 03 lives respectively injuring many more. On 23rd July 11 fishermen lost their lives with another 10 missing due to strong winds over the southwestern neighbouring sea.

(a) DPP Activities by National Disaster Relief Services Centre (NDRSC)

Floods claimed the highest proportion of financial allocation in 2008 also (66%, in comparison to ~ 65% in year 2007 and 62% in 2006) and Epidemics (Chickungunya fever) claimed to the next highest proportion (12%), then Landslides (6%). In the year 2008, the drought relief allocation

(4.8%) was just over half of in the previous year (8.2%) due to good rain in the first part of the year in the frequently drought affected areas.

(i) Financial Assistance for Relief, Rehabilitation and Reconstruction Activities-2008

Type of Disaster	**Allocation (Rs)**	Percentage of Total Allocation
Floods	210339335	66.38
Epidemic	38000000	11.99
Landslides	20502716	6.47
Droughts	15286758	4.82
Cyclones	11675820	3.68
Other widespread disasters	10440300	3.29
Civil conflict	5586192	1.76
Fires	2864374	0.90
Accidents	1387500	0.44
Minor disasters	286550	0.09
Relief to missing fishermen families	225220	0.07
Sea erosion	153420	0.05
Other relief	118950	0.04
Total	316867135	100

(b) DPP Activities by Disaster Management Centre (DMC)

Staff released from Forces (Army, Navy, Air Force & STF) continue to offer services in the DM units with senior level Military/ Police officers placed as coordinators in each of the districts, under the supervision of Government Agents/ District Secretaries.

(i) Programmes of Disaster Management

1. Final draft of the National Policy to be submitted at the National Council for Disaster Management (NCDM) after receiving comments from Ministry Secretaries.

2 Final Draft of the National Disaster Management Plan is to be submitted to the NCDM.

3. DMC commenced the construction of new building for the main operation centre in the Department of Meteorology premises.

4. Under the provincial Disater preparedeness and response plans, the initial awareness workshop has been conducted for Uva province and data collection and preparing the plan are in progress.

5. 15 District management plans have been prepared and the copies of the plans are to be distributed to the district stakeholders.

6. DMC assisted Ratnapura and Kalutara districts to rehabilitation roads and drains constantly affected by floods.

7. On a request made by District Secretaries, the National Building Research Organisation studied the landslides in Hanguranketha and Walapone Divisional Secretary areas and made recommendations to mitigate the impacts. Hazard maps are being developed for Nuwara Eliya district.

8. **Disaster Information System (Disinventer)** is a data collection and analysis methodology which uses open-source computer software to record and assess disaster losses and trends. It was launched in June 2007 as an online web based information system at www.desinventer.lk

9.Development of Risk Profile in Sri Lanka in which National Building Research Organization, Irrigation Dept., and Coast Conservation Dept., continues as to develop hazard maps for Landslide, Flood and Tsunami.

10. National Safety Day was commemorated by the Government in Kandy on 26 December to focus on disaster reduction awareness.

(ii) Training and Public Awareness

1. DMC conducted a training programme for Assistant District coordinators on Disaster Management and another one for newly appointed district coordinators and assistant coordinators.
2. Training programmes were also held for Scientific and Technological officers (Vidatha)
3. Conducted a session for National Cadet corps, Randenigala on Disaster Management.

4. **Continuous Programs**: Different target groups for training included staff of Disaster Management Coordinating Units, The District and Divisional Secretaries, Social service and Land use policy planning, estate managers Vulnerable communities, Disaster Management Committee members, Officers of the Line Ministries, School Children, School Teachers, Principals, Hospital staff etc.

   Pilot project for Training of Trainers (TOT) for school teachers of Kalutara and Galle districts have been planned in collaboration with the Fund for Relief and Development (FRD) for the last quarter. Video clips on tsunami, cyclones, landslides, drought, and floods will be completed during the last quarter for distribution to DDMCs as standard training material. These will be integrated to core disaster management training material as a standard training tool kit by the end of the year with the help of UNDP and BCPR, India.

Awareness creation for stakeholders

1. Training programmes for DMC staff and other stakeholders have been conducted on different disaster management related areas and the communities have been sentizied via awareness campaigns.
2. CBDM guidelines have been formulated in collaborations with other stakeholders and community level risk reduction activities have been carried out.
3. A discussion forum, Sanhinda to discuss current Disaster related issues with the participation of relevant authorities and specialists.

(c) DPP Activities by Irrigation Department

Continuous programs:

As one of the most harmful disasters, flood hazard maps for Kalu Ganga area are developed using hand held GPS instruments.

Under the comprehensive study on disaster Management in Sri Lanka provided by JICA, 08 hydrological observation centres in Kelani Ganga basin are equipped with automatic rainfall and water level records with telemetry system enabling real time data and 90% of the work of the project has been completed. The project is further extended to Kalu Ganga.

The hydrology division of the Irrigation department has also installed 02 Automatic Rainfall recorders with loggers and 02 number of bubble in sensor instruments with data loggers for water level monitoring in Gin Ganga and KaluGanga.

The Hydrology Division of the Irrigation Department installed 04 Automatic Rainfall recorders with Loggers, and 04 Bubble in Sensor instruments with data loggers for water level monitoring in Gin Ganga and Kalu Ganga.

6. TRAINING ACTIVITIES (Agenda No. 5.4)

Officers from the SLMD attended following conference/seminar/workshop/training events sponsored by the WMO.

Training in operational cyclone forecasting, India. (WMO)	India	14/01/2008	25/01/2008
UNFCCC Meeting on Climate Change, Mexico. (UNFCCC & WMO)	Mexico	04/03/2008	07/03/2008
Regional Symposium on Disaster Management Support Systems - Satellite Information Access Systems, Thailand, (ESCAP)	Thailand	18/03/2008	23/03/2008
WS on Advisors on External Relations, Korea. (WMO)	Korea	28/04/2008	03/05/2008
35th Session of WMO/ESCAP PTC, Bahrain. (WMO)	Babrein	05/05/2008	09/05/2008
KOICA Training in ICT, Korea	Korea	26/05/2008	27/06/2008
Workshop on climate change and Disaster - Nepal	Nepal	21/08/2008	22/08/2008
Climate Change, Security and Sea Level Rise in South Asia, Bangladesh (WMO)	Bangladesh	25/08/2008	29/08/2008
Space Tools and Solutions for monitoring atmosphere and land cover - Austria, Vienna	Vienna	09/09/2008	12/09/2008
Symposium on strengthening NMHSs external relation and field study China. (WMO)	China	13/10/2008	23/10/2008
Enhancing South-South Cooperation roles on Disaster Risk management focusing on climate change adaptation - Indonesia	Indonesia	14/10/2008	17/10/2008
International Training programme 'Climate change mitigation and Adaptation" part 2 - Jordan	Jordan	20/10/2008	24/10/2008
Training on Storm Surge Forecasting, IIT, India. (WMO)	India	10/11/2008	21/11/2008

WMO Technical Conference on Meteorological and Environmental Instruments and Methods of observation, St. Petersburg, Russian Federation. (WMO)	Russian Federation.	27/11/2008	29/11/2008
WMO Regional Seminar on Strategic Capacity Development on National Meteorological and Hydrological Services (NMHSs) in Regional Association II, Tashkent, Uzbekistan. (WMO)	Tashkent, Uzbekistan	03/12/2008	04/12/2008
Training Course on Air Quality Forecasting for India and South Asia, Pune, India. (WMO)	India.	08/12/2008	12/12/2008

Two positions to train Meteorological Observers of SLMD in general meteorology have been generously offered by the PMD. These trainees are expected to start training in PMD in early March and the Government of Sri Lanka express its sincere thanks to the Government of Pakistan**.**

7. RESEARCH ACTIVITIES (Agenda No. 5.5)

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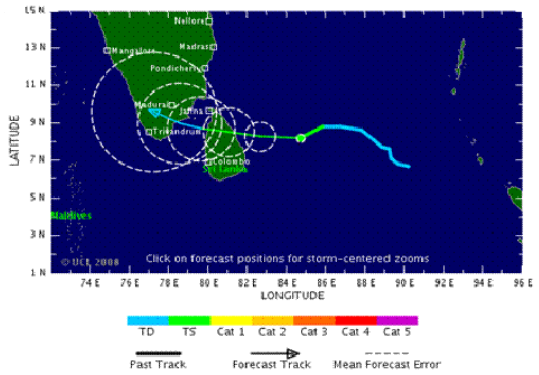
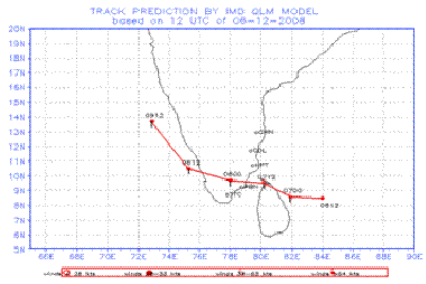
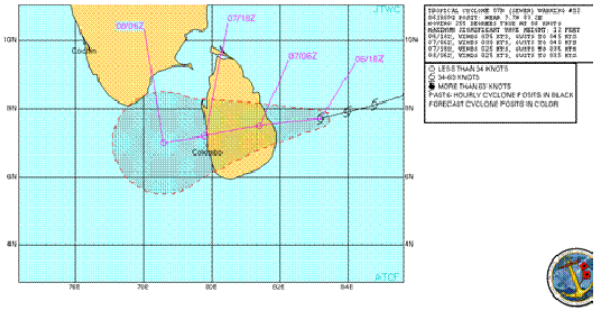
1. Monsoon Rainfall Prediction using power regression model (Master Research)
2. Storm Surge Modeling using GIS (Master Research)
3. Possibility of Thunderstorms with K – Index (Under graduate Final Research)
4. Possibility of Thunderstorms with Lifted Index (Under graduate Final Research)
5. Simulate Hambantota Drought in 2001 with Standard Precipitation Index (SPI) (Under graduate Final Research)
6. Correlation between SPI and Rice Production in Kurunegala District (Master Research)
7. Monthly Rainfall Prediction using Climate Predictability Tool (CPT).
8. Monsoon onset date Predicting
9. Temperature Analysis over past century
10. MM5 Modeling
11. Effect of Temperature on Paddy (ongoing)
12. Decadal rainfall variability (ongoing)
13. Analyzing of El-Niño and La-Niña effect on Inter monsoon Rainfall
14. Extreme Climate Indices and changes with altitude
15. Influence of Heat Index on Heart Diseases (ongoing)
16. Seasonal Weather Prediction (3 month)

FIG.1- TRACK OF DEEP DEPRESSION







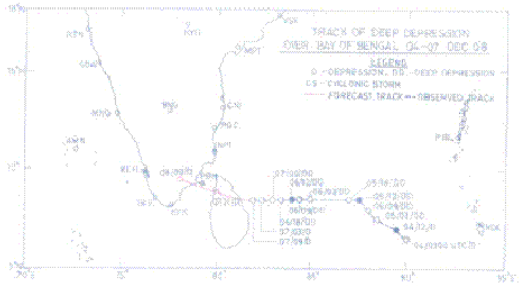
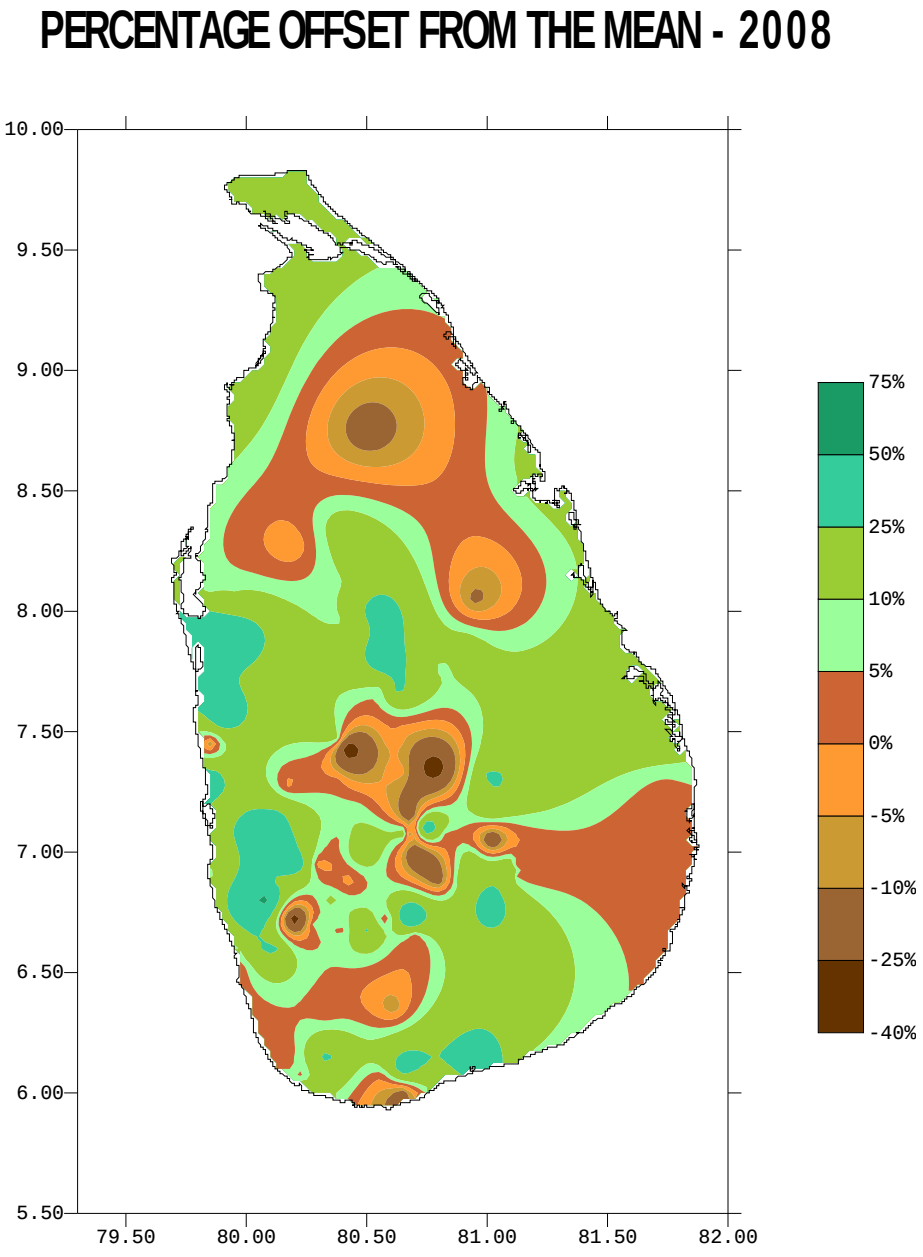


FIG.2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Thailand Country Report
(2008)

for
The 36th Session of
WMO/ESCAP Panel on Tropical Cyclones

2 - 6 March 2009
Muscat, Oman

Annual Country Reports (2008)

COUNTRY NAME: THAILAND

1. NARRATIVE ACCOUNTS OF TROPICAL CYCLONES IN 2008

In 2008, started from 1st November 2007 to 31st October 2008, an area responsibility of Thailand (0°- 25° N and 90°-120°E) experienced 2 tropical storms as follow:

1) The first tropical cyclone which developed in the central area of Bay of Bengal and intensified to very severe tropical cyclone "NARGIS" (01B) on 27th April 2008 that caused the worst natural disaster in the recorded history of Myanmar. Initially, it tracked slowly northwestward and encountering favorable conditions, it quickly strengthened. It then moved in a north-easterly direction and made landfall near Dassein and Yangon over Irrawaddy Delta in central Myanmar on 2nd May 2008, causing catastrophic destruction and at least 146,000 fatalities with thousands more people still missing. It continued to be weakening as it moved further inland, and finally downgraded to be low pressure cell over the border of Myanmar and Mae Hong Son province, Thailand on 4th May 2008. It was feared and quite possible that due to lack of relief efforts, a total of a million people already had or would have died from this catastrophe. Damage was estimated at over $ 10 billion (USD), which made it the most damaging cyclone ever recorded in this basin. In Thailand, it caused abundant rainfall in most of the places of the country for few days. There are 31 provinces, 101 districts, 144 Sub-Districts, 261 communities were affected by heavy rainfall during 3rd – 8th May 2008. Abundant rainfall occurring were reported from southern part of Thailand in Narathiwas, Pattani, Song Khla, Trang, Nakhon Srithammarat, Chumphon, Prachuab Khirikhan and Petchaburi provinces. The northern parts were reported in Chiang Rai, Phayao, Lampang, Lamphun, Sukhothai, Phitsanulok, Kamphaengphet, Uthaithani and Phichit provinces. In the northeastern parts where were far away from centre of the cyclone but still affected in Nong Khai, Udon Thani, Roi Et, Sisaket, Khon Kaen, Chaiyaphum and Nakhon Ratchasima provinces, while heavy to very heavy rainfall were also reported in central and east parts in Nakhon Pathom, Suphanburi, Saraburi, Angthong, Chacherngsao, Rayong and Trad provinces.

2) The tropical storm in the South China Sea which formed from the active low pressure cell in the middle of the South China Sea and then intensified to be tropical depression on 28th September 2008 and later strengthened to be tropical storm 'MEKKHALA' (0816) on the following day. It moved westerly and rather intensified before making landfall at Dong Hoi, Viet Nam on 30th September 2008. Inland, it downgraded to be tropical depression and passed Lao P.D.R. and moved into northeastern part of Thailand at Nong Khai province, thereafter it was weakening to active low pressure cell which covered the central part of northern of Thailand in Uttraradit, Phitsanulok, Sukhothai, and Kamphaengphet provinces on 1st October 2008, and finally dissipated over the said areas on the same day. The tropical storm 'MEKKHALA' produced huge rainfall while moving through the northeast of Thailand with isolated heavy and very heavy rainfall in the areas. There are 26 provinces, 79 districts, 84 Sub-districts and 127 communities were affected these included Yala, Narathiwas, Nakhon

Srithammarat, Chumphon and Prachuab Khirikhan provinces in southern part, Petchaburi, Ratchaburi, Nakhon Pathom, Suphanburi, Angthong provinces in central part, Chacherngsao, Chonburi, Rayong and Trad provinces in eastern part, Roi Et, Loei, Chaiyaphum and Nakhon Ratchasima provinces in northeastern part, while northern part were reported in Chiang Rai, Phayao, Lamphun, Lampang, Tak, Kamphaengphet, Pichit and Nakhonsawan provinces. The tracks of tropical cyclone 'NARGIS' and tropical storm 'MEKKHALA', are shown in Figure 1.

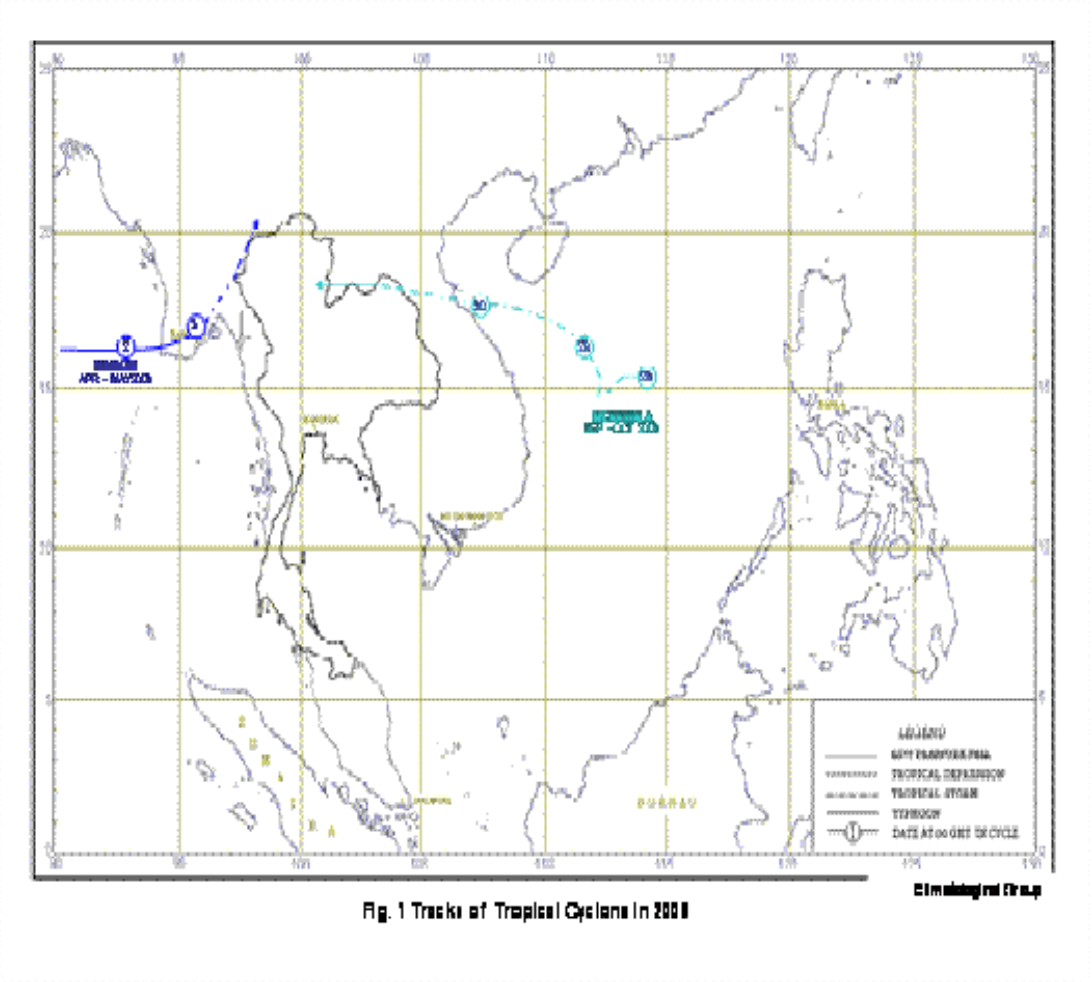

Figure 1 Tracks of Tropical Cyclone 'NAGIS' and Tropical Storm 'MEKKHALA' in 2008

Assessment of impacts from Tropical Cyclone 'NARGIS' for Thailand

Affected Areas	People Affected	Household Affected	House Partly Damaged	Number of Death	Number of Injuries	Farmland Affected (acre)	Number of Livestock Affected	Damage Cost (USD)
10 provinces in the NORTH 7 provinces in the NORTH-EAST 6 provinces in the CENTRAL 3 provinces in the EAST 6 provinces in the SOUTH	6,947	1,800	1,133	1	3	570.9	308	130,131

Assessment of impacts from Tropical Storm 'MEKKHALA' for Thailand

Affected Areas	People Affected	Household Affected	House Partly Damaged	Number of Death	Number of Injuries	Farmland Affected (acre)	Damaged Cost (USD)
8 provinces in the NORTH 5 provinces in the N-E 6 provinces in the CENTRAL 4 provinces in the EAST 4 provinces in the SOUTH	2,208	661	447	0	1	128.89	39,378

2. METEOROLOGICAL COMPONENT

a. Improvement of facilities

1. High Impact Weather Monitoring Activities

- To support and strengthen severe weather observation and monitoring networks in the country, TMD established two C-band Doppler Radars which are under installed in the North of Thailand as follows:
  1. Lumphun, it is expected to complete and operate in early 2009
  2. Petchaboon, it is expected to complete and operate in early 2009

- To increase and enhance rainfall observations and networks density in TMD, and improvement of automatically data transmission, there are 820 automatic rain gauges, completely installed in the main river basins across the country, it then be increased in number of automatic gauges to 930.

- To support and strengthen safety air navigation during takeoff and landing at regional international airport, Chiang Mai, Low Level Windshear Alert System (LLWAS) was installed and expected to be completed in early 2009

- To enhance and upgrade meteorological data dissemination effectively via the global communication lines, GTS circuits of TMD's RTH were upgraded as follows:

  1. Upgraded Bangkok – Beijing Circuit to digital leased line (IPLC) from X.25 9.6 Kbps to 64 Kbps, completed on 9 January 2008
  2. Enhancement Bangkok – Yangon Circuit from Asynchronous 50 bps to TCP/IP socket via internet, completed on 29 January 2008
  3. Upgraded Bangkok – New Delhi Circuit to digital leased line (IPLC) from Asynchronous 200 bps to 64 Kbps, completed on 16 June 2008

2. Improvement of weather and storm surge forecasting

1. The WRF have been introduced for TMD's medium and long-ranged predictions, enhancement of supercomputer is under consideration for capacity of model utilization, MM5 and Thailand Model have been run for short-ranged forecasts.

2. The storm surge model contributed by Mr. Masakazu HIGAMI, Office of Marine Prediction, Marine Division, Global Environment and Marine Department, Japan

Meteorological Agency (JMA), is under experiment and adjustment for operational purposes at TMD. The Virtual Wave 3D program which developed at MMC has been used to display the results.

b. Technical Advancement

- Bureau of Meteorology for Transportation (BMT), TMD updated the Aerodromes Operations and Planning (AOP) information in the Asia and Pacific Regions, Air Navigation Plan-Doc 9673, Volume I – Basic ANP and Volume II – FASID, including conclusion 18/58.

- TMD participate the Asia/Pacific on-line Air Navigation Deficiency Data Base, and conclusion 18/62 – Resolution of air navigation deficiencies which available in MS access in the ICAO APAC website.

- The new provision of 9-hr TAF and 24-hr TAF have been provided by BMT in earlier an hour than previously, effective from 5th November 2008. However, 30-hr TAF for VTBS VTBD VTCC VTSP which requested by IATA is being under consideration and consultation with regional meteorological centers of TMD.

c. Training achievements

National training by Meteorological Institute, TMD

TMD conducted training courses with foreign expert collaboration and expert in its related meteorology as follows: 1) Regional training courses in Agricultural Meteorology: Agrometeorology of National Disasters and Extreme Events in South East Asia for 42 participants from Lao PDR, Malaysia, Vietnam, Myanmar, Cambodia and Thailand in March 2008, 2) Remote Sensing of Global Precipitation using Passive Microwave Satellites for 68 participants from national agencies in March 2008, 3) Radar Images Interpretation for 99 participants in April, June, August 2008, 4) Radar Application for Nowcasting for 38 participants by Expert from Taiwan in July 2008, 5) Dynamic Meteorology in Tropics by Expert from Germany for 30 participants in August 2008.

Overseas training

TMD staffs attended overseas training courses in 2008 as follows:
1) One staff attended training course in Tsunami Disaster Mitigation in Japan, 2) One staff attended training course in Analysis of COMS Data in Republic of Korea, 3) One staff attended training course on Application of Satellite Remote Sensing and Satellite Communication Technologies in Disaster Reduction in China under China-ASEAN partner project, 4) One staff attended training course in Automatic Weather Station Network in Hong Kong, China, 5) one staff attended training course in Meteorology and

Environment Aspects Sustainable Water Management in Israel, 6) one staff attended the third training course on Operational Tropical Forecasting in India, 7) Two staffs attended Initial Forecasting Course in England, 8) One staff attended training course in Satellite and Radar Meteorology.

Remark: Trainings for other related agencies may not include in this report

3. HYDROLOGICAL COMPONENT

Hydrological Activities from November 2007 – October 2008

Annual rainfall accumulation of Thailand in 2008 was greater than 30 years averaged record (1971 – 2000) 11% as shown in Figure 2 and separated into the parts as follows: 1) north 13%, 2) northeast 22%, 3) central 19%, 4) east 3%, 4) south (east coast) 17% and 5) south (west coast) -3% which different from other parts due to less rainfall in April, July, August, November and December. Normally, November is the end of rainy season and transition of SW Monsoon to NE Monsoon over the country. In 2008, occurrence of heavy to very heavy rainfall which caused flash floods and floods were occasionally reported over the southern part of Thailand, except west coast of southern part at Indian Ocean. According to southwest monsoon onset in the first week of May and influences of tropical cyclone 'NARGIS' (01B), it caused heavy rainfall in Tak province (135.1 mm/day at Mae Sot district, 132 mm/day at Phobphra district). Flash flood was reported over lowland and cultivated areas in this province on 1st May 2008, about 1000 ha of farmland in Nakhon Sawas province was also damaged by abundant rainfall from this cyclone. Spatial rainfall distribution affected from cyclone was shown in Figure 3

In the middle of May 2008, the trough of low pressure dominated over central and north of Thailand, flood was reported once again in Tak province and damaged cultivation areas of about 500 ha. Heavy rainfall (173 mm/day) was reported at Kamphaengphet station and four districts were reported with floods on 16th May 2008. Additional of floods were reported at Singburi province that affected 3,100 ha of cultivated areas, and Suphanburi province that affected about 1,000 ha. In the same period, floods were reported over urban areas of Nakhon Ratchasima for consecutively 9 days, and were also reported in the south of Phang Nga and Surat Thani provinces.

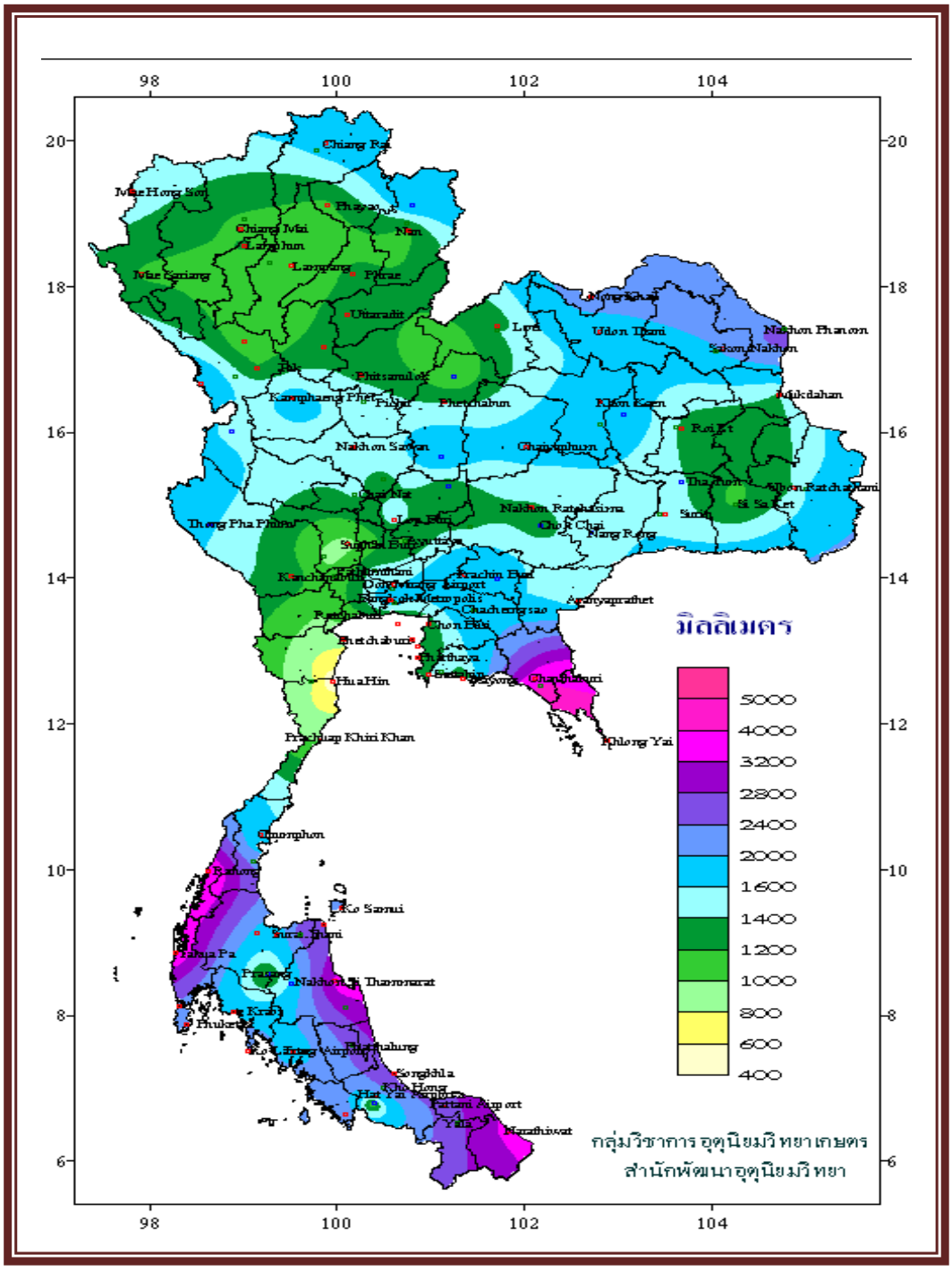

Figure 2 Annual accumulation of rainfall over Thailand in 2008

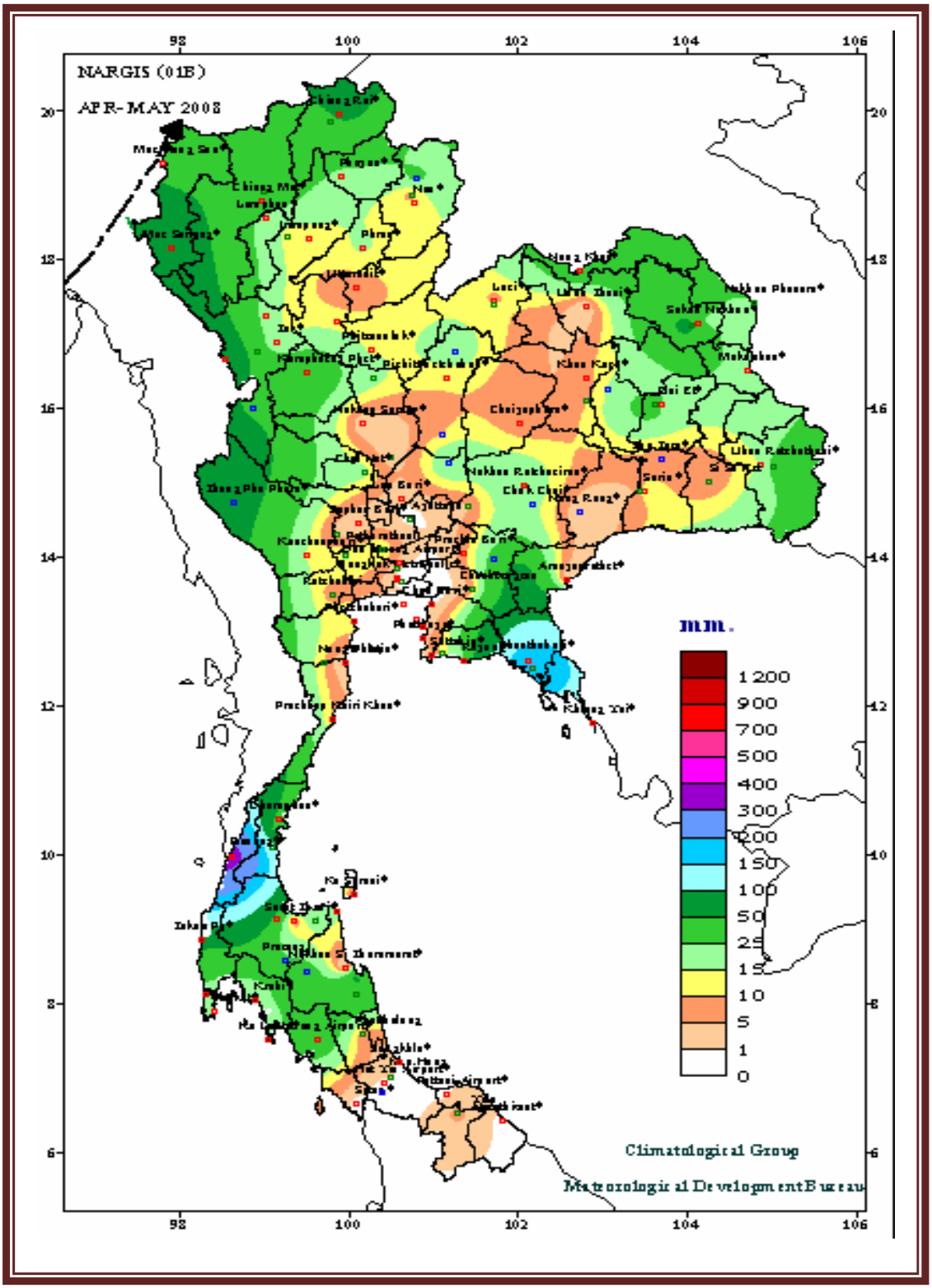

Figure 3 Spatial rainfall distributions during 2nd - 4th May 2008

During 8th – 10th August 2008, tropical storm 'KAMMURI' moved northwesterly from the South China Sea and made landfall in the north of Viet Nam. It then moved and dissipated in Yunnan of China. On the same period, an active low pressure cell in Inter-Tropical Convergence Zone (ITCZ) covered over the north and northeast of Thailand. The impacts of tropical storm 'KAMMURI' and ITCZ caused abundant rainfall in Yunnan of China, north of Viet Nam, north of Lao P.D.R. and partially north of Myanmar where all mentioned areas are in the Upper Mekong River Basin, thereafter water level in the Mekong River dangerously increased to high and flooded levels starting from Luang Prabang and Vientiane in Lao P.D.R. and Nong Khai, Nakhon Phanom and Mukdahan in Thailand.

The combined effects of tropical storm 'KAMMURI' and ITCZ caused severe flash floods and floods as follows:

1) In the north part, floods were reported in 6 districts of Chiang Rai province, both urban and cultivated areas. Severe flash flood with 1 meter height of water level over the bank of the Yom River in Phrae province same as the Nan River where water level over flew and higher than the river bank about 0.4 – 0.7 meter in 6 provinces in the Nan River Basin. The historical park and city of Sukhothai province were also flooded from the Yom River while 1,500 ha of cultivated and urban areas of Uthai Thani province were also reported with flash flood and floods.
2) In the northeast part, floods were reported in 12 districts of Nakhon Phanom province and seriously affected 43,627 ha of urban and cultivated areas while Nong Khai province was reported more seriously damaged than Nakhon Phanom in 18 districts and areas of about 333,272 ha. There were also slightly affected in urban areas of Loei and Mukdahan provinces.
3) Even quieted faraway from dominated areas of tropical storm and ITCZ, however floods were reported over the south in Nakhon Srithammarat and Satoon provinces.

According to general situation of weather patterns when trough and ITCZ covered North, northeast and central parts of Thailand during 6 - 11 September 2008, flash flood and floods were reported in Tak, Mae Hong Son, Sukhothai, Phetchaboon, Phichit, Phitsanulok, Loei and Chaiyaphum provinces. Moreover, serious damaged were reported in Khon Kaen, Mahasarakam, Roi Et, Kalasin, Nong Khai, Udon Thani, Nong Bua Lamphu, Nakhon Ratchasima, Sri Saket, Prachinburi, Chonburi, Chacherngsao, Trad, Saraburi, Lopburi and Phranakhon Sri Ayudhya provinces. These impacts combined with the influence of tropical storm 'MEKKHALA' that moved into and covered Thailand during 28 September to 1 October 2008. The spatial distributions of rainfall are shown in Figure 4.

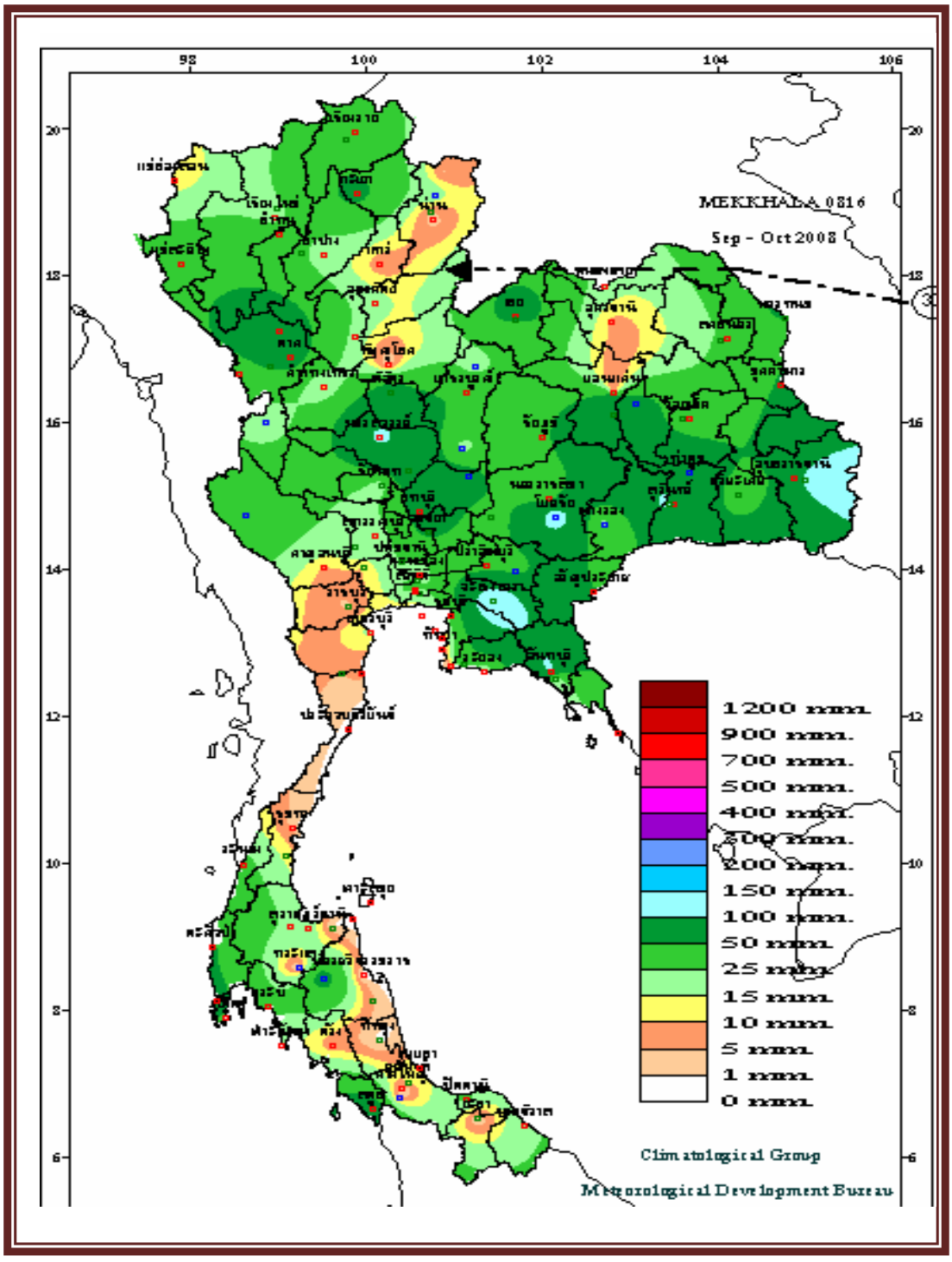

Figure 4 Spatial distributions of rainfall during September – October 2008

a. Improvement of facilities

Royal Irrigation Department (RID) has strategies for flood prevention and mitigation with aims to reduce the loss of lives and properties of population at risk, and also impacts in urban and cultivated areas. Management plans were set in terms of monitoring, prediction and warning by establishment of Water Watch and Monitoring System for Warning Center (WMSC) to monitor flood situations 24 hours. In addition, the collaborations with national related agencies for implementation plan to cope with local flood protections in economic zones where severe flood may be occurred. The state-of-art technologies were established, such as telemetry systems for water resources management and flood prevention and mitigation.

Department of Water Resources (DWR) established Water Crisis Prevention Center (WCPC) named 'MEKKHALA' since 2005 and developed an operational system for flash flood and landslide warning system over the mountain and highland areas. The conceptual designed the alert activation systems when heavy rainfall was reported and water levels in the rivers or basins were reported to critical and alarm stages and warning will be sent with light signals in green > yellow > red, like a traffic signal, to subscribers and communities in real time. DWR installed the systems in 458 villages of 2370 villages in disaster risk areas. In 2008, 95 villages were reported to install this system in Prachinburi and Chanthaburi provinces of the east part, Ratchaburi and Prachuabkhirikhan provinces of the west and upper of the south parts, including Nan, Phrae and Chiang Mai provinces in the north.

b. Technical advancement

Thai Meteorological Depart (TMD) launched to projects to support hydrological activities as follows: 1) Quantitative Precipitation Estimate (QPE) using Radar-Rainfall Observations, 2) Flood forecasting using MIKE 11 Model for flood inundation mapping over designed river basins.

Royal Irrigation Department (RID) established telemetry systems for flood forecasting and warning in the Upper Ping Watershed, such as Mae Tang regulator, Mae Ping regulator, medium size reservoir at Mae Ngat Somboonchon Dam and Mae Kuang Udomthara Project. These implemented projects can partially relief floods over the Ping River basin, however urban of Chiang Mai municipal was still damaged from heavy rainfall and over-bank flows every year. Therefore, RID initiated to implement telemetry project and flood warning system over the Upper Ping Watershed of 9,733 sq.km. areas, from Vieng Haeng district of Chiang

Mai to Nong Saleak regulator in Muang district of Lamphun where the Ping River merged with the Kuang River before running to the mainstream of the Ping River to the Bhumibhol Dam in Tak province. These projects aim to monitor the affected urban areas in Muang, Mae Tang, Sun Kamphaeng districts of Chiang Mai province and Muang district of Lamphun province, respectively. The project components included: 1) flood foresting system by MIKE 11 and MIKE GIS, 2) Database and website development, 3) flood watch and management model developed by Delft Hydrological Institute (DHI) for water and environment, 4) 12 stations of telemetry in the field plus 1 station at Chiang Mai downtown, running by SCADA. The projects now were completed and are in the validation and further implementation phases.

c. Research achievements

Department of Water Resources (DWR) set up the research topics for its implementation as follows: 1) Delineation of river basin boundaries (25 major river basins, including 254 sub-basins), 2) Integrated Water Resources Management (IWRM) in the Nam Yom river basin, 3) Study on Social Model for Water Conflict in Bang Pakong river basin, 4) API application for flash floods and landslides, 5) Developments of participatory process to empower local community in Water Resources Management: a case study in Mun river basin, 6) Study on the risk factors and community livelihood in flood and landslide hazardous areas: a case study in Nam Yom river basin.

d. Training achievements

National training

Department of Water Resources (DWR) conducted two training courses as follows: 1) Training on Telemetry and InfoWorks & FloodWorks Model, 24 April – 2 May 2008, Bangkok, 2) Training on standard procedures on hydrological survey, 23-25 June 2008, Kanchanaburi.

Oversea training

Thai Meteorological Department (TMD) dispatched staffs to attend training in overseas as following courses: 1) Operation Flood Forecasting System and Its Analysis (OTFSIA) in China, 2) Expert on Flood-Related Disaster Mitigation, in Japan.

Remarks: Hydrological training for other agencies may not include in this report

e. Regional cooperation achievements

Thailand by TMD and Viet Nam by NHMS has collaboration on Joint Research Project on Remote Sensing: Using the Geo-Informatics Technology for Flood Risk Areas Management.

Department of Water Resources (DWR) has cooperation with Mekong River Commission (MRC) and member countries (Cambodia, Lao PDR, Thailand and Viet Nam) to improve the hydro-meteorological monitoring network in the Mekong Mainstream under the Appropriate Hydrological Network Improvement Project (AHNIP), and Mekong Hydrological Cycle Observation System (Mekong-HYCOS) Project for Basin Development Plan (BDP), Water Utilization Programme (WUP), Environment Programme (EP), Flood Management and Mitigation Programme (FMMP), and Drought Management Programme. Now, MRC and member countries start up Integrated Knowledge Management Programme (IKMP) for Integrated Water Resources Management.

Department of Water Resources (DWR) as Thailand National Committee for the International Hydrological Programme (IHP) presents its support to the proposal framework for the IHP-VII. Specific issues which shall be highlighted are following: 1) Methodologies for integrated river basin management, 2) Promotion of public awareness raising on water management, 3) Institutional development and networking for WET, 4) Guidelines on the sustainable and Integrated Water Management with due consideration to public's living quality and participation, 5) Increasing available sources of water by improving both existing natural and man-made sources, 6) Flood and Drought Management.

Department of Water Resources (DWR) has its collaboration as follows: 1) APN Inter-government on Global Change, 2) Convention on Climate Change, 3) ASEM WaterNET, 4) Network of Asian River Basin Organization (NARBO), 5) ASEAN Working Group on Water Resources Management, 6) ADB on Challenge Programme on Water and Flood (CPWF).

Department of Water Resources (DWR) has other initiatives as follows: 1) Hydro-Agronomic-Economics Model for Mekong River Basin, and Local Adaptation in Thailand and Lao PDR under ADB supports, 2) The impacts study of Climate Change on Irrigation systems and its adaptation measures in collaboration with Japan Institute of Irrigation and Drainage (JIID).

4. DISASTER PREVENTION AND PREPAREDNESS COMPONENT

a. Overview of Department of Disaster Prevention and Mitigation (DDPM)

Disaster management in Thailand took on the new phase in October 2002 when the government decided to re-structure the government organizations. New ministries and departments were established, including the consolidation of scattered disaster related agencies to form a new department as Department of Disaster Prevention and Mitigation (DDPM) under Ministry of Interior, to serve as a national disaster management organization. On 7 November 2007, the new Disaster Prevention and Mitigation Act B.E. 2550 was enacted and came into force and significantly changed Thailand Disaster Management System, particularly on the re-structure of the National Disaster Management Committee to increase efficiency and improve the inter-ministries coordination. The structure of the new national committee for disaster management in Thailand chaired by Prime Minister or designed Deputy Prime Minister, and Minister of Ministry of Interior as the Vice Chairperson, and the Permanent Secretary of Ministry of Interior as the second Vice Chairperson. The flowchart of committee members as shown in Figure 5

As one of the intermediary agencies in Thailand Disaster Management, DDPM is primary responsible for imposing and implementing program policy, formulating operational guidelines and establishing criteria on disaster management. In addition, DDPM still organizes and conducts training activities which are related to all disaster management by collaboration with local and international organizations.

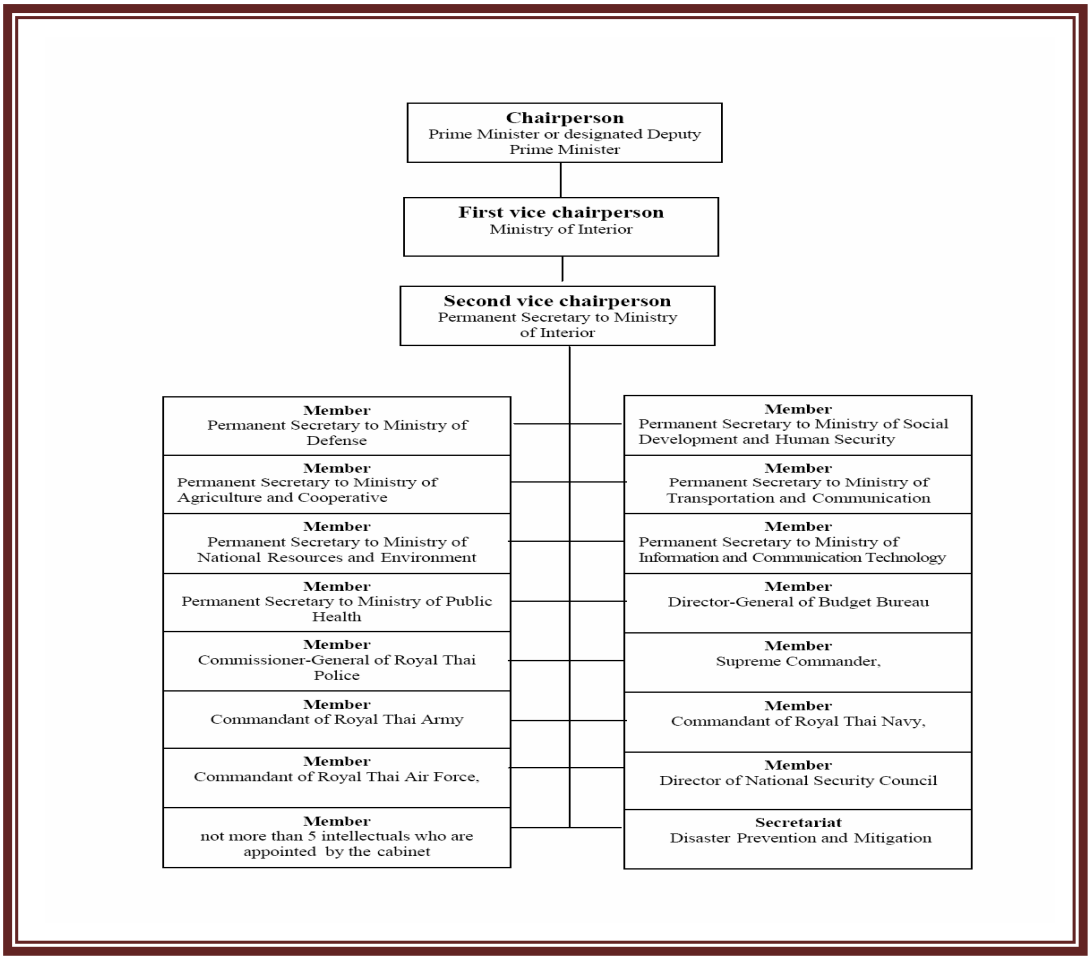

Figure 5 Structure of National Committee for Thailand Disaster Management

Recently, Disaster Management in Thailand has been focused on preparedness activities to reduce the vulnerability impacts and increase the resilience in disaster prone areas, as well as general public using Community-Based Disaster Risk Management (CBDRM) approaches. As the intermediary government agency, DDPM in cooperation with all national involved agencies has initiated various successful projects, such as CBDRM, One Tambon (Sub-district) One Search and Rescue Team (OTOS), Mr. Disaster Warning, and Civil Defense Volunteers (CDVs). The structure of institutional and agencies' operation procedures for disaster prevention and mitigation management in Thailand as shown in Figure 6 with flowcharts of command lines in Figure 7, respectively.

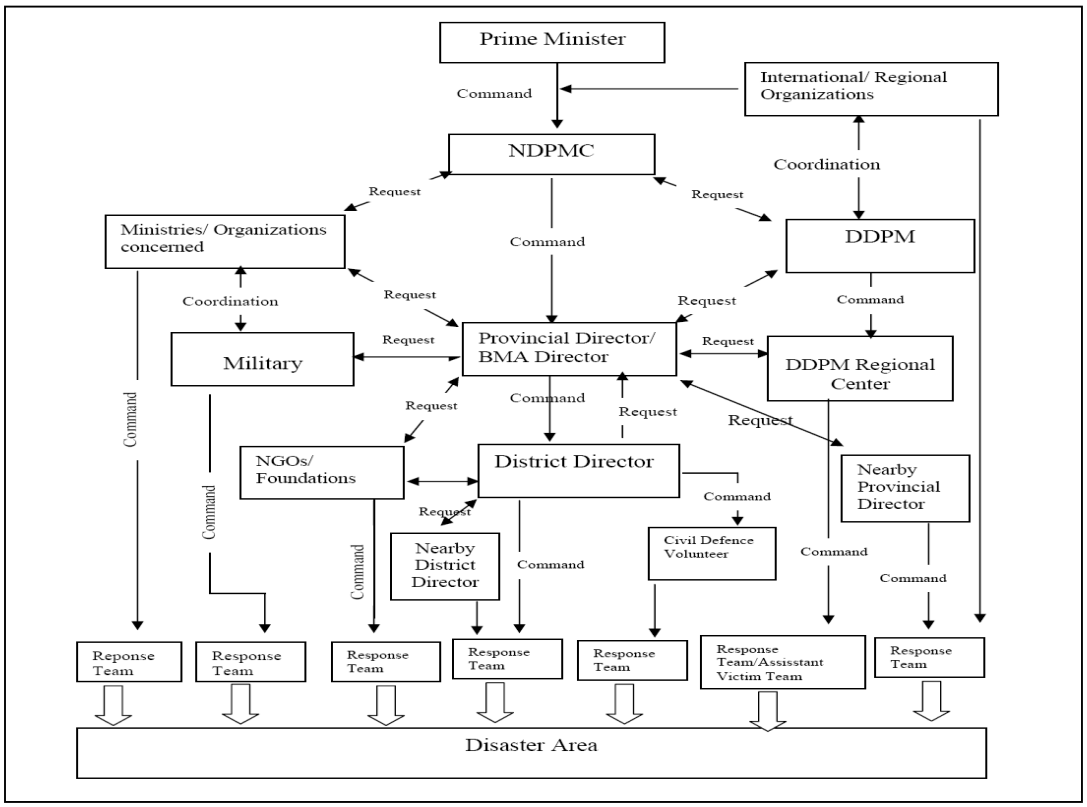

Figure 6 structure of institutional and agencies' operation procedures for disaster prevention and mitigation management in Thailand

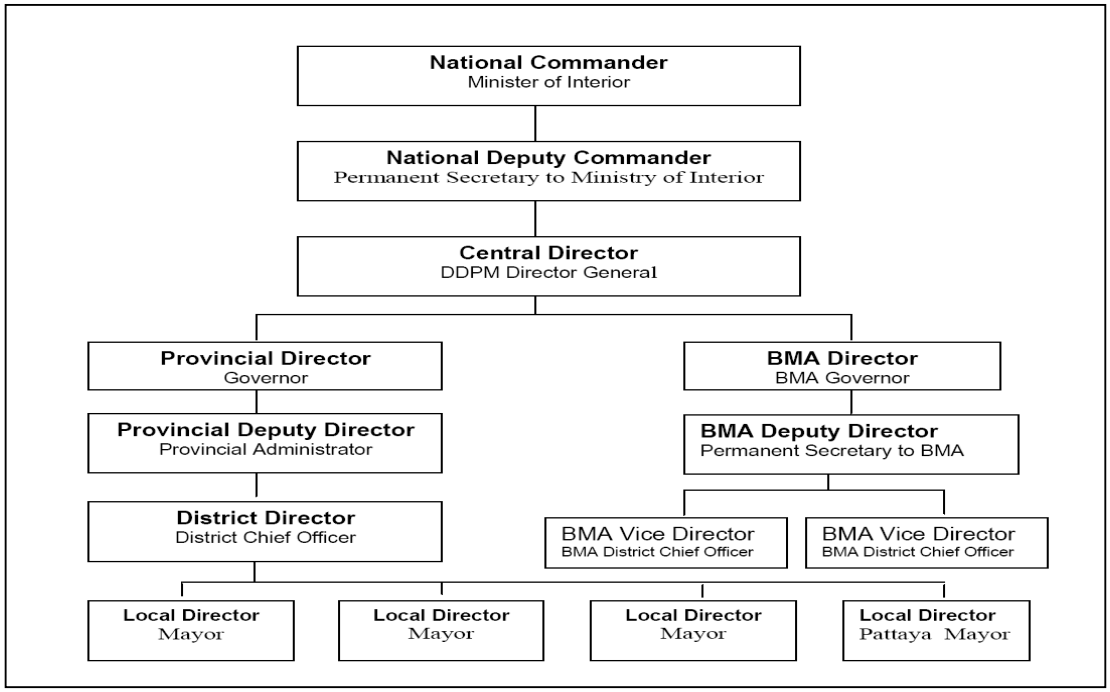

Figure 7 Command Lines in National Disaster Management in Thailand

b. Structure of Disaster Management System

In Thailand, the structure of disaster prevention and mitigation system was divided into 3 levels as shown in Figure 6 and Figure 7, as policy level, command level and operational level while national prevention and mitigation plan has significantly changed to the Disaster Prevention and Mitigation Act 2007. Under the present Act 2007, the Disaster Prevention and Mitigation Committee are responsible for formulation of national disaster prevention and mitigation plan. The substantial of the national plan shall comprise as follows: 1) Guideline, measures budget allocations systemically and continuously, 2) Guideline the method to assist the victims in short and long terms for evacuation of effected people with providing of public health and solving problems for communications and utilities, 3) Concerned government agencies and local agencies have to follow the procedures and instructions which were advised by 1 and 2, 4) Guideline for assessment of resources preparedness and operation system, including capacity building of staffs and people at risks, 5) Guideline to effected people on reconstruction, recovery and rehabilitation. Schematic for Formulation of Disaster Prevention and Mitigation Plan for Thailand is shown in Figure 8.

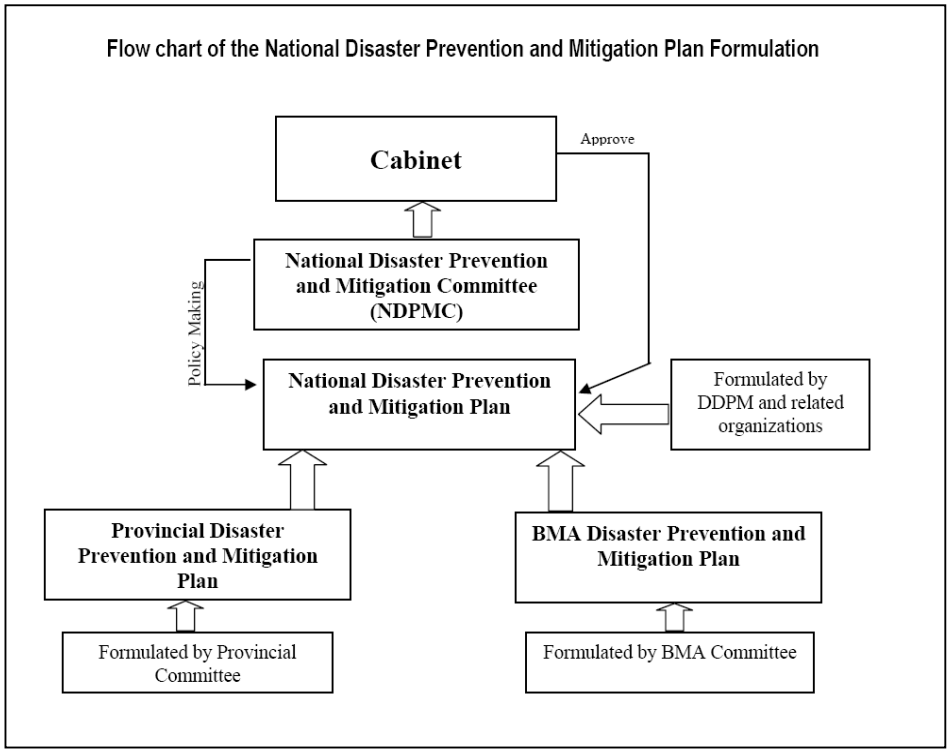

Figure 8 Flowchart Formulations of National Disaster Prevention and Mitigation Plan

c. Strategic Action Plan (SNAP) for Disaster Risk Reduction

The strategic plan on disaster risk reduction has been recognized as essential implementation plan to minimize the incidents, consequently, and DDPM cooperated with the United Nations International Strategy for Disaster Reduction (UNISDR) and Asian Disaster Preparedness Centre (ADPC) to formulate Strategic Action Plan (SNAP) for the country and set up a Working Group with is consisted of representatives of concerned government agencies, experts and private sector to draft the plan and process to submit to the Cabinet for approval as described in above for formulations. In Thailand, the early warning system can divide into 2 levels: 1) National level with various of national agencies, such as TMD, RID, DWR, and Disaster Forecasting and Warning of Electricity Generating Authority of Thailand (EGAT) to take their responsibilities for relevant tasks of disaster warning by their own functions. Early Warning Information from these agencies will disseminate to public via mass media and to DDPM, thereafter in a short or near real time, will disseminate all warning information through the mechanism of Ministry of Interior to province > district > local organization > communities > people at risks.

Now, DDPM has established 18 Regional Centers for Disaster Prevention and Mitigation, and 75 Provincial Offices over the country. Regional Centers and Provincial Offices will carry out the task in the front lines while DDPM will cooperate with concerned agencies, private sectors to perform the key tasks. DDPM has also cooperated with various international organizations, such as ADRC, ADPC, JICA, GTZ, UNDP, UNISDR, UNOCHA, UNEP, etc., to mobilize technologies and know-how for experiences and information sharing.

d. Community-Based Disaster Risk Management (CBDRM)

Thailand has realized that it is essential to improve public safety, particularly for people who are in the risk areas. CBDRM approach is to reduce vulnerabilities and to strengthen capacity for people to cope with the disaster risk. Therefore, CBDRM has been applied to generate the awareness and also to implant the culture of safety in disaster prone areas. Cooperation with local agencies, such as Thai Red Cross, Local Authority Department and various international agencies which previously described. It has attracted the intervention of people in communities to participate in holistic disaster management.
During 2003-2008, DDPM has continuously launched CBDRM training with more than 30,000 participants from 3,354 villages in 75 provinces.

DDPM initiated Flash Flood and Mudslide Warning Program to enhance capacity of people for risk assessment and early warning. In collaboration with Department of Provincial Administration, Department of Local Administration, TMD, National Park, Wildlife and Plant Conservation Department, and National Disaster Warning Centre to design 'Mr. Disaster Warning' training course which aims to create disaster warning network, particularly in flash flood and mudslide prone villages. 'Mr. Disaster Warning' is the village volunteer who has been selected and trained to function as a vigilant, a forewarner and also a coordinator, with number of 7,817 people in flood prone areas were trained under this programme.

DDPM has recognized the urgent need to establish a range of search and rescue capacities at national, provincial and particularly in local level. Since 2004, DDPM has launched the 'One Tambon (sub-district) One Search and Rescue Team (OTOS) Programme' which will be resulted in the establishment, training and long-term maintenance of specially trained search and rescue team in every tambon community. OTOS programme has completed in 2008, and search and rescue (SAR) team with 10 members based in 7,255 tambons throughout the country.

e. DDPM Training Achievements

DDPM established Disaster Prevention and Mitigation Academy (DPMA) since October 2004 as National Training Centre for Disaster Management. DDPM cooperated with various agencies both national and international organizations in developed countries to develop curriculum and mobilize technology, including know-how for standard training. The course will be conducted to serve government officers, local administration officers, private sectors who are in charge of disaster managements, including civil defense volunteers for increasing of their capacities. DPMA has extended to 6 campuses in upcountry. The standard curriculum consists of Fire Fighting, Building Collapse (Search and Rescue), Hazmat Emergency Management, Civil Defense Volunteer and Disaster Management.

Civil Defense Volunteer is important resources in operation level which will be recruited from local residents who are over 18 years old and will be trained on the course for consecutively 5 days. Their functions are to holistically assist the government's operation in all types of disaster. As of 31 October 2008, there are approximately 1 million Civil Defense Volunteers in the country.

Youth Volunteer Camp for Disaster Prevention and Mitigation Project

King of Thailand always concern about his people and provide assistance whenever they need especially when disaster occurs. To reciprocate and commemorate His Majesty the King's 80th Birthday Anniversary, therefore Department of Disaster Prevention and Mitigation had launched a project entitled "Youth Volunteer Camp for Disaster Prevention and Mitigation Project to the Auspicious Occasion of His Majesty the King's 80th Birthday Anniversary, 5th December 2007"on 5th December 2007. This project focused on encouraging the secondary school to have safety mind and safety culture which will help to reduce loss of life and promote disaster prevention and mitigation among younger population. The main objective is to provide knowledge and understanding of disaster prevention, mitigation, and implementation when disaster strikes school area. The goal of this youth camp is to train youth volunteer for disaster prevention and mitigation in order to make them a key player in promoting Community Based Disaster Risk Management and participating in a support team for One Tambon One Search and Rescue Team (OTOS). As a result, there were 1,371 youth trained in 2007 and 1,477 youth trained in 2008.

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WMO

WORLD METEOROLOGICAL ORGANIZATION

AND

ECONOMIC AND SOCIAL COMMISSION FOR ASIA AND THE PACIFIC

ESCAP

COORDINATED TECHNICAL PLAN

(2009-2011)

WMO/ESCAP PANEL ON TROPICAL CYCLONES

APPENDIX VI

DRAFT COORDINATED TECHNICAL PLAN (CTP)
2009 - 2011

Submitted by
Dr Qamar-uz-Zaman Chaudry
Chairperson of the PTC Policy Working Group

1. INTRODUCTION AND BACKGROUND

Hydro-meteorological disasters account for approximately 70-80% of disaster losses in the world. Among them, tropical cyclone associated disasters remain to be serious threats to people in both developed and developing countries in the tropical cyclone prone regions. This is obviously true for the North Indian Ocean region, where the devastating disasters repeated during the past decades proved that this region is extremely vulnerable to the tropical cyclone risks. The recent serious losses caused by Cyclone Sidr in Bangladesh in November 2007 and Cyclone Nargis in Myanmar in May 2008 sent us a sharp reminder of the urgency to reduce the vulnerability. Also, Cyclone Gonu which took an unusual track and caused serious damages in Oman and the Islamic Republic of Iran in June 2007 awakened authorities in the Gulf States to pay more attention to tropical cyclones and triggered discussions concerning the relationship between ongoing climate change and the courses and strength of tropical cyclones in the Arabian Sea.

WMO/ESCAP Panel on Tropical Cyclones for the Bay of Bengal and Arabian Sea has been exerting its effort to mitigate the impact of tropical cyclones in this region since its inauguration in 1973. The Panel's activities are fundamental contribution to improving the regional and national resilience against the tropical cyclone threats. In view of the growing demand for further mitigation of tropical cyclone disasters in this region as well as enhancement of visibility of its activities, the Panel decided to review its Coordinated Technical Plan (CTP) at its 29th session in 2002. The present CTP (2009-2011) has been developed based on the general framework of CTP adopted at the 31st session and the draft CTP submitted to the 32nd session by Ahmed Hamoud Mohamed Al-Harthy (Oman), Chair of the CTP Working Group. It also took into account Hyogo Framework for Action (2005-2015) adopted during the World Conference on Disaster Reduction in 2005, the WMO Strategic Plan and the Strategic Plan for the Enhancement of National Meteorological and Hydrological Services in Regional Association II (2009-2011).

1.1 Panel Region

Currently, the Panel is composed of eight Members; Bangladesh, India, Maldives, Myanmar, Oman, Pakistan, Sri Lanka and Thailand.

The Panel region covers a vast expanse of the North Indian Ocean and contains a large and diverse range of ecosystems, including deserts, forests, rivers, lakes and seas. The desert extends from Oman into Pakistan and northwest India. Compared to other WMO tropical cyclone regions, this region includes the highest mountains, the rainiest areas and the driest deserts, with their associated variation in culture and biodiversity. Over the long period of human occupation in the region, exploitation of natural resources, urbanization, industrialization and economic development have led to land degradation and environmental pollution. Climate change and climate variations also represent future stress.

Tropical cyclone warning services of the Members vary in duties, size and status of advancement, geography and state of development. Therefore, they are highly differentiated in capabilities and vulnerabilities. Some Members have very advanced facilities while others have limited budgets; shortage of observation instruments, spare parts, consumables; lack of

calibration, data collection, processing and communication facilities; insufficient qualified staff; and old technology.

1.2 Vision and mission of the Panel

Vision of the Panel

To promote and coordinate the planning and implementation of the measures required to minimize damage caused by tropical cyclones and associated floods and storm surges in the Bay of Bengal and the Arabian Sea.

Mission of the Panel

a. *To review regularly the progress made in the various fields.*

b. *To recommend measures to improve the multi-hazard early warning systems in the Bay of Bengal and the Arabian Sea, including necessary training and research, with regard to meteorological, hydrological and other ocean hazards such as storm surges and tsunamis*

c. *To recommend measures to improve telecommunication system to ensure timely provision of warnings for community preparedness and disaster risk management.*

d. *To advise on possible sources of financial and technical support for such measures.*

e. *To coordinate the activities among the Panel Members, including all other activities carried out as part of or in conjunction with the WMO and regional tropical cyclone programmes.*

1.3 Priorities of the Panel

The Panel agreed that the following as priority issues:

a. Maintenance and further development of existing observing and telecommunications systems and data processing facilities for better information sharing;

b. Natural disaster reduction, mitigation and prevention through the implementation of improved detection, prediction and warning systems of tropical cyclones, depressions and associated storm-surge and flash floods etc., and tsunamis;

c. Implementation of CTP to provide better services to the public, governments and users, through improved infrastructure and by modern technology in a user-friendly manner;

d. Enhancement of capacity building, including technology transfer and human resources development, to bridge the gap between the Members through bilateral and multilateral arrangements;

e. Enhancement of the collaboration and cooperation among the Members and RSMC New Delhi by exchange of information and knowledge and research studies related to tropical cyclone including numerical modeling;

f. Encouragement to improve hydrological forecasting and warning services for flood prone areas;

g. Encouragement to plan and manage water resources, including assessment of surface and ground water resources in relation to tropical cyclones;

h. Improvement of the operational linkages between hydrological and meteorological services and disaster management agencies with the aim to minimize the impacts of natural disasters;

i. Improvement of the capacity of early warning dissemination and response to the warning at the national and community levels;

j. Facilitation of tropical cyclone disaster risk assessment at the country level, especially along the coast, delta, and urban areas where risks are the highest;

k. Increase of tropical cyclone risk awareness at the community level through awareness events, school education, trainings, and drills where technical knowledge could be properly supplied and adopted by authorities;

l. Strengthening information exchange with various disaster-related information systems in the region;

m. Strengthening partnerships with relevant international and regional bodies, such as ISDR, UNDP, UNESCO/IOC, UNEP, ESCWA, ASEAN, SAARC, IFRC, ADRC, ADPC, ICHARM, JICA, KOICA, TICA, USAID, ADB, and WB;

n. Enhancement of resource mobilization activities for implementation of CTP.

1.4 Challenges and Opportunities

Panel is facing challenges and opportunities that have been raised in recent years in its implementation of the activities to fulfill its vision, such as rapid changes in technology, globalization, commercialization, urbanization, and emerging scientific research results. This section identifies in broad terms the challenges and opportunities of which the Panel Members could take advantage through a strategic regional approach.

Meteorology

(1) Observation systems

Observation systems are fundamental to the operations of National Meteorological and Hydrological Services (NMHSs). Standardization of observation ensures that data collected by each country are compatible with other countries. This includes accuracy, instrument response times and other characteristics of instruments, frequency of observations, exposure, network densities and other related matters.

The existing gaps in the observational data coverage of the Panel region continues to be due to the deficiencies in the operations of both observing and telecommunication networks, high cost and therefore the lack of consumables and spare parts.

New types of earth observing satellites including meteorological satellites which are useful to weather monitoring, forecasting, and research have been launched from time to time. However, no single receiving system is capable of receiving and processing the data from all these satellites. This poses difficulty to some Members that may not afford to have more than one satellite receiver. It would be useful if imageries and data from different satellites can be put under and distributed through one or two low cost distribution channels.

(2) Telecommunication

The collection of observational data within each country and the exchange of observational data and processed information between countries are made through the

WMO Information System (WIS). The WIS includes the GTS for time-critical and operation-critical data exchange, and the data discovery, access and retrieval service through the Internet.

The GTS part includes the national meteorological telecommunication networks (NMTNs) and the regional meteorological telecommunication networks (RMTNs), respectively. The NMTNs are implemented and operated by each country according to both the telecommunication services available and the financial and technical capacities of each country.

The implementation of RMTN circuits in the region has made significant progress, in particular the implementation of the IMTN plan for MTN circuits in the region according to CBS plans; the upgrade of a number of regional circuits to Frame Relay circuits in the southeastern part of the region; the upgrade of a number of regional circuits to 64 kbit/s digital leased circuits, in particular in the area of responsibility of regional telecommunication hub (RTH) Jeddah; the upgrade of a number of regional circuits to V.34 (19.2-33.6 kbit/s) leased circuits in the northern part of the region; upgrades of data-dissemination systems by the replacement of an HF radiobroadcast by satellite–based systems using DVB or DAB techniques (such as operated by RTH Jeddah, RTH New Delhi and in the TV-Inform-Meteo system operated by WMC/RTH Moscow); and the introduction of the TCP/IP procedures.

However, there are still a number of shortcomings in the RMTN. In particular, four NMCs were only connected by GTS connections operating at low speeds (Colombo, Katmandu, Male and Yangon); five NMCs have no connection to the GTS (Baghdad, Dushanbe, Kabul, Phnom Penh and Sana); and a number of regional circuits were operating at low speed, with a very low cost-effectiveness.

(3) Data-processing and forecasting systems

While there had been considerable improvements in the infrastructure and models in some Global Data Processing and Forecasting System (GDPFS) centers of the Region, there are still large deficiencies in the capabilities of some Members in their forecasting function, i.e., the production of forecasts and warnings. Some of the data processing systems of NMHSs have not been automated and the Members concerned were not able to derive full benefits from the technological advances that have taken place in the recent past. Some GDPFS centers in the Region still plot stations and produce weather charts manually.

As regards the generation and dissemination of the GDPFS products, Regional Specialized Meteorological Centre (RSMC) New Delhi produces a large number of products on a daily basis. The availability on the Internet of high-quality products from advanced high-resolution NWP systems operated by major GDPFS centers within and outside the Region has opened up new opportunities for NMHSs to enhance their capability in providing weather forecast service to their respective users

Hydrology and Water resources

Freshwater is a natural resource vital to the survival of all living things; however, it is limited. The sources of freshwater are river basins, groundwater reserves, lakes and manmade reservoirs. These are increasingly under pressure to meet increased domestic needs as well as demands from agriculture, industry and other human activities.

Weather is the most important factor in water availability as it determines the timing and the location of precipitation and the amount lost to evaporation. Some arid countries in the region like Oman, Southern Pakistan and Northwestern India have such low precipitation (as little as a few millimeters per year) and high evaporation, that only a small amount of freshwater can be captured for human use. By contrast, some countries receive abundant rainfall each year (thousands of millimeters). Seasonality is particularly pronounced

throughout the region and, in most cases, plays a major role in water availability; those countries which receive high rainfall - Bangladesh and India for example - are inundated with rainfall during the monsoon season, but lack rainfall the rest of the year.

This seasonality problem can be tackled by preventing the precipitation during the wet season from running off into the sea. The traditional method of rain harvesting, that is, retaining water through construction of ponds/lakes etc in individual villages or towns could ensure the optimum use of precipitation. Many demonstration projects have established that with proper storage techniques, rainfall during a season could be utilized throughout the year for agriculture and other human activities. It is such mini projects, rather than big dams, that are most cost-effective in conserving fresh water resources.

At the other end, for countries suffering from rain shortage, the conduct of cloud physics and precipitation enhancement projects should be encouraged, if feasible, in a collaborative basis.

The decline of hydrological networks in the region is a challenge at a time when more high quality hydrological data are required, often in near real time. Hydrological networks need to be improved together with the capacity of Hydrological Services to provide relevant information to a variety of users of hydrological data. In this respect, the need for improving forecasting systems particularly to predict floods and droughts that could lead to disasters is a high priority in the region. The management of international rivers in the region is a most challenging problem as well. In the context of integrated water resources management, the joint management of river basins opens a window of opportunity for transnational collaboration in hydrology.

The potential extension of several HYCOS projects into the region are expected to foster this process and contribute to the capacity building of National Hydrological Services as well as integrated water resources management on the basis of timely, reliable hydrological data. Especially for prediction and forecasting of extreme events, the data collection and forecasting capacities of the meteorological and hydrological branches of national Services need to be integrated to provide the results required by the general public.

Likewise, the introduction of rational water resources assessment methods, promoted by WMO and the United Nations Educational, Scientific and Cultural Organization (UNESCO), are expected to enhance the capacity of National Hydrological Services in the region to act as service providers for planning, decision-making and implementation of water resources projects. A crucial issue for much needed regional collaboration between national Hydrological Services is the free exchange of hydrological data and information which has been documented in Resolution 25 of the Thirteenth Congress of WMO.

Disaster Prevention and Preparedness

The Panel region is one of the most disaster prone regions in the world. It has a very high frequency of disaster events and suffers from immense damage due to various types of disaster such as tropical cyclones, storm surges, floods, landslides, drought, earthquakes, volcanic eruptions, tsunamis, etc.

A large percentage of these disasters has occurred in many countries of the Region. A rapid urbanization, high population increase rates, and high population densities without reducing the poverty levels led their societies to be with high vulnerability to disasters, resulting in heavy loss of life and property damage. A single cyclone in 1970 caused approximately 300,000 deaths and another one in 1991 caused 130,000 deaths in Bangladesh. More recently, the Cyclone Sidr in Bangladesh caused more than 4,000 deaths in 2007 and the Cyclone Nargis in Myanmar caused more than 130,000 deaths in 2008. Such losses significantly interrupt the sustainable development of the countries in the Region, and it is highly expected to build disaster resilient communities in the countries. The

Disaster Prevention and Preparedness component of the CTP will aim at reducing tropical cyclone disaster risks at the community level by enhancing the local capacities to cope with the risks.

(1) Tropical cyclone related disaster risks

In the Bay of Bengal, tropical cyclones usually form over the southern end then move either towards the east coast of India, or to Bangladesh. A few tropical cyclones form in the Arabian Sea and move to the north affecting the western part of India, southern Pakistan and Oman. These tropical cyclones can generate very heavy rainfall and cause severe flooding and landslides, high wind and waves, and are often accompanied by devastating storm surges which are the most common risk factor to the tropical cyclone deaths.

(2) Regional technical coordination on tropical cyclones

Regional cooperation and coordination in disaster prevention and mitigation among the Members are gaining importance in the region. Indian Meteorological Department was designated by WMO a Regional Specialized Meteorological Centre (RSMC) to monitor and forecast the track and intensity of all tropical cyclones in this region, to provide the track and intensity information to the international community, and to provide real-time advisory information and guidance to NMSs in the region.

The WMO Fourteenth Congress has approved an Inter-Commission approach in formulating a strategy for natural disaster reduction “Marine Impacts on Lowland Agriculture and Coastal Resources (MILAC). Accurate forecasting of storm surges due to tropical cyclones in the Bay of Bengal has been proposed to be undertaken as a demonstration project which on completion would lead to dramatic reduction in loss of life and property due to these tropical cyclones. The TCP in cooperation with JCOMM had also organized two workshops in 2002 and 2003 on the forecasting of tropical cyclones, storm surges and waves in the South China Sea. Steps have been taken to organize in China (July 2005) the Third Workshop on Storm Surges, Waves and Ocean Circulation Forecasting in the South China Sea and Bay of Bengal areas.

(3) Disaster risk reduction

Accurate and timely tropical cyclone forecast and warning issued by the NMHSs is crucial information to reduce risks. The challenge is that such information needs to be reached to the communities at risk for prompt actions. This is quite a challenge, especially rural areas in developing countries where the communication system is limited. Even reached on time, false information or technical information lacking clear directions and guidance for a specific location may mislead response to the warning and hinder people’s willingness to take actions for the next events. It is vital to understand the perception of individual and collective behaviors when receiving the warning. Another important issue is whether people have a safe place when responding to the warning. Without such places, people would be ended up facing the risks. Whether they could move quickly to the safe place is additional issue, in particular, for infants, small children, the elderly, and the handicapped.

Structural measures such as building a cyclone shelter have been very effective to save lives in Bangladesh although the number of shelters is not enough to accommodate all the people. Some old shelters do not function due to problems with their structure and foundation. Some people do not evacuate to the shelter without their livestock. Some people do not evacuate for looters. Furthermore, cyclone shelters would save people’s lives but do not reduce economic losses. A complete early warning system must take into consideration of the above issues in a planning stage.

The National Disaster Management Offices have an important role here. Not only functioning during the emergency period during and after a disaster, they need to invest their resources for prevention and preparedness. Such actions include the following elements: contingency planning, trainings and drills, public awareness, public education, coordination with different institutions at the different levels, mass media, etc. The Panel would provide an excellent opportunity to share practices among Members.

Capacity Building

In considering the rapid changes in technology and the social, political and economic circumstances in addition to the global environmental issues, Members need to respond to these challenges in such a way as to enable them to properly manage their meteorological and hydrological services, and to have qualified and trained manpower and adequate facilities. Therefore, proper management, continuing training and development are important for the advancement of those services.

With RSMC New Delhi and Indian Institute of Technology (IIT), New Delhi may continue supporting the plans and requirements related to capacity building and transfer of technology in close cooperation with the Members.

Capacity building is to be underpinned by infrastructure and human resource development through training and technology transfer in the areas of:

a. Forecasting of tropical cyclone intensity and track, and associated storm surge
b. Observing and processing data and interpretation of outputs from regional centres;
c. Information and communication technology (ICT);
d. Equipment maintenance;
e. Provision of weather services for the public, including service-oriented media/communication skills;
f. Provision of weather services for aviation and shipping, including marketing of services and liaison with clients;
g. Provision of climate information services;
h. Application of NWP products;
i. Nowcasting of severe weather; and
j. High level and middle management skills.

Training through fellowships, seminars and workshops with assistance from outside the region needs to be also intensified.

1.5 International and regional projects relevant to the Panel's activities

The following international/ regional projects with significant potential benefits to Members especially the developing ones are worth pursuing:

(a) Establishment of an Early Warning System for Tsunamis

After the devastating tsunami which affected most of the countries of the Panel towards the end of December in 2004, there has been an urgent need to establish an Early Warning System for the Panel region. In this connection, WMO, along with other International Organizations, worked towards bringing the countries of the region to work together in identifying an ideal mechanism that will support an Early Warning System for the region. The Panel should take advantage of this situation and participate in all the forums that are called upon by WMO in this regard. It is important that the Panel collaborates with the adjacent regions in establishing this project. It should then draw up a plan for implementation having all the Members participate.

(b) Storm Surge Watch Scheme

. In view of the fact that storm surges associated to the recent tropical cyclones Sidr and Nargis in the Bay of Bengal, which caused widespread flooding in the exposed coasts of Bangladesh and Myanmar, were the major cause of devastation and loss of lives in the most populous and low-lying areas of these countries, the WMO Executive Council, at its 60th session in 2008 (EC-LX), addressed the need for the provision of storm surge guidance information to the WMO Members exposed to these risks as a matter of priority.

The Council therefore agreed that a storm surge scheme attached to the tropical cyclone advisory arrangements would help to increase advisory lead-time and thus contribute to saving lives and properties, and would be the first step towards a comprehensive and integrated marine multi-hazard forecasting and warning system for improved coastal risk management. It appealed to all the regional tropical cyclone bodies to develop Storm Surge Watch Scheme (SSWS) that will make available to WMO Members concerned the storm-surge advisories including daily marine processed data and information they require for real-time uses. Regional SSWS adhoc teams have been set up for this purpose in the Western-South Pacific and South Indian Ocean regions.

In the Panel region, efforts have been continued under TCP for attachment training on storm surge forecasting in cooperation with India Institute of Technology since 2001. Also, India suggested at EC-LX that RMSC New Delhi could conduct storm surge training workshops for South Asian countries.

(c) The Hindu Kush-Himalayan Hydrological Cycle Observing System (HKH-HYCOS)

The principal objective of the HKH-HYCOS project is to implement and operate a regional flood information system. This will also use precipitation estimates/forecasting from satellites and terrestrial stations. In turn, this links to tropical cyclone activities and especially to tracking tropical cyclones in the region, i.e. over India and Pakistan, associated with precipitation forecasts that are then inputs in the regional flood information system while being used for national operational flood forecasts likewise.

Over a period of 3 years the project had been fully prepared in collaboration with the International Centre for Integrated Mountain Development (ICIMOD) and agreed by the riparian 6 countries (Bangladesh, Bhutan, India, Pakistan, China, Nepal). Myanmar and Afghanistan had been observers in this process. A demonstration project in 2006 had also demonstrated the feasibility of the approach chosen for this regional system. While the preparation phase was supported by USAID/OFDA funding is sought or the full implementation of the project.

(d) The Mekong River Hydrological Cycle Observing System (MEKONG-HYCOS)

This project is the direct “sister” project to the HKH-HYCOS mentioned above with the same objectives. This project is successfully being implemented since 2008 for a period of 5 years in collaboration with the Mekong River Commission (MRC) and full funding provided by the French IRD. Riparian participating countries are: Cambodia, Laos PDR, Thailand and Viet Nam.

(d) The Flash Flood Guidance System with Global Coverage (FFGS)

In collaboration with NOAA-National Weather Service, the US Hydrologic Research Centre, WMO and USAID/OFDA, this project is currently being implemented in the Mekong River Basin in collaboration with MRC. Other areas under development for the implementation of the project are southern Africa and near/middle East. The reference project had been implemented over the past years in Central America. The success of the project there was the basis to expand it globally where feasible. The core of the project is to provide flash flood guidance (not forecasting!) to disaster managers based on real-time

satellite-derived precipitation estimates merged with resolution GIS and hydraulic conditions of rivers that trigger an alert once “bankful” flow conditions are to be expected based on the precipitation estimate for a given time under prevailing ground and hydraulic conditions.

(f) WMO Programme for the Least Developed Countries (LDCs)

This Programme was established by the Fourteenth Meteorological Congress in May 2003 to contribute efficiently and in a timely manner to the social and economic development efforts of LDCs through the enhancement of the capacities and capabilities of their NMHSs. A number of activities are being carried out in support of NMHSs of most of the 50 LDCs under the WMO Programme for LDCs and through the other WMO scientific and technical programmes. This includes the development and implementation of Internet connection projects in LDCs; provision of fellowships; supporting the participation of experts from LDCs in WMO meetings; carrying out special advocacy and project-formulation activities; and the organization of innovative capacity-building initiatives including workshops on good practices in the beneficial and effective use of weather-, climate-, and water-related services in sustainable socio-economic development.

Planned activities include the following:

- Development and organization of demonstration/pilot projects on the contribution of meteorological and hydrological and related environmental information, products and services to the sustainable development of the LDCs and Small Island Developing States (SIDS), especially in poverty alleviation, disaster risk reduction, environmental protection, food security, health, energy and water resources management;
- Organization of capacity-building activities for senior- and middle-level staff of LDC NMHSs, particularly in leadership, management, resource mobilization, strategic planning, marketing and communication;
- Preparation and implementation of development and modernization plans of NMHSs of LDCs and SIDS, including projects that are of relevance to, and consistent with, national development strategies and programmes and of high impact value to the relevant commitments enshrined in the Brussels Programme of Action for the LDCs;
- Promoting the awareness of policy- and decision-makers and other stakeholders of the socio-economic benefits of weather-, climate- and water-related services;
- Preparation of guidelines for promoting the contributions of NMHSs and WMO towards the attainment of internationally agreed development goals including those contained in the Millennium Declaration.

1.6 WMO Programmes and other Regional/International Programmes in support of the Panel Members

(a) WMO Programmes

The major WMO Programmes concerned are the World Weather Watch (WWW), the World Climate Programme (WCP), the Atmospheric Research and Environment Programme (AREP), the Applications of Meteorology Programme, the Hydrology and Water Resources Programme (HWRP), the Disaster Risk Reduction (DRR) Programme, the Education and Training Programme (ETRP), the WMO Space Programme (SAT), the Technical Cooperation Programme (TCOP) and the Regional Programme (RP).

(b) Regional and international programmes

Programmes of the following organizations are of interest:

ESCAP; the ASEAN Subcommittee on Meteorology and Geophysics (ASCMG); the Interstate Council on Hydrometeorology of the Countries of the Commonwealth of Independent States (ICH CIS); the Coordinating Committee on Hydrometeorology and

Pollution Monitoring of the Caspian Sea (CASPCOM); the UNESCO Intergovernmental Oceanographic Commission (IOC); the United Nations Environment Programme (UNEP); the Global Environment Facility (GEF); the Economic Cooperation Organization (ECO); the Economic and Social Commission for Western Asia (ESCWA); the South Asia Association for Regional Cooperation (SAARC); the League of Arab States (LAS); the Permanent Meteorological Committee; and the Regional Organization for the Protection of the Marine Environment (ROPME).

1.7 Agreements and conventions

Members are required to undertake national responsibilities or contribute to national obligations under many regional and international agreements and conventions. Some of the most important ones are the WMO Convention; Agenda 21 adopted at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992; the 1994 Global Conference which adopted the Barbados Programme of Action for Sustainable Development of Small Island Developing States; Resolution 40 of Twelfth Congress (1995) on the policy and practice for the exchange of meteorological and related data and products including guidelines on relationships in commercial meteorological activities; Resolution 25 of Thirteenth Congress (1999) on the exchange of hydrological data and products; the Geneva Declaration of Thirteenth Congress (1999); Millennium Development Goals (2000); Hyogo Framework for Action 2005-2015 adopted at the World Conference on Disaster Reduction organized by the International Strategy for Disaster Reduction in 2005; the United Nations Framework Convention on Climate Change (UNFCCC); the United Nations Convention to Combat Desertification (UNCCD); the Convention of the International Civil Aviation Organization (ICAO); the Convention of the International Maritime Organization (IMO); the International Convention for the Safety of Life at Sea (SOLAS); and the Convention on the Protection of the Ozone Layer.

There are also a number of United Nations programmes and agencies having activities related specifically to meteorology, climate or hydrology or providing financial support to countries. These include UNEP, the United Nations Development Programme (UNDP), the Food and Agriculture Organization (FAO) of the United Nations and others.

2. DEVELOPMENT OF COORDINATED TECHNICAL PLAN

2.1 Purpose of Coordinated Technical Plan

Coordinated Technical Plan aims to promote and co-ordinate the planning and implementation of the measures required to minimize damages caused by tropical cyclones and associated floods and storm surges in the Bay of Bengal and the Arabian Sea. It is expected to establish an effective integrated regional early warning system for those hazards in the region covering all the five components; meteorology, hydrology, disaster prevention and preparedness, training and research.

Specific purposes of the Coordinated Technical Plan are:

(a) To develop an understanding among the Panel Members on the priorities and objectives for their individual development and for the overall development of the Panel region through cooperation; and to guide the implementation of Panel's programmes and activities for achieving these objectives;

(b) To develop and provide access to appropriate databases, resources and expertise to produce appropriate advice and products required for forecasting and warning services to the private and public sectors as well as to the decision makers and ordinary people;

(c) To encourage the development of joint projects by all Members or some of them with the projects under formulation and/or consideration by the Members;

(d) To raise general awareness of the status of the work of the Members and to have a framework under which development assistance would be provided and coordinated among the Members and the various contributing agencies; and

(e) To develop a system for training specialists of the Members, transferring and exchanging experience in observation and data processing, and taking advantage of advances in science and technology.

2.2 Institutional Arrangement

Coordinated Technical Plan cannot be successfully implemented without adequate institutional arrangements. Such arrangements should include mandate, programme management, human resources, funding, sectoral and organizational linkages, and reporting. These are to be considered when formulating the Plan.

2.2.1 Countries and organizations involved

Members will work together to contribute towards the implementation of joint programmes and activities, deriving benefits from pooling of resources within the region with the support of WMO and ESCAP.

2.2.2 Duration of the Coordinated Technical Plan

Coordinated Technical Plan covers a four-year term to keep pace with the financial periods of WMO (4 years) and ESCAP (2 years). Since the current financial periods of WMO and ESCAP are 2008-2011 and 2008-2009 (followed by 2010-2011), respecrively, the present Plan should cover the period from 2009 to 2011 to coincide with the end of those periods. Coordinated Technical Plan will then continue to be reviewed and updated by the Panel every four years.

2.2.3 Regional programmes and projects

Regional programmes or projects involved in the Plan are those that address problems that are common to the whole Panel region. Initial pilot phases may be undertaken in a limited number of countries only. Sub regional programmes and projects are those which address problems that are common to only few Members. Country-specific projects are those which are specifically required by a particular Member to address a problem in that country, given its particular circumstances. Country-specific projects are unique to individual countries and are identified through in-country consultations.

2.2.4 Steps for the implementation of the Coordinated Technical Plan

The steps for implementing the Coordinated Technical Plan include:

a. The thirty-sixth session (Muscat, Oman; 2-6 March 2009 to consider and approve the proposed Coordinated Technical Plan;

b. Members to take the Coordinated Technical Plan into account in developing their capacities and carrying out their national programmes in meteorology, hydrology, DPP, training an research and related disciplines;

c. Panel, WMO and ESCAP, though cooperative efforts to assist and/or support the implementation of the Coordinated Technical Plan;

d. Development of projects for implementation by Panel and its Members, and other regional and sub regional economic groups and institutions to implement effectively the Coordinated Technical Plan to enable Members to play their full role in sustainable socio-economic development of their countries.

2.3 Reporting

As part of implementation of the Coordinated Technical Plan, Chairperson of the Policy Working Group (PWG) will report on progress on the implementation of the Plan to the Members for evaluation at annual sessions. This Annual Evaluation Report (AER) will be prepared based on the results of annual surveys on the basic capability of Members (AER format shown in **ANNEX**).

3. EXPECTED RESULTS AND STRATEGIC OBJECTIVES

3.1 Meteorology

3.1.1 Expected Result 1

- Enhanced capabilities of Members to produce and provide better forecasts and warnings of tropical cyclones and storm surges

This is expected to be achieved based on the development of an efficient and expanded observation and telecommunication network and with acquisition of the latest forecasting technology, improved exchange of data and development of skills of personnel through national, bilateral and regional programs.

3.1.2 Strategic Objectives

1-a To improve and expand the observing system of surface, upper-air, ship, buoy, aircraft, radar and satellite observations in the Member countries.

1-b To implement and operate the WMO Information System (WIS) for operation-critical data exchange through dedicated telecommunication means of the GTS, and through broadband Internet access for Data Discovery, Access and Retrieval service.

1-c To increase accuracy, timeliness and usefulness of tropical cyclone forecasts and warnings.

1-d To extend the operational use of ensemble prediction techniques and probabilistic forecasts for more effective disaster risk assessment and management.

1-e To upgrade the computing facility of RSMC New Delhi and NMHSs so as to facilitate efficient data processing and data assimilation from different observing systems/platforms to suit the national and regional needs.

1-f To establish a regional storm surge watch scheme to provide Members with the storm-surge advisories including daily marine processed data and information they require for real-time uses

3.2 Hydrology

3.2.1 Expected Result 2

- Enhanced capabilities of Members to produce and provide better hydrological forecasts and assessments

Members will formulate accurate and timely forecasts and warnings on floods and other water related hazards with a view to supporting preparedness and response mechanisms of their governments and the public.

3.2.2 Strategic Objectives

2-a To improve regional cooperation in real time monitoring and exchange of relevant data and information, derived (forecasting) products and technical expertise related to hydrological hazards.

2-b To improve flood forecasts and warnings particularly in deltaic and coastal areas by coupling meteorological storm surge forecasts with river flow forecasting.

2-c To enhance regional capabilities relating to flood hazard mapping in delta and coastal regions through continued interaction with the user agencies.

2-d To improve management of water resources, including assessment of surface and ground water resources in relation to cyclonic disturbances;

3.3 Disaster Prevention and Preparedness (DPP)

3.3.1 Expected Result 3

- Enhanced capabilities of Members to promote tropical cyclone disaster resilient communities through providing guidance on multi-hazard early warning dissemination and response mechanism

Disaster prevention and preparedness in the region will be improved through enhanced public awareness, establishment of institutional and legal framework and participation of stakeholders for more effective disaster risk reduction. These are expected to be achieved through improvement in standard procedures on DPP and exchange of national and international experiences and information on disaster management among the Members.

3.3.2 Strategic Objectives

3-a To improve regional cooperation in policies and strategies on DPP, especially those related to tropical cyclones.

3-b To establish a regional information system to support development of policies and strategies on DPP at the regional level as well as at the national level by creating a regional database on disaster information and best practices on DPP from 2009 onward.

3-c To improve public awareness of the impacts of tropical cyclones and possible mitigation and response actions through effective communication with the media prior to, during, and after tropical cyclone occurrences.

3-d To improve coordination and interaction between meteorological/hydrological services on the one hand and emergency management/disaster response agencies on the other through integrated emergency management, disaster response and preparedness programmes.

3-e To strengthen regional cooperation on DPP information exchange through networking by making available disaster preparedness and mitigation information through Internet web sites and other means.

3-f To improve disaster risk management, especially those related to cyclone-related disaster preparedness by developing and implementing national pilot projects on multi-hazard disaster risk management programmes into the development plan of the Panel Members in the next four years.

3.4 Training

3.4.1 Expected Result 4

- Development of a strategic approach to capacity building with a regional perspective

Training activities will be enhanced through strengthening skills of personnel engaged in various aspects of cyclone prediction and early warning through regular training programmes including organization of workshops, seminars, etc.

3.4.2 Strategic Objectives

4-a To promote training programmes on the use of NWP model products and their application in Cyclone (track and intensity) and storm surge prediction.

4-b To promote training programmes on media coordination during disasters and their effectiveness on “human response”.

4-c To promote training programmes on the use of Doppler Weather Radar products in Cyclone forecasting.

4-d To promote visits of experts among Member countries to share their experiences and expertise in cyclone related fields.

4-e To enhance WMO’s fellowship support on tropical cyclone related programmes.

3.5 Research

3.5.1 Expected Result 5

- Enhanced capabilities of Members to cope with high impact weather through research

Collaboration will be promoted on research activities related to updating forecasting technologies, including NWP, storm surge and flood forecasting models.

3.5.2 Strategic Objectives

5-a To assess the impact of climate change on tropical cyclones in the region.

5-b To improve regional NWP models for tropical cyclone track and intensity predictions.

5-c To develop storm surge and river flood coupling model over specific river basins for forecasting of coastal inundation.

5-d To update vulnerability maps for various parameters like wind force/peak storm surge etc., based on latest available database.

3.6 Partnership

3.6.1 Expected Result 6

- *Enhanced cooperation among Members and with partner organizations in the provision of forecasts and warnings for tropical cyclones and storm surges*

Partnerships will be further developed both within and outside the region to take advantage of experience, experties, infrastrucfure and other resources, and for future initiatives and development projects.

3.6.2 Strategic Objectives

6-a To promote exchange of information and data among Members and with regional bodies to enhance regional cooperation in the five components: meteorology, hydrology, DPP, training and research.

6-b To enhance cooperation with other regional bodies, organizations, service providers and sectors for more effective provision of the forecasts and warnings.

6-c To develop and implement joint projects in the areas of the above five components and resource mobilization.

3.7 Management and Governance

3.7.1 Expected Result 7

- *Effective management and functioning of the Panel.*

Effective manegment and governance will be pursued to ensure fulfillment of Panel's vision, mission and stragic objectives.

3.7.2 Strategic Objectives

7-a To improve the coordination and decision making process of the Panel.

7-b To enhance effectiveness in implementation of CTP and AOPs.

7-c To ensure effective and collaborative relationships among working groups of Meteorology, Hydrology and DPP.

7-d To improve coodinated technical planning process as well as monitoring and evaluation.

4. ANNUAL OPERATING PLAN

The Annual Operating Plan (AOP) is designed to turn the expected results into specific initiatives and projects which are needed to achieve the expected results. The AOP will contain detailed actions and performance indicators to meet the Strategic Objectives of each of the expected results. The AOP will be prepared and adopted at the annual session.

5. CONCLUSION

Coordinated Technical Plan (CTP) for the WMO/ESCAP Panel on Tropical Cyclones for the Bay of Bengal and Arabian Sea (2009-2011) has been developed based on the general framework of CTP adopted at the 31st session and the draft CTP submitted to the 32nd session by the CTP Working Group, as well as suggestions from the Panel Members. It also took into account Hyogo Framework for Action (2005-2015) adopted during the World Conference on Disaster Reduction in 2005, the WMO Strategic Plan and the Strategic Plan

for the Enhancement of National Meteorological and Hydrological Services in Regional Association II (2009-2011).

The Plan provides proposed strategies and actions to help Members individually and collectively meet their national requirements and international commitments in relation to the provision of relevant services for mitigation of tropical cyclone disasters. Members have agreed to adopt, support and participate in the implementation of this Plan as it will lead to the strengthening of Members' capabilities to a higher standard to meet the growing demand for establishment of the multi-hazard early warning system.

Coordinated Technical Plan (CTP) for the WMO/ESCAP Panel on Tropical Cyclones for the Bay of Bengal and Arabian Sea (2009-2011)

Annual Evaluation Report for 2009

Expected Rresult	Strategic Goal	Activity
ER-1 (Meteorology) Enhanced capabilities of Members to produce better forecasts and warnings of tropical cyclones and storm surges	1-a To improve and expand the observing system of surface, upper-air, ship, buoy, aircraft, radar and satellite observations in the Member countries.	
	1-b To implement and operate adequate Members' connection to the WMO Information System (WIS) for operation-critical data exchange through dedicated telecommunication means of the GTS, and trough broadband Internet access for Data Discovery, Access and Retrieval service.	
	1-c To increase accuracy, timeliness and usefulness of tropical cyclone forecasts and warnings.	
	1-d To extend the operational use of ensemble prediction techniques and probabilistic forecasts for more effective disaster risk assessment and management.	
	1-e To upgrade the computing facility of RSMC New Delhi and NMSs so as to facilitate efficient data processing and data assimilation from different observing systems/platforms to suit the national and regional needs.	
	1-f To establish a regional storm surge watch scheme to provide Members with the storm-surge advisories including daily marine processed data and information they require for real-time uses	

ER-2 (Hydrology) Enhanced capabilities of Members to provide better hydrological forecasts and assessments	2-a To improve regional cooperation in real time monitoring and exchange of relevant data and information, derived (forecasting) products and technical expertise related to hydrological hazards	
	(1) Develop and implement regional information exchange strategy during 2009- 2010	
	(2) Organise regional workshops on data transmission mechanisms with special reference to water related hazards and sharing information through PTC web site	
	(3) Collaborate with Commission for Hydrology (CHy) and Working Group on Hydrology of RA-II	
	2-b To improve flood forecasts and warnings particularly in deltaic and coastal areas by coupling meteorological storm surge forecasts with river flow forecasting by	
	(1) Develope delta hydraulic models for river forecasting by coupling MIKE 11 (or any other model being used in the countries) with the storm surge forecasts for at least one river delta in each country	
	(2) Developing/application of coastal flood models and assocazted flood hazard and risk maps in the line as mentioned above	
	(2) Organise workshops for enhancing the capabilities of the countries	
	2-c To enhance regional capabilities relating to flood hazard mapping in delta and coastal regions through continued interaction with the user agencies.	

	(1) Undertake flood hazard mapping at least in one major delta/coastal area in each country during the next five years	
	(2) Organise workshops for capacity building	
	(3) Collaborate and share experiences with Typhoon Committee	
	2-d To improve management of water resources, including assessment of surface and ground water resources in relation to tropical cyclones;	
ER-3 (DPP) Enhanced capabilities of Members to promote tropical cyclone disaster resilient communities through providing guidance on multi-hazard early warning dissemination and response machanism	3-a To improve regional cooperation in policies and strategies on DPP, especially those related to tropical cyclones.	
	3-b To establish a regional information system to support development of policies and strategies on DPP at the regional level as well as at the national level by creating a regional database on disaster information and best practices on DPP from 2009 onward.	
	3-c To improving public awareness of the impacts of tropical cyclones and possible mitigation and response actions through effective communication with the media prior to, during, and after tropical cyclone occurrences.	
	3-d Improving coordination and interaction between meteorological/hydrological services on the one hand and emergency management/disaster response agencies on the other through integrated emergency management, disaster response and preparedness programmes.	

	3-e Strengthening regional cooperation on DPP information exchange through networking by making available disaster preparedness and mitigation information through Internet web sites and other means.	
	3-f Improving disaster risk management, especially those related to cyclone-related disaster preparedness by developing and implementing national pilot projects on multi hazard disaster risk management programmes into the development plan of the Panel Members in the next five years.	
	3-g To facilitate improved awareness through video programmes on tropical cyclone preparedness.	
ER-4 (Training) Development of a strategic approach to capacity building with a regional perspective	4-a To arrange training programmes on the use of NWP model products and their application in Cyclone (track and intensity) and storm surge prediction.	
	4-b To arrange training programmes on media coordination during disasters and their effectiveness on “human response”.	
	4-c To arrange training programmes on theuse of Doppler Weather Radar products in Cyclone forecasting.	
	4-d To exchange visits of faculty members among Member countries to share their experiences and expertise on cyclone & related disaster management aspects.	
	4-e To enhance WMO’s fellowship support on tropical cyclone related programmes.	
ER-5 (Research) Enhanced capabilities of Members to cope with high impact weather through	5-a To produce regional assessment of the impact of climate change on tropical cyclones.	

research	5-b To develop storm surge and river flood coupling model over specific river basins for forecasting of coastal inundation.	
	5-c To update vulnerability maps for various parameters like wind force/peak storm surge etc., based on latest available database.	
ER-6 (Partnership) Enhanced use of forecasts and warnings for tropical cyclones and storm surges for decision making and implementation by Members and partner organizations	6-a To promote exchange of information and data among Members to enhance regional cooperation in meteorology, hydrology, DPP, training and research	
	6-b To enhance cooperation with other regional bodies, organizations, service providers and sectors for more effective provision of the forecasts and warnings.	
	6-c To develop proposals of joint projects in the areas of five components including resource mobilization	
ER-7 (Management and Governance) Effective management and functioning of the Panel	7.a To improve the coordination and decision making process of the Panel	
	7.b To enhance effectiveness in implementation of CTP and AOPs	
	7.c To ensure effective and collaborative relationships among working groups of Meteorology, Hydrology and DPP	
	7-d To improve coodinated technical planning process as well as monitoring and evaluation	

APPENDIX VII

Proposed modification of the RSMC bulletins format

At present RSMC New Delhi issues the following bulletins.

(i) Tropical Weather Outlook daily at 0600 UTC
(ii) Special Weather Outlook, twice when there is a depression /deep depression over north Indian Ocean issued at 0600 and 1700 UTC.
(iii) Tropical Cyclone Advisory, issued every three hourly at 00, 03, 06, 09, 12, 15, 18 21 UTC.

It proposed to modify the contents of the bulletins as follows.

(a) Tropical Weather Outlook:

The Tropical Weather Outlook will include the information on the development of a low pressure area and its likely intensification into a depression in the daily one bulletin. It will also include the information on the associated convective clouds over the region.

The location of 200 hPa ridge which is mentioned at present may be stopped, In stead, we may mention location of ITCZ according to RSMC analysis.

(b) The Special Weather outlook:

The Special Weather Outlook may be modified to include satellite and radar interpretation of convection and some physical explanation about the present, past and future movement and intensification at the end of the bulletin.

The forecast intensity and the movement of system may be mentioned in a tabular form upto 72 hours at an interval of 12 hours based on NWP & statistical models and other conventional techniques.

As it is proposed to give forecast intensity in terms of sustained maximum wind speed, the information on forecast T No. may be dropped.

(c) Tropical Cyclone Advisory:

It is proposed to modify the tropical cyclone advisory to include the physical explanation as stated above.

The forecast position/intensification (sustained maximum wind) may be given in tabular form as discussed above. Hence, forecast T Number may be dropped.

All the above proposals have already been implemented with effect from post monsoon season, 2008.

With reference to storm surge RSMC New Delhi can issue storm surge forecast for other member countries, only if the hydro-dynamical model developed by IIT, Delhi is made available to RSMC for operational use. The storm surge guidance can be given in ranges or in qualitative terms corresponding to range of height of expected storm surge.

The ocean state forecast is already being issued by INCOIS. A link may be provided in IMD website for the information of other member countries. It will be an additional information apart from the qualitative indication of sea state like slight, moderate, rough, very rough high, phenomenal etc as mentioned at present in the bulletin.

Example

DEMS–RSMC TROPICAL CYCLONES NEW DELHI 05-12-2008
TROPICAL WEATHER OUTLOOK FOR NORTH INDIAN OCEAN (THE BAY OF BENGAL AND ARABIAN SEA) VALID FOR NEXT 24 HOURS ISSUED AT 0600 UTC OF 05 DECEMBER, 2008 BASED ON 0300 UTC OF 05 DECEMBER, 2008 (.)
THE DEEP DEPRESSION OVER SOUTHEAST BAY OF BENGAL REMAINED PRACTICALLY STATIONARY AND LAY CENTRED AT 0300 UTC TODAY, THE 05TH DECEMBER 2008 NEAR LAT. 7.50 N AND LONG. 88.50 E, ABOUT 650 KM SOUTHWEST OF PORT BLAIR (43333), 1100 KM SOUTHEAST OF CHENNAI (43279) AND 800 KM EAST-SOUTHEAST OF TRINCOMALEE (43418), SRI LANKA.
THE SYSTEM IS LIKELY TO INTENSIFY FURTHER AND MOVE IN A WEST-NORTHWESTERLY DIRECTION TOWARDS NORTH SRI LANKA, TAMIL NADU & PUDUCHERRY COASTS DURING NEXT 72 HOURS.

DATE/TIME	POSITION (LAT. N/LONG. E)	SUSTAINED MAXIMUM SURFACE WIND SPEED (KNOTS)
05/0300	7.5/88.5	30 GUSTING TO 40
06/0300	8.5/86.5	35 GUSTING TO 45
07/0300	9.0/84.5	40 GUSTING TO 50
08/0300	9.5/82.5	40 GUSTING TO 50

SATELLITE IMAGERY INDICATES MORE ORGANISED CONVECTION DURING PAST TWELVE HOURS. THE SYSTEM SHOWS THE CURVED BAND PATTERN WITH INTENSITY T2.0. ASSOCIATED BROKEN TO SOLID INTENSE TO VERY INTENSE CONVECTION OBSERVED OVER AREA BETWEEN LAT. 5.5 N AND 10.0 N AND LONG. 83.0 E AND 89.0 E.

SUSTAINED MAXIMUM SURFACE WIND SPEED IS ESTIMATED TO BE ABOUT 30 KNOTS GUSTING TO 40 KNOTS.
THE STATE OF THE SEA IS VERY ROUGH AROUND THE SYSTEM CENTRE.
THE ESTIMATED CENTRAL PRESSURE IS ABOUT 1004 HPA.
THE LOWEST CLOUD TOP TEMPERATURE (CTT) DUE TO CONVECTION IS AROUND -600C.
VERTICAL WIND SHEAR OF HORIZONTAL WIND OVER THE REGION IS 15 TO 20 KNOTS. WIND SHEAR TENDENCY SHOWS NO SIGNIFICANT CHANGE DURING PAST 24 HOURS.
THE SYSTEM LIES TO THE SOUTH OF THE UPPER TROPOSPHERIC RIDGE, WHICH ROUGHLY RUNS ALONG 120N. HENCE, THE SYSTEM LIES IN FAVOURABLE UPPER LEVEL DIVERGENCE ZONE FOR INTENSIFICATION.

Activities of TSU during the Inter – Sessional Period 2008-2009

- 25th Issue of the Panel News (published in April, 2008) and 26th Issue of the Panel News (published in October, 2008) have been circulated among the Panel members, Typhoon Committee, UN ESCAP, WMO and other concerned. TSU, as planed, issued the Panel News in the months of April and October to cover the seasonal weather information within Panel member countries.

- TSU was invited to send an Observer to the Twenty-ninth Session of the RA-IV Hurricane Committee, Curacao, Netherland Antilles and Aruba from 27 March – 3 April, 2007 and Thirtieth Session of the RA-IV Hurricane Committee, Orlando, USA from 23-28 April, 2008. But in both cases TSU's representative could not be nominated due to none availability of financial support from WMO.

- WMO/ESCAP Panel on Tropical Cyclones in its 35th Session, Manama, Bahrain (5-9 May, 2008) offered training to the Storm Surge Experts of Myanmar and Sri Lanka for the period of two weeks with the Indian Institute of Technology (IIT), New Delhi, India from 10-21 November, 2008. Mr. Ajith Lasantha Kumara of Department of meteorology Sri Lanka and Ms. May Khin Chaw of DMH, Myanmar were nominated to participate in the training.

- On the request of WMO/ESCAP, training on Tropical Cyclone Forecaster has been arranged at RSMC, New Delhi, India during the period from 9th to 20th February, 2009. Tropical Cyclone Forecasters - one each from Bangladesh, Maldives and Pakistan, have been invited for the training. Owing to the political situation between Pakistan and India, PMD could not send its nominee to this training. However, Mr. Md. Azizur Rahman, Meteorologist, Bangladesh Meteorological Department and Mr. Hussain Waheed, Meteorological Forecaster, Department of Meteorology, Maldives participated in the training.

- Thailand and Oman were requested to nominate Chair and Vice-Chair of DPP Working Group. Thailand has nominated Mr. Adthaporn Singhawichai, Director of Research and International Cooperation Bureau, as Chairman of DPP Working Group.

- As per Para 8.6.2 of the Final Report of PTC-35, Thailand was requested too nominate Dr. Wattana Kanbua (Director, Marine Meteorological Centre, TMD) as Chairman of the Task Force on Integrated Hazard Awareness Display (IHAD) as a mechanism to promote

multi-hazard early warning system in the Panel Area. Dr. Wattana immediately responded towards the development of IHAD and developed a website for this purpose.

- As per Para 8.6.3 of the Final Report of PTC-35, TSU contributed to the High-level Policy Working Group (PWG) meeting Chaired by the Coordinator of PTC and convened by the WMO with the cooperation of ESCAP to discuss the Coordinated Technical Plan (CTP) of the Panel for the next four years 2009-2011. The PWG met on 27th and 28th February 2009 and finalized the CTP. The PWG meeting was attended by the delegates from, India, Oman, Sri Lanka, Thailand, TSU and representatives of WMO and ESCAP.

- ESCAP's Committee on Disaster Risk Reduction (CDRR) under its Agenda item No. 6 “Report of ESCAP-affiliated regional institutions and cooperative mechanisms on disaster risk reduction” invited the Panel to report to its First Session scheduled to be held in Bangkok, Thailand from 25-27 March, 2009. Subsequently, TSU on behalf of the Panel drafted a report based on the main activities recorded in the Annual Report of PTC-35 to provide an overall picture of the framework of cooperation of the Panel and also future directions to enhance the effectiveness of collaboration in risk management of tropical cyclone-related disasters. The report was sent to ESCAP via e-mail under intimation to WMO.

- Information regarding financial support of WMO and detailed breakdown of expenses incurred by TSU during the inter-sessional period is attached as **Appendix IX**.

STATEMENT OF TSU ACCOUNTS

(2007 - 2008)

1.	Balance after 34th Session	Pak. Rs. 225,890.00
2.	Receipts during the inter-sessional period	Nil

	Total	**Pak. Rs. 225,890.00**

EXPENDITURE

1.	Running cost of TSU website for one year	Pak. Rs.	6,000.00
2.	Honorarium to TSU-Meteorologist and Technical staff	Pak. Rs.	79,000.00
3.	Expenses incurred on the printing of 26th Issues of the Panel News	Pak. Rs.	35,000.00
4. (a)	Purchase of stationery for TSU use	Pak. Rs.	5,000.00
(b)	Expenditure on postage, faxes etc.	Pak. Rs.	15,000.00

	Total	**Pak. Rs.**	**140,000.00**
	Balance in hand	**Pak. Rs.**	**85,890.00**

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PANEL ON TROPICAL CYCLONE TRUST FUND
Statement of Income and Expenditure
For the period 1 January to 31 December 2007
Amounts in US dollars

1. Balance of fund at 1 January 2007			74,496
2. Income			
2.1 Contributions		10,009	
2.2 Interest		1,937	
2.3 Total revenue			11,946
3. Total available funds during reporting period			86,442
4. Expenditure			
4.1 Direct project costs			
4.1.1 Travel - Other participants ad hoc travel	924		
4.1.2 Support to TSU	4,514		
4.1.3 Bank charges	17		
4.1.4 Total direct project costs		5,455	
4.2 Indirect project costs			
4.2.1 Support costs (13%)	709		
4.2.2 Differences in exchange	(5,602)		
4.2.3 Total indirect project costs		(4,893)	
4.3 Total project expenditure			562
5. Balance at 31 December 2007			85,880

Country	Contributions
India	2,000
Maldives	2,000
Pakistan	2,009
Sri Lanka	2,000
Thailand	2,000
Total	10,009

Certified correct:

Luckson Ngwira
Chief, Finance Division
16 February 2009

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PANEL ON TROPICAL CYCLONE TRUST FUND
Interim Statement of Income and Expenditure
For the period 1 January to 31 December 2008
Amounts in US dollars

1. Balance of fund at 1 January 2008			85,880
2. Income			
2.1 Contributions		4,000	
2.2 Interest		2,690	
2.3 Total revenue			6,690
3. Total available funds during reporting period			92,570
4. Expenditure			
4.1 Direct project costs			
4.1.1 Travel - Other participants to attend other mtgs	3,438		
4.1.2 Total direct project costs		3,438	
4.2 Indirect project costs			
4.2.1 Support costs (13%)	447		
4.2.2 Bank charges	18		
4.2.3 Differences in exchange	(7,873)		
4.2.4 Total indirect project costs		(7,408)	
4.3 Total project expenditure			(3,970)
5. Balance at 31 December 2008			96,540

Country	Contributions
Maldives	2,000
Thailand	2,000
Total	4,000

Certified correct:

Luckson Ngwira
Chief, Finance Division
16 February 2009