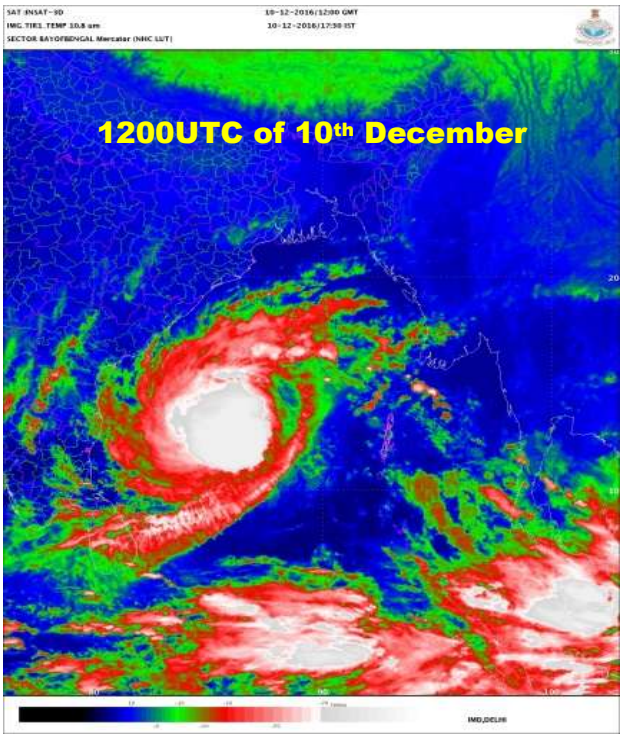
WMO/ESCAP

PANEL ON TROPICAL CYCLONES

ANNUAL REVIEW 2016



SATELLITE IMAGERY OF VERY SEVERE CYCLONIC STORM, VARDAH OVER BAY OF BENGAL

WORLD METEOROLOGICAL ORGANISATION
AND
ECONOMIC AND SOCIAL COMMISSION
FOR ASIA AND THE PACIFIC

WMO ESCAP

WMO/ESCAP

PANEL ON TROPICAL CYCLONES
ANNUAL REVIEW 2016

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PREFACE

First commenced in 1997, the publication of ***WMO/ESCAP Panel*** - *Annual Review* has entered **twentieth** year of issue for the year 2016. Considerable efforts have gone into producing this document in order to make it useful scientifically and informative for the members of panel. Panel Members are encouraged to make more contributions for further improvement of this publication.

WMO and ***ESCAP*** have played a commendable role in disaster mitigation efforts in the Panel region through continued interaction with the governments of the member countries. There is increasing realization that disaster mitigation effort must encompass all spheres including scientific research on natural hazards, establishment of integrated-all-hazard early warning system and most importantly, empowering communities to be self reliant for timely and proper response to warnings. Despite rapid technological advances made in the recent past, the problem of generating accurate weather forecasts and associated warnings/ advisories and their timely dissemination to the communities at highest risk continues to be a great challenge. In order to make the early warning system more effective, it is essential that the Panel Members take new initiatives. The basic aim of the panel is to improve the quality and content of cyclone warnings, devise methods for quick dissemination of warnings and flood advisories and ensure proper response by concerned agencies and the community.

This review highlights the achievements made during the year, 2016 in the region in pursuance of the goals set out by the ***WMO / ESCAP*** *Panel* and the activities of other international and national organisations in support of the above tasks, within the overall objective of mitigating the impact of natural hazards. I would like to express my sincere thanks to all the Panel Members for their valuable inputs and contributions and hope for the same in future.

M. Mohapatra
Chief Editor

WMO AND THE WMO / ESCAP PANEL ON TROPICAL CYCLONES

WORLD METEOROLOGICAL ORGANIZATION (WMO)

The World Meteorological Organisation (WMO), of which 185 States and Territories are Members, is a specialised agency of the United Nations. The objectives of the organisation are:

- To facilitate international co-operation in the establishment of networks of Stations and Centres to provide Meteorological and Hydrological services and observations;
- To promote the establishment and maintenance of systems for the rapid exchange of meteorological and related information;
- To promote standardisation of meteorological and related observations and ensure the uniform publication/circulation of observations and statistics;
- To further the application of meteorology to aviation, shipping, water problems, agriculture and other human activities;
- To promote activities in operational hydrology and to further close co-operation between Meteorological and Hydrological Services and
- To encourage research and training in meteorology and, as appropriate, in related fields and to assist in co-ordinating the international aspects of such research and training.

ECONOMIC AND SOCIAL COMMISSION FOR ASIA AND THE PACIFIC (ESCAP)

The Economic and Social Commission for Asia and the Pacific (ESCAP) aims to initiate and participate in measures for concerted action towards the development of Asia and the Pacific, including the social aspects of such development, with a view to raising the level of economic activity and standards of living and maintaining and strengthening the economic relations of countries and territories in the region, both among themselves and with other countries in the world. The commission also:

- Provides substantive services, secretariats and documentation for the Commission and its subsidiary bodies;
- Undertakes studies, investigations and other activities within the commission's terms of reference;
- Provides advisory services to Governments;
- Contributes to the planning and organisation of programmes of technical co-operations and acts as executing agency for those regional projects decentralised to it.

WMO / ESCAP PANEL ON TROPICAL CYCLONES

Huge loss of human life, damage to property and unbearable sufferings of human beings caused by tropical cyclones in coastal areas in various parts of the globe like Atlantic, Pacific, China Sea and North Indian Ocean (NIO) coast are regular features.

The disaster potential due to cyclones is particularly high in the NIO comprising of the Bay of Bengal & the Arabian Sea region, which is being associated with high storm surge, which is the greatest killer in a cyclone. This region has the distinction of having experienced the world's highest recorded storm tide of 41 feet (1876 Bakherganj cyclone near Megna estuary, Bangladesh) followed by 13 metres over West Bengal coast on 7th

October, 1737 in association with another super cyclone . Past records show that very heavy loss of life due to tropical cyclones have occurred in the coastal areas surrounding the Bay of Bengal. In the recent past, during the year 1998, the state of Gujarat in India experienced the impact of a very severe cyclonic storm, which crossed coast north of Porbandar (42830) on June 9, 1998 and caused huge damage to public property near Kandla Port (42639). A Super Cyclonic Storm that crossed east coast of India near Paradip (42976) in Orissa state on October 29, 1999 took a toll of 9885 lives and caused huge damage to property in 12 districts of the state. Apart from causing large-scale devastation to agriculture and plantation crops, it also affected entire infrastructure on communication, power and transport. The storm surge of 5-6 m height was experienced in areas close to and southwest of Paradip. This cyclone was century's most intense cyclone and its unusual feature was that it remained practically stationary after crossing coast and battered the State of Orissa for 36 hours. In June, 2007 another super cyclone 'Gonu' developed over southeast Arabian Sea, moved north-westward, crossed Oman coast and then entred into Gulf of Oman and made second landfall over Iran coast. It caused huge damage to the property and loss of lives in Oman and Iran. The very severe cyclonic storm, 'Nargis' crossed Myanmar coast near Irrawaddy delta on 2nd May 2008 and caused loss of about 138,000 lives in Myanmar.

Realising the importance of an effective cyclone warning and disaster mitigation machinery in the region, WMO and ESCAP jointly established the Panel on Tropical Cyclones (PTC) in 1972 as an inter-Governmental body. Its membership comprises the countries affected by tropical cyclones in the NIO. Its Member countries are Bangladesh, India, Maldives, Myanmar, Pakistan, Sri Lanka, Sultanate of Oman and Thailand.

The Panel is one of the six regional tropical cyclone bodies established as part of the WMO Tropical Cyclone Programme (TCP) namely Miami, Honolulu, Tokyo, New Delhi, La Reunion and Nadi that aims at promoting and co-ordinating the planning and implementation of measures to mitigate tropical cyclone disaster.

It also aims to initiate and participate in measures for concerted action towards the development of Asia and the Pacific including social aspects of such developments, with a view to raising the level of economic activity and standards of living and maintaining and strengthening the economic relations of countries and territories in the region, both among themselves and with other countries in the world.

The first session of WMO/ESCAP Panel on Tropical Cyclones was convened in Bangkok, Thailand in January 1973. The functions of the Panel are:

- ► To review regularly the progress in various fields of tropical cyclone damage prevention;
- ► To recommend to the member countries plans and measures for the improvement of community preparedness and disaster prevention;
- ► To promote, prepare and submit to member countries plans for co-ordination of research programmes and activities on tropical cyclones;
- ► To facilitate training of personnel from member countries in tropical cyclone forecasting and warning, flood hydrology and its control within the region;

- To plan for co-ordination of research programmes and activities concerning tropical cyclones within member countries;
- To prepare and submit, at the request and on behalf of the member countries requests for technical, financial and other assistance offered under United Nations Development Programme (UNDP) and by other organisations and contributors and
- To consider, upon request, possible sources of financial and technical support for such plans and programmes.

In carrying out these functions, the PTC committee maintains and implements action programmes under the five components of meteorology, hydrology, disaster prevention and preparedness, training and research with contributions and co-operation from its Members and assistance by the UNDP, ESCAP, WMO and other agencies.

The Panel at its twelfth session in 1985 at Karachi (Pakistan) adopted a comprehensive cyclone operational plan for this region. The basic purpose of the operational plan is to facilitate the most effective tropical cyclone system for the region with existing facilities. The plan defined the sharing of responsibilities among Panel countries for the various segments of the system and recorded the co-ordination and co-operation achieved. The plan also recorded the agreed arrangements for standardization of operational procedures, efficient exchange of various data and its archival related to tropical cyclone warnings, issue of a tropical weather outlook and cyclone advisories from a central location having the required facilities for this purpose, for the benefit of the region and strengthening of the operational plan. Further the Panel agreed upon the issue of tropical cyclone advisory bulletin for use of aviation as per recommendation No. 1/21 of International Civil Aviation Organisation (ICAO) in its 12^{th} meeting of 161^{st} session held at Montreal, Canada during 09-26 September, 2002

The operational plan is evolutionary in nature. Its motivation is to update or raise the text of the plan from time to time by the Panel and each item of information given in the annexes of the plan to be kept up to date by the member country concerned.

RSMC- Tropical Cyclones, New Delhi:

Regional Specialized Meteorological Centre (RSMC) - Tropical Cyclones, New Delhi, which is co-located with Cyclone Warning Division of IMD and came into the existence in 1988 as per the recommendation of first session of WMO/ESCAP Panel on Tropical cyclones held in January,1973. It has the responsibility of issuing Tropical Weather Outlook and Tropical Cyclone Advisories for the benefit of the countries in the World Meteorological Organization (WMO)/ Economic and Social Co-operation for Asia and the Pacific (ESCAP) Panel region bordering the Bay of Bengal and the Arabian Sea, namely, Bangladesh, Maldives, Myanmar, Pakistan, Sultanate of Oman, Sri Lanka and Thailand. It has also the responsibilities as a Tropical Cyclone Advisory Centre (TCAC) to provide Tropical Cyclone Advisories to the designated International Airports as per requirement of International Civil Aviation Organization (ICAO).

The area of responsibility of RSMC- New Delhi covers Sea areas of north Indian Ocean (north of equator between 45^0 E and 100^0 E) and includes the member countries of WMO/ESCAP Panel on Tropical Cyclones viz. Bangladesh, India, Maldives, Myanmar, Pakistan, Sri Lanka, Sultanate of Oman, Thailand and Yemen. The Yemen became member of the Panel in 2016.

The broad functions of RSMC- Tropical Cyclones, New Delhi are as follows:

- Round the clock watch on weather situations over the entire north Indian Ocean.
- Analysis and processing of global meteorological data for diagnostic and prediction purposes.
- Detection, tracking and prediction of cyclonic disturbances in the Bay of Bengal and the Arabian Sea.
- Running of numerical weather prediction models for tropical cyclone track and storm surge predictions.
- Interaction with National Disaster Management Authority and National Disaster Management, Ministry of Home Affairs, Govt. of India to provide timely information and warnings for emergency support services. RSMC-New Delhi also coordinates with National Institute of Disaster Management (NIDM) for sharing the information related to cyclone warning.
- Implementation of the Regional Cyclone Operational Plan of WMO/ESCAP Panel.
- Issue of Tropical Weather Outlook and Tropical Cyclone Advisories to the Panel countries in general.
- Issue of Tropical Cyclone advisories to International airports in the neighbouring countries for International aviation.
- Collection, processing and archival of all data pertaining to cyclonic disturbances viz. wind, storm surge, pressure, rainfall, damage report, satellite and Radar derived information etc. and their exchange with Panel member countries.
- Preparation of comprehensive annual reports on cyclonic disturbances formed over North Indian Ocean every year.
- Preparation of annual review report on various activities including meteorological, hydrological and disaster preparedness and prevention activities of panel member countries.
- Research on track, structure and intensity monitoring and prediction techniques as well as associated adverse weather including storm surge, heavy rain and gale wind.

COMMITTEE ON WMO/ESCAP PANEL ON TROPICAL CYCLONES (2016 –17)

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Chairman drafting committee:		**Mr. Komal Sakolnakhon (Thai Meteorological Department)**

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INTRODUCTION

Publication of "WMO/ESCAP Panel on Tropical Cyclones–Annual Review commenced with the review for the year 1997. This was as per the decision of the Second Joint Session of the WMO/ESCAP Panel on Tropical Cyclones and Typhoon Committee held at Phuket, Thailand 20-28, February 1997. The present Annual Review-2016 contains primary contribution from the Panel member countries.

Chapter I contains detailed information on national programmes and activities related to meteorology, hydrology, disaster prevention and preparedness, training and research as supplied by Panel Members. Technical and administrative support provided and activities undertaken by the Panel.

A summary of Tropical Cyclones during 2016 is given in the first part of Chapter II. Earlier, tropical cyclones were identified by their geographical locations. From post monsoon season 2004, the practice of naming each tropical cyclone individually has been adopted in the north Indian Ocean basin also. Tropical disturbances are classified as per the practice introduced at Regional Specialised Meteorological Centre (RSMC)–Tropical Cyclones New Delhi. The classification of disturbances is shown in the following Table. The term "Cyclone" used in the present text is a generic term for the five categories of cyclonic disturbances (S.N. 4 to 8) in the Table.

Classification of low-pressure systems at RSMC–Tropical Cyclones, New Delhi

S No.	Maximum sustained surface wind Speed in knot (kmph)	Nomenclature
1.	Less than 17 (31)	Low Pressure Area (L)
2.	17 to 27 (31-49)	Depression (D)
3.	28 to 33 (50- 61)	Deep Depression (DD)
4.	34 to 47 (62 –88)	Cyclonic storm (CS)
5.	48 to 63 (89 – 117)	Severe Cyclonic Storm (SCS)
6.	64 to 89 (118 –166)	Very Severe Cyclonic Storm (VSCS)
	90-119 (167-221)	Extremely Severe Cyclonic Storm (ESCS)
7.	120 and above (222)	Super Cyclonic Storm (SuCS)

The second part of Chapter II contains a brief report on tropical cyclones affecting Panel countries during 2016. Based on the real time and climatological data available with India Meteorological Department (IMD), India, special features of the 2016 tropical cyclone season are highlighted. It also contains realized weather and the damages caused due to cyclones. All units used in the chapters are as per standard norms.

In the context of Chapter II, sustained winds refer to wind speeds averaged over a period of 3 minutes. Kilometer per hour (kmph) / knot is the unit used for wind speed as well as speed of movement of tropical cyclones. The S.I. unit of hecta-Pascal (hPa) is used for atmospheric pressure. Reference time used is primarily in Universal Time Coordinate (UTC). Wherever possible, station names contained in WMO Weather Reporting-Observing Stations (WMO/OMM-No.9 Volume A) are used for geographical reference with code.

Chapter III consists of contributed articles / research papers on tropical cyclones received from Member countries and scientists from various organizations.

Chapter IV contains outlines of Activities of PTC Secretariat during the Inter-sessional Period 2016-2017.

CHAPTER-I

WMO/ESCAP PANEL ACTIVITIES IN 2016

1.1 METEOROLOGICAL ACTIVITIES

Activities of member countries on WMO/ESCAP Panel, WMO and UN-ESCAP for the year 2016 were presented at the forty fourth session of the WMO/ESCAP Panel on tropical cyclones held at Manama, Bahrain from 10-14 September 2017. Under this item, matters relating to the basic observational network, the telecommunication links and data-processing systems established in the region to fulfill the requirements of WMO's World Weather Watch Programme were reviewed. The Panel reviewed the activities under the meteorological component of the Members during the past year. These are briefly summarized below:

1.1.1. WMO activities

1.1.1.1. WMO INFORMATION SYSTEM

1.1.1.1.2. Introduction

Previous WMO/ESCAP Panel on Tropical Cyclones sessions have emphasized the importance of implementing WIS in order realize significant benefits to Tropical Cyclone monitoring and warning services in the Bay of Bengal and the Arabian Sea.

The Global Telecommunications System (GTS) is a core component of WIS and comprises a dedicated network of surface- and satellite-based telecommunication links operated by NMHSs. Maintenance and development of these communication systems should remain a high priority for all Members in participating in the Panel as the systemsare essential both for the collection of observations and guidance from within the region to support the functioning of the RSMCs and other NMHSs, and for the access to the guidance and products from outside of the region needed by an NMHS to prepare their forecasts and warnings. Tropical Cyclone monitoring and warning services are very dependent on the quality and timeliness of observations and guidance material that is circulated on the WMO Information System (WIS).

1.1.1.1.3. Current status of WIS.

The global infrastructure of WIS is now operational, with Global Information System Centres (GISCs) Beijing, Jeddah, New Delhi and Tokyo supporting Members participating in the WMO/ESCAP Panel on Tropical Cyclones. The Panel is invited to consider formally recognizing the role of GISC New Delhi, as the principal GISC for New Delhi Tropical Cyclone RSMC, in coordinating the activities of these GISCs in support of Tropical Cyclone services in the Bay of Bengal and the Arabian Sea.

As reported previously, the WIS implementation is now focused at the national level, guided by Regional Associations. Information on WIS Implementation in Regional Association II (RA-II) is available online[1]. However, analysis of data collected by the WIS monitoring system indicates that close working relationships are yet to be established between the

[1] http://wis.wmo.int/page=RA2-WIS

some GISCs and all the WIS Centres in their area of responsibility. The Panel is requested to note that direct exchange of information between WIS centres and their Principal GISC is critical to ensure the timely delivery of warnings and the information required for their production.

The Panel is reminded of Decision 15 of the Sixteenth Session of RA-II (RAII-16), February 2017, that endorsed the training programme for WIS competencies[2] as listed in the Annex to that Decision, requesting that GISCs and RTCs serving Members in the Region provide the necessary training.

As a priority, the Panel is urged to encourage NMHSs and New Delhi Tropical Cyclone RSMC to work closely with their Principal GISC to establish the required capabilities and information exchange, ensuring provision of necessary training and using available communication technologies such as the Internet.

Furthermore, the Panel is invited to consider the inclusion of WIS implementation as a cross-cutting issue in the Coordinated Technical Plan and Annual Operating Plan, noting the need for liaison with the Coordinators[3] of the RA-II Expert Group on the WMO Information System (RA-II EG-WIS) to provide (i) input to the planned update of the RA-II WIS Implementation Plan[4], and (ii) regional requirements for inclusion in the development and implementation of the WIS 2.0 Strategy[5] and aspects of information management pertinent to WIS Part C[6].

The Panel is reminded of the International Forum of Users of Satellite Data Telecommunication Systems ("Satcom Forum")[7]. The Satcom Forum is developing a handbook providing the information necessary to evaluate the suitability of currently available satellite-based data telecommunications systems and data retransmission systems for environmental monitoring and emergency management, and plans to pursue negotiation of a "WMO-IOC branded disaster alerting tariff" with satellite communications service providers based on the results of a 2017 survey[8] of National Hydrological and Meteorological Services.

1.1.1.2. Common Alerting Protocol and Alerting Authority Register

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[2]The WIS Competencies are described in Appendix E to the Manual on WIS (WMO-No. 1060) (http://wis.wmo.int/WIS-manual), with a complementary training and learning guide provided in Appendix A to the Guide to WIS (WMO-No. 1061) (http://wis.wmo.int/WIS-guide).

[3] The coordinators of RA-II EG-WIS are Ms Li Xiang (China) and Mr Kenji Tsunoda (Japan)

[4]http://wis.wmo.int/file=653

[5]The WIS 2.0 Strategy is provided in Annex to Recommendation 35 (CBS-16) and endorsed by Resolution 8 (EC-69)

[6]Resolution 33 (Cg-17) decided to extend the scope of WIS to include information management, to be known as WIS Part C

[7]Satcom Forum (https://wis.wmo.int/page=SATCOM) was established by the Seventeenth session of the World Meteorological Congress as a joint effort of both WMO and the Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO)

[8]https://wis.wmo.int/page=Satcom-Survey2017

The Common Alerting Protocol (CAP)[9] is widely used in the disaster response community. Given the support for CAP within WIS and its suitability for disseminating weather, climate and water related alerts and warnings, the Panel is reminded of Decisions 3 and 16 (RAII-16) encouraging the use of CAP in impact-based forecast and warning services, and the development of collaborative arrangements to share experiences of working with tools such as CAP.

The Panel was advised of the importance of registering national warning and alerting authorities in the Alerting Authority Register[10] to ensure that CAP messages are attributed to authoritative sources and given the appropriate priority. Although managed by WMO, the Alerting Authority Register is intended to include authorized issuers of any type of official warning or alert, including those that are not related to meteorology, and is used by information providers to identify alerts from official sources. The Panel is urged to encourage Members to review the Alerting Authority Register and register any national warning and alerting authorities that are missing.

1.1.1.3. GLOBAL OBSERVING SYSTEM

1.1.1.3.1. SATELLITE OBSERVATIONS

1. Satellite information is very important for tracking and determining intensity trends of tropical cyclones and other tropical storms. When a tropical cyclone is well offshore and out of effective radar range, forecasters use satellite imagery to continuously track the storm's movement and development. The imagery gives information about the top of the storm. Satellites can also give information about the winds speeds over the ocean surface. Forecasters are able to use satellite imagery over RA-II to spot the initial formation of the storms, before they even reach the classification of Tropical Depression. Forecasters use both visible and infrared satellite imagery to track the motion and cloud patterns of tropical cyclones and infrared to monitor cloud-top temperatures. Being able to see when a tropical cyclone is forming, and to continuously track where it is heading, means more timely warnings can be issued and mitigating actions taken.

2. In addition to Meteosat-10 in operation, Meteosat-8 has been relocated to the 41.5° East position for the Indian Ocean Data Coverage (IODC) mission. Operational dissemination was started on 1 February 2017.The 3-hourly imagery data and all meteorological products from Meteosat-8 are disseminated on EUMETCast Europe and Africa. The non-essential quarter-hourly imagery data is available to registered users on EUMETCast Europe and Africa. The operational data exchange enables the redistribution of EUMETSAT data and products via CMACastto all countries in the Asia-Pacific area and Chinese data from China's Fengyun (FY) meteorological polar-orbiting and geostationary satellite programmes in Europe. The data dissemination systems EUMETCast and CMACast both contribute to the global satellite dissemination system GEONETCast in support of the Global Earth Observation System of Systems (GEOSS).

[9]ITU Recommendation X.1303; CAP is a content standard designed for all-hazards and all-media public alerting
[10]https://alerting.worldweather.org/

Current Meteosat Satellites

SATELLITE	LIFETIME	POSITION	SERVICES
Meteosat-11 (MSG)	15/07/2015 – tbc	In orbit storage	n/a
Meteosat-10 (MSG)	05/07/2012 – Nominal fuel lifetime is until 2022	0° 36,000 km	0° SEVIRI Image Data. Real-time Imagery. Data Collection Service
Meteosat-9 (MSG)	22/12/2005 – Fuel lifetime is expected to be extended until 2021	9.5° E 36,000 km	Rapid Scan Service from 9 April 2013. Real-time Imagery
Meteosat-8 (MSG)	28/08/2002 – Fuel lifetime is expected to be extended until 2019	41.5° E 36,000 km	Full IODC service

(http://www.eumetsat.int/website/home/Satellites/CurrentSatellites/Meteosat/index.html)

3. China, India and Russia are producing observation from geostationary meteorological satellites for covering Indian Ocean and contributing IODC mission as follow;
FY2E (86.5°E)
The hourly imagery data and meteorological products are disseminated on EUMETCast Europe and Africa.
INSAT-3D (82.0°E)
Dissemination of the complete list of essential products from INSAT-3D on EUMETCast is under consideration.
Elektro-L N2 (77.8°E)
The dissemination of a subset of spectral channels at half-hourly frequency of the imagery data via EUMETCast Europe is currently under implementation. Dissemination of the complete list of essential products from Elektro-L N2 on EUMETCast is under consideration.

4. The Advanced Scatterometer (ASCAT) instrument onboard the European polar orbiting meteorological satellite (Metop) operated by EUMETSAT measures surface wind speeds and directions over the ocean. This is crucial for monitoring the formation and development of the tropical storms and is used to pinpoint the storm centre. These data are processed by and available from the EUMETSAT.

Metop Satellites

SATELLITE	LIFETIME	POSITION	SERVICES
Metop-A	From 19/10/2006	Low Earth Orbit	Global Data Service. Regional Data Service. Direct Readout Service. Real-time Imagery
Metop-B	From 17/09/2012	Low Earth Orbit	Global Data Service. Regional Data Service. Direct Readout Service. Real-time Imagery
Metop-C	Launch planned in October 2018	Low Earth Orbit	-

(http://www.eumetsat.int/website/home/Satellites/CurrentSatellites/Metop/index.html)

1.1.1.3.2. World Weather Watch monitoring of observation reports

The World Weather Watch (WWW) quantitative monitoring records observation reports as they pass through regional telecommunications hubs. Originally only monitoring for the first

weeks of October, monitoring has now been extended to the 1st to 15th of January, April, July and October each year. Statistical summaries are prepared that compare the number of reports containing observations for stations in the Regional Basic Synoptic Networks with those required by those networks (surface: 00Z, 06Z, 12Z, 18Z; upper air: 00Z, 12Z). Observations reported at other times are not included in the statistics. In particular, many Members release radiosondes at times that are chosen to provide the most information to support of national forecasting needs; such observations are not reported in the statistics. In future, the WIGOS Data Quality Monitoring System, by capturing statistics a part of the numerical weather prediction processing, will enable more flexible analyses of both the number of reports received and of the quality of those reports.

The table below reports the percentage of surface and upper air reports that were recorded during the WWW quantitative monitoring periods of January, April, July and October 2016 (averaged over the periods).

The Panel is requested to review the WWW monitoring statistics and to develop and implement a plan to remedy deficiencies in the number of surface and upper air reports provided.

The Panel is advised that the migration of upper air reports from traditional alphanumeric reports (TAC) to BUFR has regularly resulted in coding errors[11] and loss of upper air information. The Panel is reminded of the B/C regulations within Manual on Codes (WMO-No. 306) that specify how upper air reports should be coded in BUFR, and is urged to encourage WIS Centres providing upper air reports to work with their Principal GISC to ensure correct encoding of the upper air information in BUFR.

Percentage of reports required by the Regional Basic Synoptic Network averaged over the World Weather Watch monitoring exercises of 2016. Shaded rows denote monitoring areas that are not members of the ESCAP committee

	Surface Percent				**Upper air percent**			
	2012		**2016**		**2012**		**2016**	
	Stations	**Percent**	**Stations**	**Percent**	**Stations**	**Percent**	**Stations**	**Percent**
BAHRAIN / BAHREIN	7	8	7	9	0	-	0	-
BANGLADESH	11	59	12	74	2	18	3	48
INDIA / INDE	81	96	81	98	34	27	34	61
MALDIVES	5	86	5	92	1	35	1	30
MYANMAR	27	71	27	51	5	4	5	0
OMAN	23	75	23	97	2	33	2	40
PAKISTAN	54	75	3	78	54	11	3	0

[11] The four-part TAC message is replaced with four independent BUFR messages that cannot be recombined into a single report for assimilation by NWP centres

	Surface Percent				Upper air percent			
	2012		2016		2012		2016	
	Stations	Percent	Stations	Percent	Stations	Percent	Stations	Percent
SAUDI ARABIA / ARABIE SAOUDITE	33	72	8	75	33	89	8	92
SRI LANKA	9	91	1	91	9	-	1	0
THAILAND / THAILANDE	87	100	5	88	87	35	5	6
UNITED ARAB EMIRATES / EMIRATS ARABES UNIS	5	98	1	92	7	94	1	100
YEMEN	20	26	20	1	1	0	0	-

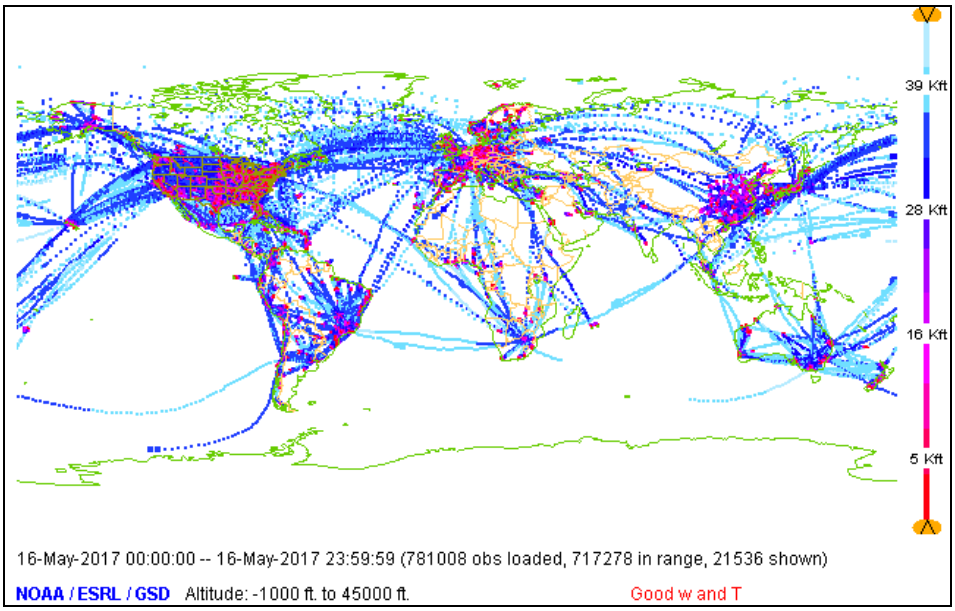
Comments on the results in the table:

- Bahrain: the only surface reports recorded in 2016 were from Bahrain international airport (January, April);
- Myanmar: no reports were recorded from any of the five upper air stations in 2016;
- Yemen: In 2016 reports were recorded from Hajjah (October), Seiyoun (October), Al-Ghaidah (October), Amran (January, October), Sana'a (October), Marib (October), Hodeidah (October), Dhamar (October), Ataq (October), Al-Saddah (October), Ibb (October), Taiz (October), Mokah (October), Aden (October), Socotra (October).

1.1.1.3.3 AIRCRAFT OBSERVATIONS

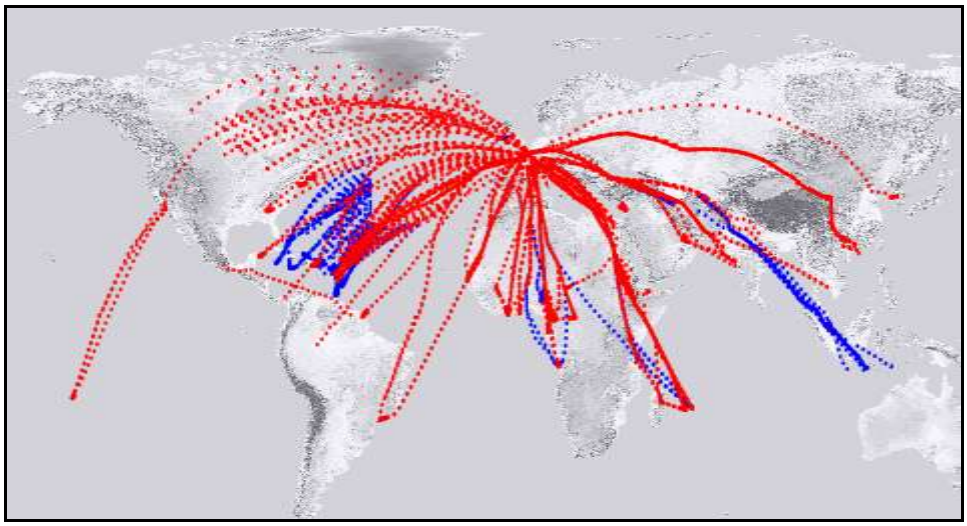
1. The aircraft-based observing system, comprising the AMDAR observing system[12] supplemented by aircraft observations derived from ICAO systems, now produces around 800,000 upper air observations per day on the WMO GTS, with the AMDAR system contributing the vast majority and over 7,000 observations from 40 participating airlines and a global fleet of around 5000 aircraft. This critical sub-system of the WMO Integrated Global Observing System produces both upper tropospheric enroute (lighter blue in coverage map below) and vertical profile (from AMDAR aircraft at airport locations – red in coverage map below) high quality, upper air temperature and wind data, that continues to demonstrate a significant positive impact on global, regional and high resolution NWP and other forecasting and meteorological applications[13]. With the advent and scientific validation of the Water Vapour Sensing System, WVSS-II, for jet aircraft, there is a growing number of aircraft (currently 151 aircraft, chiefly providing data over the US and Europe) operationally providing vertical profiles of high quality atmospheric moisture data.

[12]http://www.wmo.int/pages/prog/www/GOS/ABO/AMDAR/
[13]See : http://www.wmo.int/pages/prog/www/GOS/ABO/data/ABO_Benefits.html



Development of AMDAR in Regional Association I (RA-I, Africa)

2. The South African AMDAR Programme remains the sole AMDAR Programme in RA-I, with a fleet of 44 South African Airways aircraft, now providing around 7000 upper air observations, including around 150 vertical profiles per day on the GTS. However, based on a collaboration between WMO, EUMETNET and Météo-France to equip the Boeing B777 fleet of Air France and EUMETNET that of British Airways, the AMDAR coverage over Africa has greatly improved over the past 18 months. WMO and EUMETNET are both supporting the provision of observations from these B777 and other E-AMDAR aircraft over Africa and other data-sparse areas, leading to the additional coverage that is shown below.



Current data coverage from both AFR and BAW B777 fleets and also the E-AMDAR contribution to user requirements for data - one week snapshot of AFR (red) and BAW (blue) B777 data coverage May 2017.

3. In RA-I, since the previous WMO/ESCAP Panel session,CBS, through its Expert Team on Aircraft Based Observing Systems (ET-ABO), has been endeavouring to continue to collaborate with Regional Associations I andII and their Members in the development of new AMDAR programs in Africa and Asia in cooperation with partner organisations and the aviation industry. RA-I, at its last session and regional conference in Cabo Verde (February 2015), agreed that a regional working body for AMDAR might take on the role of coordinating and overseeing further development of the aircraft-based observing system. AMDAR programmes have commenced development in both Kenya and Morocco with Kenya Airways and Royal Air Maroc (RAM) respectively. The Morocco programme development is being undertaken in a collaboration between Maroc-Météo and the EUMETNET/E-AMDAR programme, with observations expected to be available from the RAM fleet later in 2017 or early in 2018.

4. Further growth and enhancement of the AMDAR programme within Africa would be expected to have a significant additional positive impact on tropical cyclone forecasting and monitoring skills and applications of RA I Members.

5. ***Development of AMDAR in Regional Association II (RA-II, Asia):*** In RA-II, a WMO WIGOS/AMDAR workshop for West Asia was held on 4 November 2016 in Abu Dhabi, United Arab Emirates (UAE). Invited participants from four Gulf countries have attended the workshop. From the final report of the workshop, Saudi Arabia undertook to lead the regional approach to AMDAR development in West Asia and to investigate the use of the Gulf Cooperation Council forum to promote the AMDAR programme.

6. Referring to the national ABO programme report submitted by UAE, National Centre of Meteorology & Seismology of UAE was investigating the implementation of AMDAR within UAE Flight Information Region and the possibility to transmit aircraft-based observations received from Etihad Airways on the GTS in BUFR format.

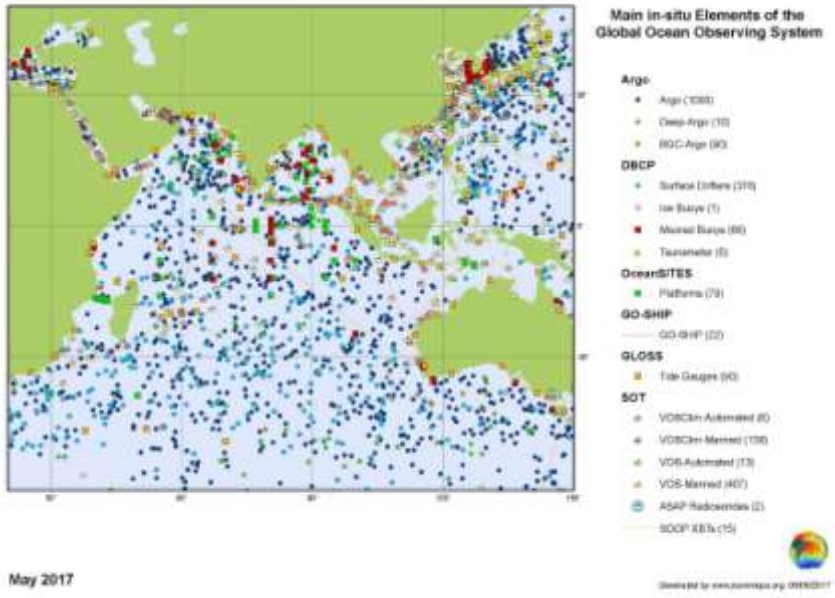
7. According to a news report, the technical director of Directorate General of Meteorology (DGM) of Oman revealed that DGM was considering discussing the matter with Oman Air on how they could take this (AMDAR) initiative forward.

8. In RA-II 16th session, the RA adopted draft resolution 5.2/8 "Pilot Project to Develop Support for National Meteorological and Hydrological Services in the Collection and Application of Aircraft Meteorological Data Relay data" and established a task team on Aircraft Based Observations under the Expert Group on WMO Integrated Global Observing System (EG-WIGOS). According to the terms of reference, the task team will "in collaboration with Regional Members and the CBS, develop a regional implementation plan for aircraft-based observations and AMDAR as a component of the Regional WIGOS Implementation Plan".

1.1.1.3.4 MARINE AND OCEAN METEOROLOGICAL OBSERVATIONS

- Although the baseline system proposed under the implementation goals for JCOMM Observations Programme Area was designed to meet climate requirements, non-climate applications, such as NWP, tropical cyclone prediction, global and coastal ocean prediction, and marine services in general, will be improved by implementation of the systematic global observations of Essential Climate Variables (ECVs) called for by the GCOS-200 implementation needs.

- Globally, the ocean in situ observing system is now 67% implemented although no substantial progress according to the completion targets has been noticed in the last few years. All data are being made freely available to all Members in real-time. Tropical oceans provide for an important heat engine of global climate and weather patterns, and the Tropical moored buoy arrays, the Argo profiling float programme, and ships of opportunity deploying XBTs provide essential upper ocean thermal data from that perspective. These data complement other existing satellite (e.g. sea level) and *in situ* observations in the region. All data are being made freely available to all Members in real-time. **Completion will require substantial additional yearly investment by the Members/Member States, including in WMO Regional Association II.**



- The map above shows the status of ocean observing networks in the Indian Ocean during May 2017. As it is apparent from the map, there are gaps in ocean monitoring in East Mariana Basin area, South east Asian region, Mozambique Channel, West of the Somali Basin and Southern Indian Ocean.

- **Therefore WMO/ESCAP Panel members are invited to explore enhanced contributions of WMO Members in the region in support of the implementation of marine meteorological and oceanographic observing systems as follows:**
    - Efforts are necessary to ensure adequate geographical coverage and ensure sustainability of the array.
    - Support the Argo profiling float programme, which is providing upper ocean temperature and salinity profiles from the world oceans. Support can be through the purchase of floats, the deployment of floats provided by other countries, and identification of new float deployment opportunities.
    - Maintain the Research Moored Array for African-Asian-Australian Monsoon Analysis (RAMA) array to assure coverage of the tropical oceans - the heat engine of global climate and weather patterns.

- Deploy Cost-effective technology that exists for surface drifters equipped with thermistor strings and designed to be deployed in tropical cyclone conditions.
- Increase Voluntary Observing Ship (VOS) observations from tropical regions, and the southern ocean which remain relatively data sparse.
- Support the Ship of Opportunity Programme (SOOP) which is providing upper ocean temperature profiles from Expendable Bathythermographs (XBTs), by for example identifying and providing ship recruitment opportunities.
- Provide international support for equipment and training in order to close gaps in the Global Sea Level Observing System (GLOSS) Core Network (GCN, sea level from tide gauges).

1.1.1.4. Activities of Panel

1.1.1.4.1. The Panel stressed the importance of the WIS monitoring system through Global Information System Centres (GISC) to the Panel. The NMHS and Tropical Cyclone RSMC were requested to take the steps to utilize these GISCs. A priority for NMHS in the Panel should be that the Panel Members should work closely with their GISC to establish the required capabilities and information exchange, using available communication technologies such as the Internet.

1.1.1.4.2. The Panel noted availability of satellite observations covering the Panel's region. The Panel also appreciated China, India and Russia for their producing satellite observations from geostationary meteorological satellites for covering Indian Ocean.

1.1.1.4.3. The Panel reviewed the Regional Basic Synoptic Network (RBSN) which is a minimum regional requirement to provide a fundamental basis for weather analysis and forecast and for tropical cyclone warning services in the Panel's Region. The Panel was alarmed by the decreasing trend of the number of surface and upper air stations, and discussed about alternative cost-effective observing systems like AMDAR system, which further growth and enhancement within Africa would be expected to have a significant additional positive impact on tropical cyclone forecasting and monitoring skills and applications of the Panel Members.

1.1.1.4.4. The Panel noted the importance of the marine observations to tropical cyclone forecasting and warnings. It was invited to explore enhanced contributions to support implementation of marine meteorological and oceanographic observing systems in the Region. The Panel was informed that ocean surface layer heat content information would soon be available for its application to support operational tropical cyclone forecasting and warning services.

1.1.1.4.5. The Panel was informed that air traffic nowadays is expanding almost two-fold every 15 years. This poses huge challenges to the future global air navigation systems if safety is to be ensured. Meteorological information has been recognized as an integral part of the future air navigation systems. The future ATM system will require access to global meteorological information on a far shorter time scale than has been customary in the past. It will be required that that meteorological information transitions from today's predominantly product centric to data centric information, in accordance with a globally interoperable information exchange model, use extensible markup language (XML)/geography markup language (GML), and be accompanied by the appropriate metadata. It is anticipated that exchange of OPMET data in digital format, of which Tropical

Cyclone SIGMET is included, will be a mandatory requirement by 2020. It is therefore recommended that Member States develop capability for handling OPMET data in digital format before 2020.

1.1.1.4.6 The Panel is reminded of Decision 15 of the Sixteenth Session of RA-II (RAII-16), February 2017, that endorsed the training programme for WIS competencies[14] as listed in the Annex to that Decision, requesting that GISCs and RTCs serving Members in the Region provide the necessary training.

1.1.1.4.7. As a priority, the Panel is urged to encourage NMHSs and RSMC New Delhi to work closely with their Principal GISC to establish the required capabilities and information exchange, ensuring provision of necessary training and using available communication technologies such as the Internet.

1.1.1.4.8 Furthermore, the Panel is invited to consider the inclusion of WIS implementation as a cross-cutting issue in the Coordinated Technical Plan and Annual Operating Plan, noting the need for liaison with the Coordinators[15] of the RA-II Expert Group on the WMO Information System (RA-II EG-WIS) to provide (i) input to the planned update of the RA-II WIS Implementation Plan[16], and (ii) regional requirements for inclusion in the development and implementation of the WIS 2.0 Strategy[17] and aspects of information management pertinent to WIS Part C[18].

1.1.1.4.9 The Panel is reminded of the International Forum of Users of Satellite Data Telecommunication Systems ("Satcom Forum")[19]. The Satcom Forum is developing a handbook providing the information necessary to evaluate the suitability of currently available satellite-based data telecommunications systems and data retransmission systems for environmental monitoring and emergency management, and plans to pursue negotiation of a "WMO-IOC branded disaster alerting tariff" with satellite communications service providers based on the results of a 2017 survey[20] of National Hydrological and Meteorological Services.

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[14] The WIS Competencies are described in Appendix E to the Manal on WIS (WMO-No. 1060) (http://wis.wmo.int/WIS-manual), with a complementary training and learning guide provided in Appendix A to the Guide to WIS (WMO-No. 1061) (http://wis.wmo.int/WIS-guide).

[15] The coordinators of RA-II EG-WIS are Ms Li Xiang (China) and Mr Kenji Tsunoda (Japan)

[16] http://wis.wmo.int/file=653

[17] The WIS 2.0 Strategy is provided in Annex to Recommendation 35 (CBS-16) and endorsed by Resolution 8 (EC-69)

[18] Resolution 33 (Cg-17) decided to extend the scope of WIS to include information management, to be known as WIS Part C

[19] Satcom Forum (https://wis.wmo.int/page=SATCOM) was established by the Seventeenth session of the World Meteorological Congress as a joint effort of both WMO and the Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO)

[20] https://wis.wmo.int/page=Satcom-Survey2017

1.1.1.4.10. The Panel was advised of the importance of registering national warning and alerting authorities in the Alerting Authority Register[21] to ensure that CAP messages are attributed to authoritative sources and given the appropriate priority. Although managed by WMO, the Alerting Authority Register is intended to include authorized issuers of any type of official warning or alert, including those that are not related to meteorology, and is used by information providers to identify alerts from official sources. The Panel is urged to encourage Members to review the Alerting Authority Register and register any national warning and alerting authorities that are missing.

1.1.1.4.11. The Panel is requested to review the WWW monitoring statistics and to develop and implement a plan to remedy deficiencies in the number of surface and upper air reports provided.

1.1.1.4.12. The Panel is advised that the migration of upper air reports from traditional alphanumeric reports (TAC) to BUFR has regularly resulted in coding errors[22] and loss of upper air information. The Panel is reminded of the B/C regulations within Manual on Codes (WMO-No. 306) that specify how upper air reports should be coded in BUFR, and is urged to encourage WIS Centres providing upper air reports to work with their Principal GISC to ensure correct encoding of the upper air information in BUFR.

1.1.1.4.13. In RA-II 16th session, the RA adopted draft resolution 5.2/8 "Pilot Project to Develop Support for National Meteorological and Hydrological Services in the Collection and Application of Aircraft Meteorological Data Relay data" and established a task team on Aircraft Based Observations under the Expert Group on WMO Integrated Global Observing System (EG-WIGOS). According to the terms of reference, the task team will "in collaboration with Regional Members and the CBS, develop a regional implementation plan for aircraft-based observations and AMDAR as a component of the Regional WIGOS Implementation Plan".

1.1.1.4.14. Therefore WMO/ESCAP Panel members' are invited to explore enhanced contributions of WMO Members in the region in support of the implementation of marine meteorological and oceanographic observing systems as follows:

- Efforts are necessary to ensure adequate geographical coverage and ensure sustainability of the array.
- Support the Argo profiling float programme, which is providing upper ocean temperature and salinity profiles from the world oceans. Support can be through the purchase of floats, the deployment of floats provided by other countries, and identification of new float deployment opportunities.
- Maintain the Research Moored Array for African-Asian-Australian Monsoon Analysis (RAMA) array to assure coverage of the tropical oceans - the heat engine of global climate and weather patterns.

[21] https://alerting.worldweather.org/

[22] The four-part TAC message is replaced with four independent BUFR messages that cannot be recombined into a single report for assimilation by NWP centres

- Deploy Cost-effective technology that exists for surface drifters equipped with thermistor strings and designed to be deployed in tropical cyclone conditions.
- Increase Voluntary Observing Ship (VOS) observations from tropical regions, and the southern ocean which remain relatively data sparse.
- Support the Ship of Opportunity Programme (SOOP) which is providing upper ocean temperature profiles from Expendable Bathythermographs (XBTs), by for example identifying and providing ship recruitment opportunities.
- Provide international support for equipment and training in order to close gaps in the Global Sea Level Observing System (GLOSS) Core Network (GCN, sea level from tide gauges).

Members interested to contribute are invited to contact the JCOMM in situ Observations Programme Support Centre – JCOMMOPS – at support@jcommops.org.

1.1.2. India

1.1.2.1. The representative of India informed the Panel that there have been augmentation of meteorological observations as mentioned below.

(i) Real time HWSR data through GPRS modules is available for 20 stations

(ii) Total network of upper air radio sounding (RS/RW) of 43 stations has been upgraded with GPS based radio sounding, and all the stations are working at present.

(iii) Indigenous GPS based radiosonde is in final stage of production. Procurement of different components in different stages-production to start on receipt of material.

(iv) At present IMD is receiving and processing meteorological data from three Indian satellites namely Kalpana-1, INSAT-3D & INSAT-3DR. INSAT-3D and INSAT-3DR have an advanced imager with six imagery channels {Visible (0.55-0.75 μm), Short wave Infra-Red (SWIR) (1.55-1.70 μm), Medium Infra-Red (MIR) (3.80-4.00 μm), Thermal Infra-Red-1(TIR-1) (10.2-11.3 μm), TIR-2 (11.5-12.5 μm), & WV (6.50-7.10 μm)} and a nineteen channel sounder (18 IR & 1 Visible) for derivation of atmospheric temperature and moisture profiles. It provides 1 km resolution imagery in visible band, 4 km resolution in IR band and 8 km in WV channel. At Present about 48 nos. of satellite images are taken daily from Kalpana-1, INSAT-3D and INSAT-3DR. Half hourly satellite imageries are also obtained from all the six imager channels and hourly images from the sounder channels of INSAT-3D satellite. All the received data from the satellite are processed and archived in National Satellite Data Center (NSDC), New Delhi. INSAT-3D Meteorological Data Processing System (IMDPS) is processing meteorological data from INSAT-3D and supports all operational activities of the Satellite Meteorology Division on round the clock basis. Cloud Imagery Data are processed and transmitted to forecasting offices of the IMD as well as to the other users in India and foreign countries. The following products derived from the satellite are useful for monitoring of tropical cyclones:

- Enhanced grey scale imagery of cyclone.
- Enhanced coloured imagery of cyclone.
- Lower level Vorticity

- Upper level Divergence.
- Lower level convergence.
- Vertical wind shear.
- Wind shear tendency.
- Outgoing Long wave Radiation (OLR) at 0.250X0.250 resolution
- Quantitative Precipitation Estimation (QPE) at 10 /10 resolution
- Sea Surface Temperature (SST) at 10 /10 resolution
- Cloud Motion Vector (CMV)
- Water Vapour Wind (WVW)
- Upper Tropospheric Humidity (UTH)
- Temperature, Humidity profile
- Value added parameters from sounder products
- Geo-potential Height
- Layer Precipitable Water
- Total Precipitable Water
- Maximum Vertical Theta-E Differential
- Wind Index

1.1.2.2. Following NWP models were operational during 2016

i. Global Forecast System (GFS-1534) (~ 12 km in horizontal over the tropics) with ENKF based Grid point Statistical Interpolation (GSI) scheme as the global data assimilation for the forecast up to 10 days.

ii. Regional Forecast System: IMD operationally runs three regional models WRFDA-WRFARW (v3.6), and HWRF for short-range prediction during cyclone condition.

iii. Dynamical Statistical Model

iv. The dynamical statistical model includes (a) Cyclone Genesis Potential Parameter (GPP), (b) Multi-Model Ensemble (MME) technique for cyclone track prediction, (c) Cyclone intensity prediction, (d) Rapid intensification and (e) Predicting decaying intensity after the landfall.

v. Extended range forecast: Experimental dynamical extended range forecast based on multi model ensemble (MME) for 4 weeks rainfall using model outputs from IITM CFS V2 and other global centres prepared every week and made available through IMD website.

vi. Models run at NCMRWF: (a) Unified model adapted from UK Meteorological Office (horizontal resolution of 17km and 70 vertical levels) with 4D-Var assimilation and (b) NCMRWF Ensemble Prediction System (NEPS) adapted from UK MET Office (Horizontal resolution of the model is approximately 33 km in the mid-latitudes) to provide 10 day control forecast and 44 ensemble members using Ensemble Transform Kalman Filter (ETKF) method.

1.1.2.3. Information System and Services: During the period 2016-2017 following new data sets were received from different circuits and routed to various stakeholders/ users:

- Twenty two (22) operational Doppler Weather RADAR(DWR) data were received in NETCDF and BUFR format and routed to users as per their requirement.
- RMDCN link has been upgraded to 6Mbps RMDCN-NG(Next Gen) which handles 6 circuits viz. Tokyo, Moscow, Beijing , Germany, Exeter and Toulouse. This has improved the data exchange from these GTS centres.
- MPLS VPN link at HQ New Delhi has been upgraded to 10Mbps MPLS-MNS IPVPN link for smooth catering of data requirements to the national users. This will help in faster data reception at Head Quarters from DWR stations & NWP Centres to various users.
- Fifty four IMD stations are connected with IPVPN connectivity speeds ranging from 512kbps to 10mbps. These VPN circuits are connected with Synergie Systems at various out stations, Doppler Weather Radar Stations, AMSS Centres and Regional Centres for National data collection /exchange.
- At present IMD has two independent Internet leased links of 150 Mbps from different Internet service providers. IMD is also connected to 1 Gbps NKN (National Knowledge Network) link of NIC for internet, data exchange within Close User Group (CUG), Video conferencing & Telepresence services. A state of the art technology upgraded LAN has been implemented at HQ.
- IMD intends to join OpenWIS association as a strategic partner and it is under process. Joining the OpenWIS association will help IMD in getting platform independent applications developed by the association from time to time as per WMO guidelines.
- Video conferencing among all forecasting offices
- IMD has started their social media services through Facebook (https://www.facebook.com/India.Meteorological.Department/) and Twitter (https://twitter.com/Indiametdept) accounts to disseminate its forecast and warnings

1.1.2.4. Followings are ongoing projects:

- Provision of adequate communication system for data and product transmission:
- As per guideline of WMO, RTH New Delhi applied for GISC as well as DCPC for South Asia. Upgradation of RTH New Delhi as GISC is under process.
- Upgradation of AMSS (Automatic Message Switching Systems) at Delhi-Palam, Kolkata, Mumbai and Chennai.
- Development of Centralized GIS Based content managed Website of IMD under process.
- Procurement of cloud based services at IMD.
- Upgradation of forecasting system with web based system.

1.1.3. Maldives

1.1.3.1. As the location of Maldives in the Indian Ocean happens to be a data sparse area in which shifting of ITCZ and phases of MJO take place, upper air observations from

both Male'(WMO # 43555) and Gan are very important to entire meteorological community in the region and globe. Maldives urge assistance from donors and Panel Members to consider rebuilding Maldives' upper air observation network.

1.1.3.2. Total of 23 Automatic Weather Stations (AWS) has been installed and only 7 are in operation. Maintenance of these have become costly.

1.1.3.3. Maldives own only one DWR while 2 or 3 are required to cover entire area.

1.1.4. Myanmar

1.1.4.1. The representative of Myanmar informed that during 2016, there were strong El-Nino events in the months of March, April and May. The highest maximum temperature recorded in central areas about 46ºC which was the new maximum temperature recorded in the whole country. There was 4 naming Cyclonic Stroms originated in the Bay of Bengal. Highest water level recorded along Ayeyarwady river.

1.1.5. Oman

The meteorological facilities of Oman under are discussed as below:

1.1.5.1. Upper Air Observation

The Sultanate of Oman operates two upper air-observing stations located at Muscat (41256) and Salalah (41316). Both these are equipped with Vaisala's Digicora GPS wind finding system. The radiosonde used is Vaisala RS41 equipment.

1.1.5.2. Ship Weather Reports

Weather Reports from Ships are received through GTS.

1.1.5.3. Wave Measurements

Three wave radar measurement station was installed offshore of Oman Sea and Arabian Sea in 6 locations another 3 wave radars are planned to be installed next year. 10 tide gauges were installed disrupted offshore Oman Sea and Arabian Sea as part of Tsunami Network.

1.1.5.4. Synoptic Land Stations

There are a total of 70 meteorological stations out of which 23 are listed in the WMO's Regional Basic Synoptic Network (RBSN) including 2 radiosonde stations, 12 Regional Basic Climatological Network (RBCN) stations out of which 3 listed in Global Climate Observing System Surface Network.

1.1.5.5. Doppler Weather Radars

Four Dual Polarization S-Band Doppler Weather Radar have been commissioned and one more is expected to be commissioned soon. The Radars are supplied by Selex Gematroniks.

1.1.5.6. Telecommunication

All the meteorological stations operated by the Directorate General of Meteorology (DGMET) are connected to the MSS computer located at the National forecasting and Early Warning Center at Muscat International Airport by a reliable telephone links (dial-up 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 16 Mbps Internet leased line has been established as well as for transmitting and receiving meteorological data with different meteorological centers such as New Delhi and Abu Dhabi.

1.1.5.7. Satellite reception

The Department installed Satellite ground receiving station for intercepting High Resolution images from Polar Orbiting satellites operated by NOAA, EUMETSAT and China as well as from geostationary satellites operated by EUMETSAT.

1.1.5.8. Oman Center of Excellence (COE)

The 12th EUMETSAT Satellite Application Course was successfully organized and conducted at Oman Centre of Excellence (COE) for training satellite meteorology during February 2016.

1.1.5.9. Data Visualization

The Directorate General of Meteorology (DGMET) is using a visual weather application for visualizing all meteorological data in most standard formats including data in GRIB1, GRIB2 and BUFR format coded data..

1.1.5.10. Data Processing System

- Global Numerical Weather Prediction NWP products are received via Internet, GTS, DWD Sat. We receive products from meteorological centers including ECMWF, NOAA, UK met office and German Weather Service (DWD). Current processing capabilities consist of a PC Cluster of 80 nodes and 4 spare nodes with total of 168 processors. 2x Intel Xeon 2.3 GHz Hexacore is used for each node. This makes a total of 960 processing core. All nodes are connected via very fast Interconnection network using 108-ports Infiniband (Mellanox – ConnectX 3, QDR 40GBit).

- Local Oman Regional Model ORM was established with the kind cooperation of National Weather Service of Germany DWD since 1999.

- DGMET has been running an operational version of COSMO model (Consortium for Small-scale Modeling) COSMO is a non-Hydrostatic limited-area numerical weather prediction. It runs on 7x7 km resolution covers the area between 30.0 E, 7.0 N

(lower left corner) to 78.0E, 35.25 N (Upper right corner). There are 769x453 grid points and 50 vertical layers. The model is running on 64 nodes from the PC Cluster. It produces up to 120-h forecast at 00 and 12 UTC. And 2.8km model resolution covering Oman and adjacent areas. COSMO was introduced to enhance the accuracy of predicting local rainfall over Hajar Mountains and adjoining area during summer.Figure.1 shows the domain covered by COSMO_07 model. WRF Weather Research and Forecast model is successfully running with two resolution; parent domain of 7 km and nested domain of 3.5 km. The parent domain covers approximately similar to COSMO_07, while the nested one cover Oman area.

- A WAM based wave model was established with the kind cooperation of HZG of Germany, which covers the Arabian Sea, gulf of Oman and Arabian Gulf. WAM model run of 14km resolution and nested into 3.5km resolution.

- With the kind cooperation and assistance from NOAA a Hurricane Weather Research Forecast (HWRF) Model was installed during June 2013 at the Oman National Meteorological Service. This Model is run with three resolutions, 27 , 9 and 3 km. The 3km moving nest covers the event domain and tracking the tropical cyclone movement. It is used to forecast Track, Intensity and Direction of Movement for Storms and Cyclones over the Arabian Sea and Bay of Bengal.

- Seasonal forecast of TCs model has been implemented in Met-office since 2014. It forecasts the probability of TC activity occurrence for the next few months. Its method is based on relating TC activity and monthly SST configurations over the NIO.

- Early Warning System was established since 2014. Part of the system responsibility deals with Tropical Cyclone events. In TC event, EW runs different models in addition of the above models. For example, IHC Swan real time to check wave status, IIT Storm Surge Model and IHC H2D real time for the storm surge status.

1.1.5.11. Aeronautical Services

In order to meet ICAO recommended practices and to fulfil the requirements for Aviation the Directorate General of Meteorology (DGMET) installed a SADIS workstation as early as 1996. In addition all the SADIS data and products are also received through a secured FTP Server from UK as a back-up. A new service was established for the provision of en-route flight folders for all Airlines operating in the Sultanate to be accessed on our web portal.

1.1.6. Pakistan

The representative of Pakistan apprised the Panel about the meteorological component, which is summarized as under:

1.1.6.1 The Government of Pakistan has approved the project entitled "Establishment of Specialized Medium Range Weather Forecasting Centre (SMRFC) and Strengthening of Weather Forecasting System in the Islamic Republic of Pakistan" with the total cost of Rs. 2.5 billion under Japanese grant-in-aid assistance. Out of the toal cost, the Government of Japan share is around 97.5%. Under this project, the Government of Japan will provide state-of-the-art technology in order to further upgrade the forecasting and early warning capabilities of PMD. Installation of high computing system (128 nodes), Weather Surveillance Radar at Islamabad and two Wind Profiler (one each at Islamabad and Multan) are part of this project. The construction of weather radar at Islamabad is underway and will be finalized in December 2019.

1.1.6.2 PMD in collaboration with RIMES and Karachi-Electric (KE) fourth National Monsoon Forum and Heatwaves Early System Workshop in Karachi on 11-12 May, 2016 in which stakeholders from different domains like DRM, Health, academia, NGOs, electronic and print media participated. The meeting focused on monsoon, its predictability, general outlook and flooding potential as well as heat waves, their warning system and precautionary measures.

1.1.6.3. In wake of severe heatwave in Karachi in 2015 that took more than 1000 precious lives, PMD established Heatwave Early Warning System in Karachi in order to inform the general public to adopt precautionary measures for effectively handle the heatwave hazard. PMD also organized heatwave awareness seminars in Karachi during 2016 and 2017 in collaboration with K-Electric, PDMA, City Metropolitan Corporation, local NGOs and concerned stakeholders.

1.1.6.4. Keeping in view of the vulnerability of Kalpani Nullah of Mardan District to flash flooding, the Government of Pakistan has approved the project titled "Establishment of Flood Forecasting & Warning System for Kalpani Nullah Basin, Mardan (KPK). Under this project, the installation of weather radar at Mardan is in progress.

1.1.6.5. An MoU was signed between Pakistan Meteorological Department and Meteo France for Cooperation in the field of Meteorology on 20th July, 2017 in France. Under this agreement, both the countries would work together to bring improvement in PMD's weather forecasting system, develop capacities in the field of early warning and weather services for the protection of human life, property and the environment, with special focus on the implementation of a heat wave early warning system.

1.1.6.6. He further informed that the General Authority of Meteorology & Environmental Protection (GAMEP) of Kingdom of Saudi Arabia has requested for the provision of two trainers / experts from PMD to impart training and capacity development of GAMEP in the field of climatology, severe weather prediction & numerical weather prediction, the Government of Pakistan has recently approved the nomination case. Both the experts are expected to join GAMEP by the end of this September, 2017.

1.1.6.7. In commemoration of establishment of World Meteorological Organization on

23rd March, 1950, PMD made special arrangements to celebrate the WM Day on 23rd March, 2017 at its Institute of Meteorology and Geophysics (IMG), Karachi. People from various walks of life, institutions, academia participated in this knowledge-sharing platform. Participants were briefed though various programmes and activities about the objectives of the WM Day celebration and theme of the year "Understanding Clouds". A brochure containing the key messages from the Secretary-General WMO, Advisor to the Prime Minister on Aviation, Secretary (Aviation), and PR of Pakistan with WMO was also distributed among the stakeholders of PMD.

1.1.6.8. The project for "Installation of Weather Surveillance Radar at Karachi in the Islamic Republic of Pakistan" was approved by the Govt. of Pakistan on 31.03.2015 with a total cost of Rs.1580.000 million (with Govt. of Japan grant-in-aid assistance is around Rs.1542 while the rest will be borne by the Govt. of Pakistan). The construction woprk for the radar building is expected to start by the end of this year.

1.1.6.9. PMD in collaboration with RIMES and KE (Karachi Electric Limited) organized 5th Monsoon Forum and 2nd Heatwave Awareness Workshop in Karachi on 8th May, 2017 in which stakeholders from different domains like DRM, Climate Change, universities, NGOs, and Electronic & Print Media participated. The meeting focused on:

- Reviewing the 2016 summer monsoon and post-monsoon seasons,
- 2017 winter season and pre-monsoon season in Pakistan
- Present the seasonal forecast for Pakistan for the summer 2017 Season (Monsoon & Heat waves);
- Apprise the existing EWS for Heat waves and identify the Gaps with consultation of stakeholders.

PMD has been running ICOsahedral Non-hydrostatic model (ICON) model since March 2015. ICON is a unified modelling system for global numerical weather prediction (NWP) and climate modelling. The model is installed on a high performance computing cluster system of 184 cores. ICON is the improved version of GME (Global Model of DWD, Germany) which has 13km horizontal grid resolution and 40 atmospheric Levels. ICON operates twice daily for 7days forecast on 00UTC and 12UTC, at 13km horizontal resolution.

1.1.7. Sri Lanka

1.1.7.1. Synoptic and upper air Observations: Data reception from 23 operational stations with the two stations commenced in 2009 namely, Polonnaruwa and Moneragala and at the new international airport in Hambanthota, operating from 2014 was very good but still unable to receive WMO numbers for these three stations. The automatic weather system network in Sri Lanka consisting of a total of 38 stations and 20 telemeter rain gauges which installed in areas prone to exceptionally heavy rain events, particularly in the central highlands of Sri Lanka. Another 100 telemeter rain gauges are planned to install with the increasing frequency of flood and landslide events. In addition agro-Meteorological Network consists of 35 stations and they are based mostly at agricultural agencies. The

total number of stations measuring only 24-hour accumulated rainfall in Sri Lanka using manual rain gauges is approximately 500. Pilot balloon observations are made at 04 synoptic meteorological stations (Colombo, Trincomalee, Hambantota and Mannar) at 00, 06 and 12 UTC and currently radiosonde (GPS-based) observation is done at Colombo headquarters three times (06 UTC) per week due to financial constrain. The satellite imageries through satellite receiving system of CMACAST and the imageries and products from INSAT , HIMAWARI and EUMETSAT down loaded through internet were utilized.

1.1.7.2. Improvement of Facilities/Technical Advancement: Observations at Meteorological office, Trincomalee (43418) was commenced links with RIMES was continued under the project Reducing Risks of Tsunami, Storm surges, Large Waves and other natural hazards in low elevation coastal zone. To improve the forecasting capability of department activities on training and utilizing WRF model was done by JICA and KOICA. Issuing of seasonal rainfall forecast under experimental basis was continued. Monsoon forum was also held two times per year with the both technical financial support of RIMES. RIMES with the collaboration of INCOIS established a " Integrated Ocean Information System for Sri Lanka and wave rider‟will be deployed in Sri Lankan sea in 2016. Preparing of three day forecast was enhanced up to 10 days using WRF with 5Km resolution. The project "Improving of Meteorological Observations, Forecasting and Dissemination" funded by JICA was on process and some experts were also dispatched. Two Doppler radars will be installed in the both East and West coasts of Sri Lanka under the project in 2020. Use of ECMWF model forecast products under SWFD project has done more effective manner and it help to improve the forecasting capabilities and department made a non commercial agreement with the financial support from World Bank from July 2017.

1.1.8. Recommendations:

1.1.8.1. RSMC is requested to provide guidance on occurrence on low-pressure area and its possible intensification leading to genesis of cyclonic disturbances over the north Indian Ocean. This may included in regional tropical cyclone operational plan (TCP-21) 2017 edition.

1.1.8.2. On the basis of the request made by the members about the guidance on rainfall and wind associated with low-pressure systems, it is suggested to utilized the guidance provided by RSMC New Delhi on heavy rainfall, strong wind, storm surge, and wave height under the SWFDP. There is a special web page (www.rsmcnewdelhi.imd.gov.in) for SWFDP Bay of Bengal, which contains various global NWP models guidance and regional severe weather guidance for day 1 to day 5 by RSMC New Delhi. RSMC New Delhi will again provide the user name and password to all the member countries of SWFDP and also to Oman and Yemen.

1.2 HYDROLOGICAL ACTIVITIES

1.2.1. WMO activities

1.2.1.1. Associated Programme on Flood Management (APFM)

The Panel noted that the Associated Programme on Flood Management (APFM) is a joint initiative of WMO and the Global Water Partnership (GWP), with the objective to promote the concept of Integrated Flood Management (IFM) for minimizing loss of life due to flooding and optimizing the net benefits derived from floodplains. The APFM is to proposes a paradigm shift from flood protection to flood management, in line with the Sendai Framework for Disaster Risk Reduction, where the emphasis has shifted to include not only protection from hazards, but also the concept of "building back better".

IFM is promoted using a user' friendly platform through which countries can get assistance in capacity-building, technical guidance, or policy formulation towards the implementation of flood management strategies. Users have the possibility either to request custom-made technical support through the Get Help function or to find flood management solutions by themselves using available literature in the Help Yourself section.

The Associated Programme on Flood Management (APFM) is an advocacy for integrated flood management, i.e., increasing preparedness and resilience to floods through a multidisciplinary approach encompassing flood forecasting, early warning, flood mapping, land-use planning and structural and non-structural measures. The APFM is already heavily involved with urban flood management, having developed training manuals and tools on integrated urban flood management, that provide best practice concepts and applications in view of integrated and cooperative approaches in water management. These manuals and tools are directed at decision-makers, professionals of various fields of knowledge, working in the urban environment as administrators, legislators, engineers, architects, geologists, biologists and others, integrating expertise from different disciplines.

Urban flooding continues to be of great importance in the APFM agenda because of the high impact that flood events have on the urban environment and because of the need for more detailed information regarding modelling and assessment of flood impacts in human settlements. Events in informal settlements are especially destructive as these settlements are particularly vulnerable. Reducing disaster risks and increasing the resilience of people living in these areas are also crucial for minimizing loss of life and maximizing net benefits from the use of floodplains and work towards achieving the post-sustainable development agenda.

The IFM Help Desk is hosted in WMO but depends on a strong decentralized network of experts and specialized institutes, called "Support Base Partners" (SBPs), providing input on advice and advocacy for flood management policy and strategy formulation; technical advice on the (inter-) national, regional and local level; facilitation of workshops and trainings supporting the Integrated approach of Flood Management; development and provision of flood management tools and capacity building material; and formulation of objectives and scoping for flood management proposals. Currently the network includes 31 partner institutions, comprising of National Meteorological and Hydrological Services (NMHSs), private sector companies, Universities, other International Organizations and NGOs.

The APFM is governed through Advisory and Management Committees (AC/MC), meeting on a yearly basis to review the progress of the last year and to formulate a work-plan for the incoming year.

At its meeting in September 2015, the AC/MC identified the APFM as a strong entry point to the Sendai Framework for Disaster Risk Reduction. The Sendai Framework aims to reduce substantially disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries. Its goal is to prevent new - and reduce existing - disaster risk

through the implementation of integrated measures inclusive of economic, structural, legal, social, health, cultural, educational, environmental, technological, political and institutional.

APFM has been since its inception focusing on this multi-disciplinary approach, and would be able to assist in the four Priorities of the Sendai Framework (Understanding disaster risk; Strengthening disaster risk governance to manage disaster risk; Investing in disaster risk reduction for resilience; and Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction; enhancing the role of stakeholders, international cooperation and global partnerships) highlighting its focus on taking preventative measures to reduce exposure to risk prior to the onset of event and in preparedness for response and recovery, activities thereby strengthening societal resilience.

To complement this multi-disciplinary approach, the WMO Flood Forecasting Initiative Advisory Group (FFI-AG), which was created by Resolution 15 (Cg-XVI), met 1-3 December 2015 and requested that the APFM Technical Support Unit (TSU) undertake an inventory of the existing guidance material and/or training material and/or expertise through its Support Base already available through the IFM HelpDesk on flood forecasting and warnings. It also requested the APFM TSU to design an appropriate interface to offer assistance (in line with the existing "Get Help" and "Help Yourself" options) in the field of flood forecasting and warnings and solicit feedback from selected FFI-AG members. This activity is seen as an important step allowing the WMO/GWP Associated Programme on Flood Management to offer increased assistance through its HelpDesk for Members wishing to strengthen their End-to-End Early Warning Systems (E2E EWS) for flood forecasting.

The most recent meeting of the APFM AC/MC, held in September 2016, reported on the APFM review, undertaken by two external experts. It is worth highlighting, the review of APFM presented seven differentscenarios regarding the APFM future, some of them more extreme than others. The result was a decision to adopt a hybrid of two proposed scenarios, termed scenario 4.5. This scenario focuses on development and support to E2E EWSs for floodforecasting and will build on IFM materials already accessible through the APFM.

The APFM has also one new important Guidance Documentthat is the operational link between the Policy Series and the Tool Series. This publication outlines the approach and steps to develop and evaluate well-balanced and well-motivated strategies to cope with the risk of flooding. The design of strategies covers the full range of possible structural and non-structural measures, including structural protection and mitigation measures, planning and building codes, emergency management, raising of risk awareness and preparedness, risk-sharing and the like.

1.2.1.2. Flash Flood Guidance System (FFGS)

The Panel was informed the WMO Congress Resolution 21 (Cg XV) which is to enhance cooperation between national meteorological and hydrological services for improved flood forecasting and to support the implementation of demonstration projects such as the Flash Flood Guidance System (FFGS) with global coverage. In this connection, a Memorandum of Understanding (MoU) was concluded in 2009 for establishing a cooperative initiative among the World Meteorological Organization, the Hydrologic Research Center, the National Weather Service of the U.S. National Oceanic and Atmospheric Administration, and the U.S Agency for the International Development Office for U.S. Foreign Disaster Assistance for the Flash Guidance System (FFG) with global coverage project. The goal of the initiative is to disseminate and implement technologies that provide early warnings for

flash floods, especially in developing countries where such flash flood early warning capability does not exist.

Within the framework of the MoU, there are three projects that cover several of the Members of the Panel on Tropical Cyclones, namely the South Asia Flash Flood Guidance System (SAsiaFFGS), the Mekong River Commission Flash Flood Guidance System (MRCFFG) and a Myanmar Flash Flood Guidance System (Myanmar-FFGS). The SAsiaFFG includes Afghanistan, Bangladesh, Bhutan, India, Nepal, Pakistan, and Sri Lanka, with two regional centres, one in India and one in Pakistan. The MRCFFG includes Cambodia, Lao PDR, Thailand and Cambodia. The MRC is the Regional Centre for this project. The Myanmar project is just commencing, and the parties are currently discussing its Initial Planning Meeting.

Efforts are underway to increase the functionality of the Flash Flood Guidance System to include options such as: landslide susceptibility mapping; urban area flash flood early warnings; scalable and expandable riverine routing (riverine flood forecasting); and multiple mesoscale numerical weather model ingestion.

Given the nature of tropical cyclones and the desire for Members to provide services that include impact-based forecasting as part of multi-hazard early warning systems, there is opportunity to increase synergies between "weather" and "water" to advance End-to-End early warning systems for flood forecasts.

1.2.1.3. WMO Regional Association II (Asia) Working Group on Hydrology

The Panel noted the WMO Regional Association II (Asia) (RA-II) which was held its sixteenth session in Abu Dhabi, United Arab Emirates from 12 to 16 February 2017. Part II of the final report of the session, pages 80 to 119, provides an overview of the activities of the RA II Working Group on Hydrology. These activities includes efforts in: water resources assessment; hydrological aspects of drought; flood forecasting; improved accuracy of hydrometric and sediment observations; sediment disasters and mass movements; and hydrological responses to climate variability and change. Advances were made in all areas, with one highlight being the development of the Dynamic Water Resources Assessment Tool (DAWT) to assist long-term planning and policy assessment and development. Its application can allow assess of land-use changes within the basin over time, the impacts on water availability under different consumptive use scenarios, and the impact on availability due to climate change through the application of scenarios.

The RA II-16 formed 4 working groups, with one focusing on Hydrological Services. The Chair of the working group and Coordinator of the Expert Group on Measurements, Monitoring and Infosystems (EG-MMI) is Dr Sung Kim (Republic of Korea). The vice-Chair and Coordinator of the Expert Group on Hydrological Applications (EG-HA) is Mr Muhammad Riaz (Pakistan). Following RA II-16, its Management Group met in Geneva on 10 May 2017 and appointed 3 experts to the EG-MMI on hydrometric measurements, mass movements and hydrological services. It also appointed 5 experts to the EG-HA on water resources assessment, water-related disaster risk management, cryosphere modelling, hydrological forecasting, and hydrological drought forecasting and prediction. It is anticipated that the Working Group on Hydrological Services will have its initial meeting in October 2017 in Seoul, RK, where it is expected that individual work plans will be developed.

1.2.1.4. WMO Commission for Hydrology (CHy) Information Note

The Panel was informed that the Fifteenth session of the Commission for Hydrology (CHy-15) was held in Rome from 7-13 December 2016, with its final report providing all relevant decisions. Of particular note is Resolution 10 (CHy-15) on the Work Programme

and Structure of CHy, which list the 11 members of its Advisory Working Group, and outlines the creation of 3 focus areas for managing its activities. These include: 1) Coordination and Implementation Support; 2) Measurement, Monitoring and Infosystems; and 3) Hydrological Applications, Products and Services. Each focus area has been assigned 6 or 7 major activity areas, all being described within Resolution 10 (CHy-15). CHy also created the opportunity to allow more effort to be directed to hydrological activities through the formation of two additional focus areas, namely 1) Activities to be supported by the Secretariat, with support of experts from the Open Panel of Commission for Hydrology Experts (OPACHE), without direct involvement of AWG members; and 2) Activities to be implemented if one or more Members volunteer to lead their Implementation. The Work Plans for each of the above-mentioned 5 main focus areas were developed in detail during First Session of the CHy Advisory Working Group, and are provided in its report of the session, which was held in Geneva from 27 February to 3 March 2017. A number of the activities listed in the individual work plans may be of interest to Members of the Panel on Tropical Cyclones. The Panel may wish to consider possible synergies with the CHy to help further advance its objectives.

1.2.1.5. Recommendations

1.2.1.5.1. Panel will circulate WMO's document on Associated Program on Flood Management to the PTC Working Group on Hydrology to formulate the project proposal for region considering the existing strength and capability, gap and future need of the region by 31st December 2017.

1.2.1.5.2. Panel noted that the Flash Flood Guidance System (FFGS) was developed by Hydrologic Research Centre (HRC), USA under the patronage of WMO and has been handed over to Pakistan, India and Oman. Pakistan has calibrated and validated that system in different basins and climatic zones reporting the performance to HRC simultaneously which addressed the identified issues over the stretch of last 4 -5 years. Pakistan and India are ready to adopt this system and waiting for its formal launch by the WMO. However, Oman has recently tested this system. Secretary PTC suggested that Oman, Pakistan and India may coordinate with each other for successful implemntation of FFGS in Panel region.

1.2.2 India

1.2.2.1. Flood monitoring and forecasting mechanism

The Representative of India informed the Panel that IMD provides the following main services in the field of Water Resources Development and Water related Monitoring Management and Disasters :

(a) Rainfall Monitoring
(b) Hydromet Forecast
(c) Hydromet Design Studies
(d) Public Awareness

During the year 2016 rainfall statistics for the meteorological sub-divisions (36), states (29), districts (660), four broad regions of India (i) North-West India ii) Central India iii) South Peninsula iv) North East) India and for the country as a whole was prepared on weekly, monthly, seasonal and annual basis and was supplied to various stakeholders

including the PMO and other important Govt. authorities. During the Monsoon Season daily sub-divisional rainfall reports also were prepared and supplied to various stake holders. District wise reports for last 5 years (2012-2016) were uploaded on IMD Website.

A book titled "Rainfall statistics of India-2015" has been published and uploaded on IMD website at the link http://hydro.imd.gov.in/hydrometweb/(S(zkrsdz45ctkgei2i54cmlnya))/PRODUCTS/Publications/Rainfall%20Statistics%20of%20India%20-%202016/Rainfall%20Statistics%20of%20India%20-%202016.pdf.

Flood is one of the natural calamity which causes huge loses of life and property in each year. In India Flood Forecast is the joint responsibility of India Meteorological Department (IMD) and Central Water Commission (CWC). IMD is the nodal agency of issuing Quantitative Precipitation Forecast (QPF) for river basins/sub-basins whereas CWC is nodal agency for issuing Flood Forecast. The QPF is used as the input in the flood forecasting models by CWC.

There are 13 Flood Meteorological Offices (FMOs) at different parts of flood prone areas of country which are located at Agra, Ahmedabad, Asansol, Bhubaneswar, Guwahati, Hyderabad, Jalpaiguri, Lucknow, New Delhi, Patna, Bengaluru, Srinagar and Chennai. These offices render their services to the river catchments. During the flood season each FMO daily provides hydromet bulletins containing Quantitative Precipitation Forecast (QPF) to CWC for flood forecasting purposes. The hydromet bulletins contain the following information.

(i) Prevailing Synoptic Situation
(ii) Heavy Rainfall Warning
(iii) Sub-catchment-wise Quantitative Precipitation Forecast
(iv) Average Areal Precipitation occurred during the past 24-hours catchment-wise/Sub-catchment-wise.
(v) Station wise significant rainfall (≥5cm) observed during the past 24hrs.

QPF bulletin is issued at 0930 hrs IST and Hydromet Bulletin at 1230 hrs IST by FMOs. Forecast for a lead time of 5-days (forecast for 3 days and outlook for subsequent 4 days) are issued daily during flood season which may be modified in the evening when situation warrants. QPF Bulletins including heavy rainfall warning are also issued by concerned FMOs during cyclonic disturbance period or when there is a chance of heavy rainfall leading to flood.

Sub basin-wise Quantitative Precipitation Estimate for Day-1, Day-2, Day-3, using WRF ARW (9km x 9km) based on 00 UTC & 12 UTC, day-1 to day-5 using MME (0.25°x 0.25°) based on 00UTC and Day1 to Day7 using GFS (0.25°x 0.25°) based on 00UTC run by IMD are computed and uploaded on IMD website operationally in graphical as well as tabular form. The digital data are also made available to CWC and many state level flood forecasting offices for running their hydrological models for flood forecasting.

Central Water Commission (CWC) under Ministry of Water Resources, Government of India is entrusted with the task of formulating and disseminating flood forecasting in various locations in inter-state rivers. Flood Forecasting is the process of estimating the future stages or flows and its time sequence at selected points along river during flood. The prediction of water level in advance is called the Level Forecasting while the prediction of flows into Dams/ Reservoirs/ Barrages is called the Inflow Forecasting. CWC maintains 221 flood forecasting stations which include 166 level and 55 inflow forecast stations spread across 22 States and Union Territories, 19 major river systems in the country. The work of formulation and dissemination of flood forecasts under various inter-state river basins is carried out directly by 29 Flood Forecasting Divisions which are designated as Divisional Flood Control Rooms (DFCR). CWC uses various communication modes including HF Wireless Sets/ Fax/ Telephone/ e-mail/ updating the CWC's flood forecasting web site (http://www.india-water.gov.in/ffs) as well as through different Google platforms like Google Search, Google Now, Google public alerts etc. In case of floods within 0.5 m of the previously recorded Highest Flood Level (HFL) & beyond HFL, SMS are issued to mobile numbers of various concerned users who are directly responsible for relief and rehabilitation measures in the State.

1.2.2. Myanmar

The Representative of Myanmar informed that in Myanmar, there are 42 Hydrological stations under the administration of DMH. Hydrological Division is responsible for issuing daily river forecast and flood forecast along 12 major rivers: Ayeyarwady, Chindwin, Sittaung, Thanlwin, Dokehtawady, Bago, Shwegyin, Ngawun, Myittha, Kaladan, Toe and Lay Myo Rivers. River Forecasting Section is using both simple and advanced techniques for issuing flood warning and bulletin to the users and public, and is also applying empirical models based on single and multiple regression analysis, HBV Model and HEC-HMS Model for forecasting peak flood level along Ayeyarwady and Chindwin rivers. The lead time for issuing flood warning is about two to three days for short range forecast and ten days for long range forecast. River Forecasting Section conducted survey to re-identify the danger levels for Shwegu, Theikbekkyin, Kani, Bago,and Maubin Cities.

During the peak monsoon period (July and August) of 2016, flood occurred one time each at Bhamo, Shwegu, Katha, Thabeikkyin, Mandalay, Sagaing, Myinmu, Pakokku, Minbu, Magway, Aunglan, Pyay, Seiktha, Hinthada and Zalun of Ayeyarwady river, Myitnge of Dokehtawady river, Ngathaung Chaung and Pathein of Ngawun river, Maubin of Toe river and Kyauktaw of Kalaten river and two times each at Nyaung Oo of Ayeyarwaddy River and Hkamti, Homalin, Paungpyin, Mawlaik, Kalewa, Minkin and Monywa of Chindwin River respectively. In 2016, maximum flood peaks are about (1) to (6) feet at Ayeyarwady river and (2) to (7) feet in Chindwin River. The flood durations are about (3) to (27) days at Ayeyarwady river, and about (7) to (17) days at Chindwin. In 2016, the highest water level at Nyaung Oo (2292 cm) and Zalun (1277 cm) of Ayeyarwaddy River were as highest record

during (51) years and (32) years respectively, and the water level at Pathein of Ngawun River (401 cm) was also recorded as highest water level during (12) years. In 2016 monsoon season, hydrological division issued flood warnings (38) times and flood bulletins (323) times and disseminated

For runoff data, discharge measurement was carried out at three sites in the selected three rivers by Hydrological Division, Upper Myanmar Division and Lower Myanmar Division. DMH implemented the discharge, and bed profile measurements for Katha and Magway for Ayeyarwady river and Madauk for Sittoung River. Further, DMH aslo implemented the discharge, and bed profile measurements for Myitkyina, Nyaung Oo, Magway and Pyay of Ayeyarwady River, Hkamti and Monywa of Chindwin River for Low flow, Nyaung Oo and Magway of Ayeyarwady River for Medium Flow and Nyanung Oo of Ayeyarwady River for high flow by using Acoustic Doppler Current Profiler-ADCP(M9) under the Ayeyarwady Integrated River Basin Management Project.

In 2017, DMH surveyed to re-identify the danger levels for Kani, Pyintha, Pinlebu, Myauk Oo, Theinzayat, and Khamonseik Cities, and set up the new flood forecasting station at Thaboung in Ayeyarwady Regin. During the peak monsoon period (July and August), hydrological division issued flood warnings (47) times and flood bulletins (209) times in timely issued and disseminated. In 2017 discharge, and bed profile measurements were also made.

During 2016 and 2017, DMH developed flood hazard Map for Mawlaik of Chindwin river, Bago of Bago river, Magway of Ayeyarwady and Pyintha of Myittha River by using HEC-RAS and HEC-GeoRASand also developed flood hazard maps for Yangon, Manadalay, Mawlamyine and Nyaung Done by using RRI model.

1.2.3. Oman

The representative of the Oman informed the Panel that during the year 2016, measurements of all hydrological parameters were made from 4692 monitoring stations. The Ministry of Regional Municipalities and Water Resources is responsible for the hydrological measurements, assessment and management of the water resources for Sultanate of Oman. There are 432 rain gauges, of which 371 Automatic telemetry using GPRS modems and 61 of standard type . During the year 2016 The highest amount of rainfall in Dhofar governorate (south of Oman) reached (289 mm) in Salalah and (283 mm) in South Batinah in Nakhal and Buraimi State in the west of Oman was (200 mm) . For Wadi flow and floods, there are 167 wadi gauge stations to measure wadi flow and to compute flood volumes. The year 2016 is considered one of the years where low discharge rates were recorded. The total flood volumes during 2016 was estimated (175 Mm^3) which is below the annual average (330 Mm^3). The highest amount of flooding the governorate of Muscat (47 million m^3) and North Batinah (18 million m^3).

The Ministry of Regional Municipalities & Water resources operate a network of 2164 groundwater wells measured for water levels . Analysis of data showed that as a result of

decrease in recharge there is a gradual decrease in water levels in most areas of the Sultanate, except Muscat , Dhofar and South Sharqiyah governorates. A total of 87.3 Mm^3 was retained by 46 recharge dams during 2016 was the highest during the floods in March months (72.2 million m3). During the year 2016 the Ministry arranged for both local and overseas training and workshops. The training Program: Operation and instillation of Rainfall weather stations Telemetry gauge, Monitoring, processing and analysis of water Resource Data, Flash Flood Forecasting Model.

The FFG system is expected to installed and operationally used by 2017, It is Immediate prediction of areas likely to be exposed to flash floods using rainfall readings available from weather stations, satellite, weather radars and numerical predictions.

DGMET currently runs Storm Surge Model based on the vertically integrated model which was developed by Prof. S. K. Dube (IIT). Storm Surge Model is program that simulate surge, current and wind stress for specific track data. The track data is included longitude, latitude, time step pressure drop and radius of maximum wind.

1.2.4. Pakistan

1.2.4.1. Flood Forecasting Method

The representative of Pakistan informed the Panel that Flood Forecasting Division (FFD) is a dedicated unit of Pakistan Meteorological Department for the issuance of Hydro meteorological flood information's in all the major rivers and nalullahs of Pakistan. He further informed that in the aftermath of 2010 historic floods in Pakistan that caused huge loss of precious lives, damage to property and disrupted socio-economic activities, the UNESCO in collaboration with JICA/Government of Japan initiated a project "Strategic Strengthening of Flood Warning and Management Capacity of Pakistan" in July 2011 in order to improve the flood forecasting and early warning capabilities of Pakistan to effectively cope with such hydrometeorological disaster risk reduction challenges in the country in future. The main beneficiaries of the project at national level were included Federal Flood Commission, Pakistan Space and Upper Atmosphere Research Commission, National Disaster Management Authority and Pakistan Meteorological Department. Under the first phase of the project, International Centre for Water Hazard and Risk Management (ICHARM) under the auspices of UNESCO and JAXA developed a flood forecasting and routing model Indus-IFAS (Integrated Flood Analysis System for River Indus) and was put into operation at PMD's Flood Forecasting Division (FFD), Lahore for dissemination of lead-time flood warnings to the communities living in flood plains of the upper Indus and Kabul River. The project was completed in June 2014.

Flood of September 2014 in the Eastern Rivers urged the need to upgrade Indus-IFAS to cover the whole Indus River catchments including the Eastern Rivers of Jhelum, Chenab, Ravi, and Sutlej. Therefore, upon request of Pakistan, UNESCO and Govt. of Japan showed their concurrence to implement Phase-II of the project in order to increase the accuracy and reliability of Flood Early Warning System in Pakistan for mitigating

hydrometeorological disasters for the safety and prosperity of people of Pakistan. The phase-II of the project was started in January, 2016. The project aimed at improving Indus-IFAS Model Improvement for Eastern Rivers of Pakistan; densening of observation network through installation of Automatic Weather Stations; undertake technical studies on strategic reinforcement of ground based observational network; organization of short-term workshops/seminars for key stakeholders on river profiling and discharge measuring to understand the information, warning, technical terminologies, used in flood bulletins / advisories / warnings. Under this project, two PMD officers have recently one year Master program in Flood Disaster Risk Reduction" from Japan.

Under this UNESCO funded project, the designing, assembling, testing and calibrating of AWS was introduced. This activity was initiated after a model AWS was designed by the FFD engineers in the past. The UNESCO authorities appreciated the worthy effort of FFD staff. Later on it was included in the ongoing project to produce 24 AWS. The main aim behind this idea is to enhance the capability of FFD under capacity building besides saving foreign exchange in procuring this item from local market. Under this project 05 AWS have already been prepared while another 10 AWS are at production stage for which the raw material has been procured.

During 2016, training workshops concerning the development of Indus-IFAS model, were held which are numbered below:

a. A two days international workshop was held on "Standardizing Flood Forecasting and Warning Approaches in Trans-boundary Catchments" 19-20 April 2016 Lahore in which about 150 participants attended the workshop.
b. A two days international workshop on "Efficient Parameterization Strategy of IFAS model for Eastern Rivers" was held on 19-21 December 2016. More than 60 participants attended the event. (07 international participants besides local experts)
c. Two training sessions were arranged to deliberate into the model operation problems in which ICHARM experts helped to solve the problems.

The representative further added that an Addendum to LOA between ICIMOD and PMD was signed on 3rd August, 2016, which focused on strengthening the hydrometeorological stations in the Shimshal Valley in the Hunza sub-basin in Gilgit-Baltistan and to support the database management system of PMD. This agreement is as a continuation of the collaboration both organizationas for the establishment of a regional flood information system in the Hindu Kush Himalayan Region (HKH-HYCOS).

1.2.5. Sri Lanka

The representative of the Sri Lanka informed the Panel that Irrigation Department (ID) is the pioneer organization responsible for flood management and development of water resources in Sri Lanka and the Hydrology Division (HD) of the department was formed in 1947 to collect hydro-meteorological information required for water resource management and flood control works. Recently, a project named 'HMIS (Hydro-meteorological Information System)' was implemented with the financial assistance of the

World Bank to modernization and upgrading of the country's hydro-meteorological data collection and processing system, and enhance the capacity of key government agencies to undertake surface water monitoring, analyzing and providing flood & water supply forecasts.

1.2.6. Thailand

The representative of the Thailand informed that for hydrology and water management in the country comes mainly under the care of two government agencies i.e. Royal Irrigation Department (RID) and Department of Water Resources (DWR). There are 25 main river basins inThailand.

The RID has strategies for flood prevention and mitigation, as well as impacts in urban and cultivated areas, with aims to reduce the loss of lives and properties at risk. The management plans are set in terms of monitoring, predicting and warning by establishment of Smart Water Operation Center (SWOC), to examine flood situations 24 hours by providing the data from the other concerned agencies to summarize the situation, predict and announce warning to the expected effect area and propose the operation to the command persons. In addition, the collaborations with national related agencies for implementation plan cope with local flood protections in economic zones where severe flood may occur.

RID collaborates and discusses with other agencies to take decisions during the flood situation under the government to reduce the loss from Typhoon and tropical cyclones-related disasters for monitoring and analysis of flood situation.

RID coordinates and exchanges information of climate, rainfall, runoff and water operation to analyze and forecast the future situation for water management before announcement to public. The forecasting situation is then announced to public through different modes of communication like website or radio broadcasting or networks. After flooding situation, pumping for water drainage has to be arranged in order to reduce the height of water level or inundated areas.

1.3 DISASTER RISK REDUCTION ACTIVITIES

1.3.1. WMO activities

The Panel was presented with WMO DRR activities which include or are related to:

- Sendai Framework for Disaster Risk Reduction 2015-2030
- WMO Disaster Risk Reduction Roadmap (DRR Roadmap)
- The Multi-Hazard Early Warning Conference
- 2017 Global Platform for Disaster Risk Reduction
- International Network for Multi-Hazard Early Warning Systems (IN-MHEWS)
- WMO DRR Activities (including MHEWS Initiatives) in the Region
- Key Priorities of Arab Strategy for Disaster Risk Reduction 2020

- Updated Arab Strategy for Disaster Risk Reduction 2030 in step with Sendai Framework for DRR.

1.3.1.1. Sendai Framework for Disaster Risk Reduction 2015-2030

The Panel may wish to consider undertaking to, where possible, enhance cooperation with regional bodies of international organizations as well as regional organizations, to further strengthen partnerships and support WMO regional centres in order to promote the implementation of the Sendai Framework, and particularly MHEWS as a contribution to the WMO DRR Strategic Priority.

The Committee noted that the Sendai Framework for Disaster Risk Reduction 2015-2030 addresses four priorities for action:

1. Understanding disaster risk;
2. Strengthening disaster risk governance to manage disaster risk;
3. Investing in disaster risk reduction (DRR)for resilience; and,
4. Enhancing disaster preparedness for effective response, and to "Build Back Better" in recovery, rehabilitation and reconstruction;

and defines the role of stakeholders and of international cooperation and global partnerships.

1.3.1.2. It also highlighted that the Framework's global target g), which reads "*substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to the people by 2030*", is particularly relevant to WMO and its DRR priority in particular.

1.3.1.3. The Committee also noted that the Disaster Risk Reduction Roadmap (DRR Roadmap) for the World Meteorological Organization had been approved by the President of WMO in April 2017 and this is now available on the website here: http://www.wmo.int/pages/prog/drr/documents/roadmap/index.html.

1.3.1.4. The DRR Roadmap stemmed from a request by the WMO Executive Council, at its sixty-sixth session (EC-66), for the WMO Secretariat, "*in consultation with Members, to develop a WMO DRR roadmap of prioritized and realistically achievable activities and deliverables that are consistent with the WMO Strategic and Operating Plans as well as the work plans for relevant WMO programmes and projects*". In addition, EC called for a clear identification of the role of NMHSs and WMO, working with their partners, in the implementation of international frameworks and planning processes, such as the Sendai Framework for DRR 2015-2030. First ideas were discussed with Members at the RA I & II sessions and IBCS-2 in 2014 and at WCDRR in March 2015.

1.3.1.5. The Multi-Hazard Early Warning Conference

1.3.1.5.1. The Committee further noted that the WMO/UNISDR run Multi-Hazard Early Warning Conference (MHEWC)(http://www.wmo.int/earlywarnings2017/) convened on 22 - 23 May 2017 in Cancun, Mexico. Over 400 practitioners from a wide variety of institutional and technical backgrounds participated in six plenary sessions and a further six side events

and workshops while a poster session presented more than 80 innovative early warning practices from around the world. The Conference was opened by WMO SG Prof. Petteri Taalas and Special Representative of UN Secretary General, Dr Robert Glasser.

1.3.1.5.2. The focus of the discussions at the Conference were aligned with the Sendai Framework's target g), namely to substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to the people by 2030.

1.3.1.5.3. The conference drew on previous efforts towards international cooperation in facilitating advances in early warning systems. The **First International Early Warning Conference** was conducted in Potsdam, Germany, in 1998 and provided a global forum to share lessons learned regarding advances in early warning systems. The **Second International Early Warning Conference** took place in Bonn, Germany in 2003, and introduced the notion of *efficient, people-centred early warning systems*. The **Third International Early Warning Conference**, conducted in Bonn, Germany, in 2006, consolidated the agreed norm for the four components of an effective early warning, namely: (1) disaster risk knowledge; (2) detection, monitoring, analysis and forecasting of the hazards and possible consequences; (3) dissemination and communication and (4) preparedness at all levels to respond to the warnings.

1.3.1.5.4. The deliberations were structured to learn from, exchange information on and promote the replication of good practices in multi-hazard early warning systems (MHEWS). Each session drew on reviews of the current status on each topic and provided action oriented recommendations captured in these proceedings.

1.3.1.5.5. The recommendations are expected to guide efforts and investments by countries and international organizations for effective, impact-based, multi-hazard early warning systems.
The conference validated three additional outcomes:

i. An Updated Checklist on MHEWS to guide countries and local authorities in their efforts to establish successful early warning systems;

ii. A document on measuring early warning access and effectiveness prepared by the CREWS (Climate Risk and Early Warning Systems) partners for this Conference that will guide the development of baselines, sources of data, information, and methodologies.

iii. A collection of good and innovative practices drawn from the poster session.

1.3.1.5.6. Participants recommended in particular:

- To widely disseminate the Checklist on MHEWS and the compilation of good practices;
- To further develop and consolidate the guidance to measure the access and effectiveness of early warning systems, in support of countries efforts to monitor Sendai Target g), the 2030 Sustainable Development Agenda and the Climate Change Paris Agenda; and,

- To reconvene in two years to assess progress on the recommendations contained in the proceedings of the Conference under the aegis of the International Network on Multi-Hazard Early Warning Systems (IN-MHEWS).

1.3.1.5.7. The Conference took place immediately prior and in the same venue as the Fifth Global Platform on Disaster Risk Reduction. Participants requested the organizers to bring forward the messages and outcomes of the Conference to Global Platform. In particular, to the Special Session on the "availability of and access to multi-hazard early warning systems and disaster risk information".

1.3.1.5.8. The Conference participants agreed that all countries should strive to ensure that their MHEWS be designed to provide relevant impact and risk information to enable individuals, communities and organizations threatened by a hazard or hazards to prepare and to act appropriately in sufficient time to reduce the possibility of harm or loss.

1.3.1.6 2017 Global Platform for Disaster Risk Reduction

The Committee noted that the 2017 Global Platform (GP) for Disaster Risk Reduction(http://www.unisdr.org/conferences/2017/globalplatform/en/) followed the MHEWC at the same venue on 24-26 May 2017. The key outcomes of the GP were encapsulated in the High Level Communiqué from the event. In the communiqué, the participants in the GP's Leaders' Forum, recognized that globally, direct economic losses attributed to disasters are increasing significantly, having over the last decade reached close to US$1.4 trillion. Indirect economic losses magnify the figure further. Losses to countries' capital stock, including housing, infrastructure, productive assets and livelihoods, and impacts on health and education have had major fiscal implications, hindering economic growth and development.

The GP Leaders' Forum also noted that global models suggest that the risk of economic losses is rising as a result of the rapidly increasing number and the value of the assets that are exposed to hazards, inadequate maintenance and a globalized economy. In some regions the risk of losing capital stock in disasters may be growing at a faster rate than the capital being produced. They understand that climate change affects the frequency and intensity of weather-related hazards and presents greater challenges in disaster risk reduction and building resilience and are aware that disaster, and particularly small-scale, slow-onset and recurring disasters, severely damage infrastructure, housing, work places, livelihoods, ecosystems and economic production which are key pillars of growth and development. The loss becomes itself a driver of further vulnerability and exposure, and thus of disaster risk, weakens resilience and increases the likelihood of disaster displacement. We further recognize the low penetration of risk transfer mechanisms, in particular for the poor.

The Leaders' Forum further identifies the close nexus between climate change and water related disasters which account for almost 90% of the 1,000 most disastrous events since 1990. They acknowledged that Integrated Water Resources Management is an effective way to strengthen resilience for disaster risk reduction and adaptation to climate change, and they invited other leaders and all stakeholders to join in this approach.

The Leaders' Forum finally noted that the public and private sectors are interdependent when it comes to the development, functioning, maintenance and upgrading of infrastructure. Together they can reduce disaster risk and losses by ensuring that investment practices and regulatory frameworks are risk informed, jointly planned, data are exchanged and an enabling environment is build.

1.3.1.7. International Network for Multi-Hazard Early Warning Systems (IN-MHEWS)

5.3.4.1 The Committee noted that the International Network for Multi-Hazard Early Warning Systems (IN-MHEWS) is now fully established and the MHEWC was an outcome of the Network. This network is in the process of facilitating the sharing of knowledge and good practices and making available to governments and other key stakeholders policy-relevant guidelines to strengthen MHEWS as a national strategy towards building disaster and climate resilience.

1.3.1.8. WMO DRR Activities (including MHEWS Initiatives) in the Region

1.3.1.8.1 WMO has several initiatives that support DRR, in particular the development and strengthening of EWS. Examples include further the Severe Weather Forecasting Demonstration Project (SWFDP), flood EWS, including the Flash Flood Guidance System (FFGS), and drought EWS and seasonal forecasts, all linking to the Global Framework of Climate Services (GFCS). WMO is promoting the establishment and strengthening of institutional collaboration for MHEWS supported by Standard Operating Procedures (SOP) that could facilitate the efficient and effective interaction between and among various key stakeholders on MHEWS. It is expected that the IN-MHEWS will provide guidance in these endeavours.

1.3.1.8.2 The Committee noted that the Disaster Risk Reduction Focal Points of Regional Associations, Technical Commissions and Technical Programs (DRR FP RA-TC-TP) met in 2015 and 2016 and is expected to meet again in 2017.

1.3.1.8.3 The Committee notes that the 2016 meeting recommended that all existing WMO plans (such as the WMO Strategic and Operating Plans, the RAs', TCs' and TPs' plans, etc.) need to be considered when implementing the DRR Roadmap. Several TCs (such as CBS and CHy) are in the process of developing new work plans.

1.3.1.8.4 Moreover, the Committee also noted the DRR FP RA-TC-TP 2016 meeting recommended that DRR Programme activities need to be more tightly coupled and coordinated with SWFDP, CIFDP and other projects and activities and that this should be incorporated into the implementation plans for the DRR Roadmap. The activities should also complement the roles of the RAs (since almost all projects are regionally/sub-regionally organized) and of other WMO community groups as well as the overarching WMO Strategy for Service Delivery.

1.3.2. PTC contribution to WMO DRR strategic priority

1.3.2.1. Panel may wish to consider undertaking to, where possible, enhance cooperation with international and regional organizations, to further strengthen partnerships

and support WMO regional centres in order to promote the implementation of the Sendai Framework, and particularly MHEWS as a contribution to the WMO DRR Strategic Priority.

1.3.2.2. Panel may wish to consider to improve DRR approaches based on suggestions made in Sendai Framework.

1.3.2.3. Regional Co-operation

The Panel may wish to consider undertaking to, where possible, enhance cooperation with regional bodies of international organizations as well as regional organizations, to further strengthen partnerships and support WMO regional centres in order to promote the implementation of the Sendai Framework, and particularly MHEWS as a contribution to the WMO DRR Strategic Priority.

1.3.2.4. PTC contribution to WMO DRR strategic priority

- Panel may wish to consider undertaking to, where possible, enhance cooperation with international and regional organizations, to further strengthen partnerships and support WMO regional centres in order to promote the implementation of the Sendai Framework, and particularly MHEWS as a contribution to the WMO DRR Strategic Priority.

- Panel may wish to consider to improve DRR approaches based on suggestions made in Sendai Framework.

1.3.3. Activities of Members

1.3.3.1. India

The representative of India informed the Panel that the institutional and policy mechanism for carrying out response, relief and rehabilitation has been well established for effective management of various meteorological disasters and it is a 3-tier system at National Level, State Level and District level. There is a National Crisis Management Committee (NCMC), Crisis Management Group, Control room for emergency operation, National Disaster Management Authority (NDMA) for policy guidelines, National Disaster Response Force for response action, National Institute of Disaster Management for capacity building. There is a well established co-ordinated mechanism among various stake holders including warning providers like IMD, INCOIS, CWC and disaster managers at national, regional, state and district levels. As a result, death toll due to intense cyclones like Very Severe Cyclonic Storms, Phailin during 2013, Hudhud during 2014 and Vardah in 2016 has been reduced to a minimum (22, 46 and 24 respectively). Various measures have been taken up for improvement in warning dissemination including use of (i) community radio, FM radio, government and private television (ii) SMS alert (iii) internet (iv) Common Alert Protocol (vi) NAVTEX, etc. IMD has launched a dedicated website for cyclones over North Indian Ocean (www.rsmcnewdelhi.imd.gov.in). Awareness campaigns on various disasters in Hindi, English and regional languages being implemented through various modes.

- Audio-Video campaigns on Radio and Television.
- Campaign in the Print Media and through Posters and Leaflets.
- Campaign through Railways - Messages printed on Railway tickets.
- Campaign through Department of Post - Messages printed on Inland Letters in disaster prone states.
- Other efforts - Participation in IITF and other exhibitions.
- Regular conduct of Mock Exercises.

1.3.3.1.1 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 Head, Regional Specialised Meteorological Centre-Tropical cyclones, New Delhi monitors technical aspects and review the standard practices in the area of cyclone forecasting.

1.3.3.1.2 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 Maritime 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.

The format of Cyclone Warning bulletins issued by IMD at national level has been made more comprehensive for the use of Disaster Managers in view of the recent introduction of graphical warning products.

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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. The SMS is also sent to general public, farmers, fisherment and the disaster managers at central, state and district levels

1.3.3.1.3 Cyclone Warning Dissemination

Various measures have been taken up for improvement in warning dissemination including use of (i) community radio, FM radio, government and private television (ii) SMS alert (iii) internet (iv) Common Alert Protocol (vi) NAVTEX, etc. IMD has launched a dedicated website for cyclones over North Indian Ocean (www.rsmcnewdelhi.imd.gov.in). Awareness campaigns on various disasters in Hindi, English and regional languages being implemented through various modes.

- Audio-Video campaigns on Radio and Television.
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- Campaign through Railways - Messages printed on Railway tickets.
- Campaign through Department of Post - Messages printed on Inland Letters in disaster prone states.
- Other efforts - Participation in IITF and other exhibitions.
- Regular conduct of Mock Exercises.

1.3.3.1.4. Specific objectives

1.3.3.1.4.1. Automatic generation and dissemination of warning & advisory bulletins

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. is being pursued by Cyclone Warning Division at New Delhi.

1.3.3.1.4.2. Common Alert Protocol (CAP)

Guidelines of implementation of Common Alert Protocol (CAP) have been received from WMO and India Meteorological Department (IMD) taken action for implementation of CAP with respect to cyclone.

1.3.3.1.4.3. Coastal hazard analysis

Cyclone Hazard Maps for coastal zones is made available on IMD Website.

1.3.3.1.4.4. Last mile connectivity

Efforts are on to increase the last mile connectivity through National Cyclone Risk Mitigation Project (NCRMP), initially under implementation in Odisha and Andhra Pradesh. It will be subsequently extended to all coastal states

1.3.3.1.5 On-going Projects

1.3.3.1.5.1 FDP on landfalling cyclones over the Bay of Bengal

This project is continuing since 2008 to demonstrate the performance of various numerical models. It has helped in improving the SOP for monitoring and prediction as well as forecast accuracy.

1.3.3.1.5.2. TC Wind

A project on development and execution of a software tool **TCWIND** - for depicting winds associated with 43 Tropical Cyclones over North Indian Ocean during 2000-2010 (time series of maximum sustained wind speed, vertical wind shear, tangential and radial velocities) based on IMD's best track data and 6-hrly NCEP FNL data is in progress.

1.3.3.1.5.3. Research on diabatic heat source and moisture sink associated with rapid intensification of north Indian ocean cyclones is being carried out.

1.3.3.1.5.4. *Cyclone eAtlas-IMD*

Cyclone eAtlas – IMD, a software for generation of tracks and statistics of cyclones and depressions over the North Indian Ocean was brought out in CD form by IMD during 2008 and subsequently hosted in the web at the URL: www.rmcchennaieatlas.tn.nic.in. The database for the software for 2017 updated and uploaded in the web. It is also sent to all buyers of the CD every year.

1.3.3.1.5.5. Statistical prediction of seasonal cyclonic activity over the North Indian Ocean

An experimental outlook on the seasonal cyclonic activity over the North Indian Ocean for the period October-December is continued and efforts are on for improving the prediction model.

1.3.3.1.5.6. Experimental efforts are on for **Cyclone Intensity and Track prediction based on Ocean atmosphere coupled HWRF model**. Track and Intensity predictions were generated on real time basis during 2017, for the North Indian Ocean.

1.3.3.1.6 Disaster Management

1.3.1.6.1 Institutional and Policy Framework

The institutional and policy mechanisms for carrying out response, relief and rehabilitation have been well-established since Independence. These mechanisms have proved to be robust and effective in so far as response, relief and rehabilitation are concerned.

At the national level, the Ministry of Home Affairs is the nodal Ministry for all matters concerning disaster management. The Central Relief Commissioner (CRC) in the Ministry of Home Affairs is the nodal officer to coordinate relief operations for natural disasters. The CRC receives information relating to forecasting/warning of a natural calamity from India Meteorological Department (IMD) or from Central Water Commission of Ministry of Water Resources on a continuing basis. The Ministries/ Departments/Organizations concerned with the primary and secondary functions relating to the management of disasters include:

India Meteorological Department, Central Water Commission, Ministry of Home Affairs, Ministry of Defence, Ministry of Finance, Ministry of Rural Development, Ministry of Urban Development, Department of Communications, Ministry of Health, Ministry of Water Resources, Ministry of Petroleum, Department of Agriculture & Cooperation. Ministry of Power, Department of Civil Supplies, Ministry of Railways, Ministry of Information and Broadcasting, Planning Commission, Cabinet Secretariat, Department of Surface Transport, Ministry of Social Justice, Department of Women and Child Development, Ministry of Environment and Forest, Department of Food. Each Ministry/Department/Organization nominate their nodal officer to the Crisis Management Group chaired by Central Relief Commissioner. The nodal officer is responsible for preparing sectoral Action Plan/Emergency Support Function Plan for managing disasters.

1.3.3.1.6.2 National Crisis Management Committee (NCMC):

Cabinet Secretary, who is the highest executive officer, heads the NCMC. Secretaries of all the concerned Ministries /Departments as well as organizations are the members of the Committee The NCMC gives direction to the Crisis Management Group as deemed necessary. The Secretary, Ministry of Home Affairs is responsible for ensuring that all developments are brought to the notice of the NCMC promptly. The NCMC can give directions to any Ministry/Department/Organization for specific action needed for meeting the crisis situation.

1.3.3.1.6.3. Crisis Management Group:

The Central Relief Commissioner in the Ministry of Home Affairs is the Chairman of the CMG, consisting of senior officers (called nodal officers) from various concerned Ministries. The CMG's functions are to review every year contingency plans formulated by

various Ministries/Departments/Organizations in their respective sectors, measures required for dealing with a natural disasters, coordinate the activities of the Central Ministries and the State Governments in relation to disaster preparedness and relief and to obtain information from the nodal officers on measures relating to above. The CMG, in the event of a natural disaster, meets frequently to review the relief operations and extend all possible assistance required by the affected States to overcome the situation effectively. The Resident Commissioner of the affected State is also associated with such meetings.

1.3.3.1.6.4 Control Room (Emergency Operation Room):

An Emergency Operations Centre (Control Room) exists in the nodal Ministry of Home Affairs, which functions round the clock, to assist the Central Relief Commissioner in the discharge of his duties. The activities of the Control Room include collection and transmission of information concerning natural calamity and relief, keeping close contact with governments of the affected States, interaction with other Central Ministries/Departments/Organizations in connection with relief, maintaining records containing all relevant information relating to action points and contact points in Central Ministries etc., keeping up-to-date details of all concerned officers at the Central and State levels.

1.3.3.1.6.5 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.

1.3.3.1.6.6 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.
x. Salient initiatives recommended for implementation as part of the National Guidelines for Management of Cyclones are listed for undertaking action by various relevant Departments.
xi. The detail Guideline is hoisted in the NDMA website.

1.3.3.1.6.7 National Disaster Management Plan

The National Disaster Management Plan has been published in 2015 for management of various disasters including cyclones. Meetings related to development and execution of this plan as well as cyclone preparedness and disaster management activities conducted by the central and state Govt. departments are regularly attended by IMD officers to provide necessary briefings and inputs.

1.3.3.1.6.8. National Disaster Response Force (NDRF)

Two national calamities in quick succession in the form of Orissa Super Cyclone (1999) and Gujarat Earthquake (2001) brought about the realization of the need of having a specialist response mechanism at National Level to effectively respond to disasters. This realization led to the enactment of the DM Act on 26 Dec 2005. The NDMA was constituted to lay down the policies, plans and guidelines for disaster management.

The DM Act has made the statutory provisions for constitution of National Disaster Response Force (NDRF) for the purpose of specialized response to natural and man-made disasters. Accordingly, in 2006 NDRF was constituted with 08 Bns (02 Bn each from BSF, CRPF, ITBP and CISF). As on date NDRF is having strength of 10 Bns. Each NDRF Bn consists of 1149 personnel. Union cabinet has also approved the conversion/up-gradation of 02 Bns from SSB.

The force is gradually emerging as the most visible and vibrant multi–disciplinary, multi-skilled, high-tech, stand alone force capable of dealing with all types of natural and man-made disasters.

The DM Act, 2005 envisages a paradigm shift from the erstwhile response centric syndrome to a proactive, holistic and integrated management of disasters with emphasis on prevention, mitigation and preparedness. This national vision inter alia, aims at inculcating a culture of preparedness among all stakeholders.

NDRF has proved its importance in achieving this vision by highly skilled rescue and relief operations, regular and intensive training and re-training, capacity building & familiarization exercises within the area of responsibility of respective NDRF Bns, carrying out mock drills and joint exercises with the various stakeholders.

Vision of NDRF is to emerge as the most visible and vibrant multi-disciplinary, multi-skilled, high-tech force capable to deal with all types of natural as well as manmade disasters and to mitigate the effects of disasters.

1.3.3.1.6.8.1. Role and Mandate of NDRF

- Specialized response during disasters
- Proactive deployment during impending disaster situations
- Acquire and continually upgrade its own training and skills
- Liaison, Reconnaissance, Rehearsals and Mock Drills
- Impart basic and operational level training to State Response Forces (Police, Civil Defence and Home Guards)
- Vis-à-vis Community- All NDRF Bns are actively engaged in various:
- Community Capacity Building Programme
- Public Awareness Campaign
- Exhibitions : Posters, Pamphlets, literatures

1.3.3.1.6.8.2. Unique Force

- The only dedicated disaster response force of the world.

- The only agency with comprehensive response capabilities having multi-disciplinary and multi-skilled, high-tech, stand alone nature.
- Experienced paramilitary personnel specially trained and equipped for disaster response.
- Capabilities for undertaking disaster response, prevention, mitigation and capacity building

1.3.3.1.6.9 National Institute of Disaster Management (NIDM)

- The National Institute of Disaster Management (NIDM) was constituted under an Act of Parliament with a vision to play the role of a premier institute for capacity development in India and the region. The efforts in this direction that began with the formation of the National Centre for Disaster Management (NCDM) in 1995 gained impetus with its redesignation as the National Institute of Disaster Management (NIDM) for training and capacity development. Under the Disaster Management Act 2005, NIDM has been assigned nodal responsibilities for human resource development, capacity building, training, research, documentation and policy advocacy in the field of disaster management.
- Both as a national Centre and then as the national Institute, NIDM has performed a crucial role in bringing disaster risk reduction to the forefront of the national agenda. It is our belief that disaster risk reduction is possible only through promotion of a "Culture of Prevention" involving all stakeholders. We work through strategic partnerships with various ministries and departments of the central, state and local governments, academic, research and technical organizations in India and abroad and other bi-lateral and multi-lateral international agencies.
- NIDM is proud to have a multi-disciplinary core team of professionals working in various aspects of disaster management. In its endeavour to facilitate training and capacity development, the Institute has state-of-the-art facilities like class rooms, seminar hall, a GIS laboratory and video-conferencing facilities etc. The Institute has a well-stocked library exclusively on the theme of disaster management and mitigation. The Institute provides training in face-to-face, on-line and self-learning mode as well as satellites based training. In-house and off-campus face-to-face training to the officials of the state governments is provided free of charge including modest boarding and lodging facilities.
- NIDM provides technical support to the state governments through the Disaster Management Centres (DMCs) in the Administrative Training Institutes (ATIs) of the States and Union Territories. Presently NIDM is supporting thirty such centres. Six of these centres are being developed as Centres of Excellence in the specialised areas of flood risk management, earthquake risk management, cyclone risk management, drought risk management, landslides risk management and management of industrial disasters. Eleven larger states (Andhra Pradesh, Bihar, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal

and Odisha) have been provided with additional centres to cater their needs in this area.

- NIDM hosts the SAARC Disaster Management Centre (SDMC) and works as its national focal point.
- The vision is to create a Disaster Resilient India by building the capacity at all levels for disaster prevention and preparedness.

1.3.3.1.6.10. Common Alert Protocol (CAP)

Guidelines of implementation of Common Alert Protocol (CAP) have been received from WMO and India Meteorological Department (IMD) already has taken action for implementation of CAP with respect to cyclone, thunderstorm & earthquake. Initially it has introduced Google Alert for cyclones from 2014.Currently the NDMA is coordinating with various agencies for implementation of CAP.

1.3.5. Maldives

Maldives Meteorological Service followed the Standard Operating Procedure (SOP) for issue of cyclone Alerts.

1.3.6. Myanmar

The representative of Myanmar informed the Panel that during 2016, DMH cooperated with internal organization for capacity building of meteorological staffs. In number of capcotu building training, workshop and meeting were organized. Main responsibility of DMH is to provide early warning to the higher authorities, local government, and disaster risk reduction relevant agencies, media, INGOs, Myanmar NGOs and general public. DMH actively cooperate and coordinate with National Disaster Management agencies for Hyogo Framework of Action Plan preparation, disaster risk reduction activities, workshops and training program to implement community awareness, risk reduction, public education programme and officials interviewed with State run TV and mass media about public awareness program, existing weather and climate phenomenon and role of early warning, adverse weather phenomenon in Myanmar.

Meteorological articles about current weather events, significant weather, and updated information of El-Nino were published in State Newspapers, Ministry of Transport and Communications' Journal and other private Journals. DMH established a link first time in 2011 with Myanmar RADIO for live radio broadcasting about early warning and advisories while depression approaching Myanmar Coastal areas. Latest position, expected weather, suggested actions were informed to general public effectively.

DMH owned weather studio for effective communication with clear, understandable weather information and DMH issues the information/warning by using website (http://www.dmh.gov.mm), face-book, two automatic weather answering phones and call center are fulfil early warning system with updated warning and news. Early Warning decision making processes were accomplished with valuable support and close cooperation

with WMO and its Regional office, RSMC, New Delhi, WMO GTS, GFS forecast, CIMSS's analysis, WMO SWFDP products and neighbouring NMHSs for the early warning, training and other technical support for Myanmar.During this period, DMH jointly organized the following public awareness for disaster risk reduction trainings, workshop and meetings;

a) Training on Forecast Translation and Application and EWS Audit for Regional and Community levels.
b) 17th National Monsoon Forum jointly organized regional partner agencies, ESCAP, RIMES and stakeholders for Seasonal Climate Outlook and reviewed hydro-meteorological disasters.
c) Workshop on Landslide Early Warning System.
d) CRM in Dryzone of Myanmar Stakehdder Meeting
e) Regional Monsoon Forums

1.3.7. Oman

The representative of the Oman informed the Panel that the risk assessment study on coastal areas was carried out, for two hazards namely, tsunamis and storm surge at two different scales:

-National scale, along the whole coast of Oman

-Local Scale, at 9 selected study areas (Sohar, Wudam, Sawadi, Muscat, Quriyat,

Sur, Masirah, Al Duqm, and Salalah

1.3.8. Pakistan

The representative of the Pakistan informed the Panel that PMD has a state-of-the-art National Seismic Monitoring and Tsunami Early Warning Centre at Karachi and backup centre at Islamabad for monitoring of earthquakes and associated tsunamis. The centre is supported by a network of 20 remote seismic monitoring stations located throughout the country which are continuously recording the earthquake activity in the region. PMD issues SMS to media and other stakeholders immediately about the location, magnitude, depth, times and shock-wave information. Such SMS cover all earthquakes greater than magnitude 2 on Richter scale and earthquake information is disseminated within 3-minutes of the occurrence of earthquake through SMS to media and other concern stakeholders/government functionaries.

He further informed that in the past, Pakistan nation had suffered severe life and economic losses due to devastating earthquakes and tsunami. To mitigate these hazards in Pakistan, the Islamic Development Bank (IDB), Kingdom of Saudi Arabia in collaboration with Marmara Research Center (MRC), Turkey has sketched out "Reverse Linkage Project on Earthquake Seismological Research between MRC and PMD" to enhance the capabilities of Pakistan in the field of earthquake, tsunami, and tectonics of the earthquake prone areas of the country. The total cost of the project is PKR 101million through which IDB and MRC

share is 78% while Government of Pakistan's share is around 23%. This project is for the study of Makran Subduction zone and the tectonics of southern Baluchistan. Targets to be achieved under this project are;

(a). Up gradation of earthquake analysis system of PMD, i.e. SeisComP3 which also works as a tsunami early warning system. The newer version will replace the old one installed at Islamabad and Karachi.
(b). Deployment of 05 Global Positioning System (GPS) stations for Makran coast of Balochistan province and one set of equipment for backup.
(c). Deployment of five new seismic monitoring stations for Balochistan province and one set of equipment for backup.
(d). Installation of 03 sets of site classification measurement systems for risk assessment.

The completion of the project would facilitate PMD to further enhance its capacities in the field of seismological research, help to mitigate seismic risk through provision of improved seismological information and thus significantly contribute to the safety of lives and property of the people of the country in wake of geophysical disasters.

Scientists/seismologists at National Seismic Monitoring Centre of PMD remained involved in different research activities during 2016-2017, and published the following reports:

- Megathrust and accretionary wedge properties and behavior in the Makran Subduction zone.
- Mapping of Tsunami Hazard along Makran Coast of Pakistan
- Tsunami Hazard Modelling for an earthquake Mw 7.6 near Karachi, Pakistan

Furthermore, the Government of Pakistan has recently approved an MoU on 'Technical Cooperation in Tsunami Early Warning System' to be signed between PMD and Sultan Qaboos University, Oman. The purpose of the MoU is to share real-time seismic data regarding earthquake and tsunami for monitoring of seismological activities associated with the Arabian Sea and Gulf of Oman so that well in time both countries could generate warnings according the SOPs mutually agreed in order to save the precious lives and to reduce the economic losses at both sides.

For strengthening its early warning capabilties, PMD has submitted a submitted a comprehensive proposal to the Government of Pakistan for the priority-wise implementation in which replacement of out-dated weather radars and establishment of 18 new weather radar stations, induction new meteorologial equipment, establishment of 40 new Met. Observatories and automation of 97 existing Met. Observatories, establishment of regional flood warning centres at 15 locations, establishment of 36 centres in northern areas for monitoring of Glacial Lake Outburst Flood (GLOF), to monitor upper atmospheric wind profile 20 Wind Profiler Radars are proposed. The Government of Pakistan has approved the proposal in CDWP meeting held on 23rd December, 2016. Now, the project document is referred to Economic Affairs Division to find the funding for the project.

1.3.7. Sri Lanka

Disaster Management Centre (DMC) one of the coordinating and implementation body under the Ministry of Disaster Management. It involves in disseminating the warnings and advisories from the technical agencies to the grass root level, conducting public and awareness programmes, disaster mitigation activities, research & development activities, emergency operation activities in 24 x 7 basis and preparedness and planning activities for prevention of the disasters with the respective agencies to create a safer culture in Sri Lanka. More than 200 -220 mock drills, four National Drills and one international drill were completed in 2016. Hazard mapping (cyclone, landslide, drought and flood) has been completed with technical support from relevant technical agencies and financial support from UNDP. Structural measures for land slides are also conducted with National Building Research Organization was developed in Sri Lanka. Local authorities in the disaster prone areas have been strengthen to face for the disaster by providing necessary equipment by the DMC. In the event of a Natural or Manmade disaster, Emergency Operation Centre EOC coordinates dissemination of warnings, search &rescue operations, distribution of resources, data base management and emergency relief supplies with the assistance of Armed Forces, Police, NGO's, INGO's and UN systems and other relevant stakeholders to ensure quick evacuation and efficient distribution of relief items. 77 early warning towers which installed over a coast line of 1,340 km were supposed to issue warning messages in an emergency situation. The messages issued in all three key languages used in the island, vary depending upon the nature and criticality of the situation. The advantage of having towers is the ability to issue a warning even in an occasion of telecom system congestion, a common phenomenon seen multiple times before. In addition, SMS, cell broadcast, VHF and HF communication, Satellite communication and number of other communication techniques also been completed up to the grass root level. Very successful and efficient evacuation plans, sign boards and processes were successfully introduced with utilizing the assistance of military and other relevant organization. Media coordination is conducted in 24 x 7 basis with all relevant stake holders.

1.3.8. Thailand

The represenative of Thailand infromed the Panel about the Department of Disaster Prevention and Mitigation (DDPM) of Thailand is the responsible agency for imposing and implementing program policy, formulating operational guidelines and establishing criteria on disaster management, In addition, DDPM organizes and conducts training activities covering all aspect of disaster management by collaboration with local and international organizations. The Cabinet has endorsed the National Disaster Prevention and Mitigation Plan in the year 2015, it is the 2nd Disaster Management Plan and undergone a participatory planning process, where related sectors were engaged, including public, private and civil society. The above mentioned Plan has enforced related sectors at all levels to implement the plan, to develop their own action plan and to incorporate projects and programmes on disaster risk management into their annual plan, and particularly for the Budget Bureau, concerned agencies and local governments to give priority to projects/programmes on disaster risk reduction, emergencies response and recovery in a sustained manner. The

improvement and evolution of this National Management Plan is derived and gathered from lessoned learned from global, regional, national and local level and the trend of future disaster. Department of Disaster Prevention and Mitigation (DDPM) has assigned Disaster Management Center as dissemination center for providing early warning to the public, after receiving severe storm forecasting from Thai Meteorological Department or Regional Meteorological Center, Disaster Management Center will inform disseminate warning messages to DDPM provincial offices in risk area by LINE application or Fax or radio channels. DDPM provincial office will report the warning messages to the Governor, Province Public Relation Office and risk prone community via telephone or fax to prepare for evacuation.

Additionally, Ministry of Interior by DDPM under the organizational structure of National Emergency Operation Headquarter/Incident Command Center, Emergency Support Function 5, Emergency Management, the duties of monitoring, providing early warning messages to the public and related agencies and preparing for evacuation are under DDPM, MOI.

The Cooperation with agency concerned, DDPM has 76 provincial offices and 18 Regional Centers, they are working closely with community level and other government organizations to provide victim assistance and share data and information for disaster management. (Including typhoon and storm forecasting data sharing with Thai Met. Department).

During normal situation, DDPM by Disaster Prevention Promotion Bureau cooperates with DDPM provincial offices to provide CBDRM Training Approach (Community Base Disaster Risk Management) to support risk prone communities to handle with disaster during emergency. The community people know and understand their risks better than people who live outside prone areas.

The main challenge is Thailand has more than 10,000 risk communities from landslide and flash flood, according to the constraint of budget, it is difficult to provide CBDRM training to all risk areas in a short period of time.

In order to integrate effectively early warning systems to vulnerable communities, DDPM has promoted and developed CBDRM approach for risk communities by providing training them how to prepare and respond to disasters properly. The CBDRM activities include conduct risk assessment, prepare risk map, set up warning system for community etc. The DDPM has recognized the importance of socio-economic impact in Macro sector, which is also affected by large-scale disaster, therefore, DDPM has cooperated with, NESDB JICA and ADPC to promote BCP (Business Continuity Plan) to private sector and SMEs. BCP can support private sector and SMEs work smoothly while disaster occurs and reduce economic lost from disaster. In addition, in normal situation we conduct exercises regularly with other government organizations and related sectors to ensure the appropriate preparedness.

1.4 TRAINING

1.4.1. ACTIVITIES OF THE WMO

1.4.1.1. The Panel noted the training events and workshops which were organized during the intersession for the benefit of its Members. Since its last session, the Panel had benefited from education and training activities of WMO through the provision of attachments, relevant training courses, workshops, and the provision of advice and assistance to Members.

- Attachment Training
  RSMC Tokyo, 15-26 August 2016
- WMO Training Workshop on TC Forecasting and Warnings for PTC Region
  New Delhi, India , 19-30 September 2016

The Panel noted the forthcoming training events planned for 2017, and the Members were encouraged to make maximum benefit of attachments, training seminars, workshops and courses to be organized or co-sponsored by WMO.

- Attachment Training
  - *RSMC Tokyo (11-21 December 2017)*
  - *RSMC New Delhi (11-22 December 2017)*

1.4.1.2. The Panel noted that the RA II at its 16th session made a decision to: 1) request the Secretary-General to make the necessary arrangements for mobilizing resources to provide training opportunities to forecasters from those Members through the existing training programmes under the WMO Tropical Cyclone Programme (TCP) and Education and Training Programme (ETR); 2) call for Members of the Association prone to tropical cyclones, that have the resources and capabilities, to contribute to the tropical cyclone training activities; 3) invite those RSMCs with activity specialization in tropical cyclones and relevant WMO Regional Training Centres to be proactive in pursuing support from their national governments to organize, and provide necessary resources to conduct training activities on tropical cyclone forecasting and warnings. In this connection, PTC recommended WMO through TCP and ETR to consider to make necessary support and arrangement for a training workshop for RA II Members prone to tropical cyclones in 2018.

1.4.1.3. The Panel also noted that the Cooperative Program for Operational Meteorology, Education and Training (COMET) has produced a number of new training modules on tropical cyclone and storm surge which have been available online at https://www.meted.ucar.edu/training_detail.php?topicSorting=8&languageSorting=1&module_sorting=publishDateDesc.

The modules include:

- Introduction to Tropical Cyclone Storm Surge;
- Forecasting Storm Surge;
- Storm Surge Datums;
- Tropical Cyclone Forecast Uncertainty.

The Panel Members are encouraged to utilize this distance-learning based training resources for capacity development of their forecasters.

1.4.1.4. The Panel was informed that the book <<Global Guide to Tropical Cyclone Forecast>> has been reformatted with multiple formats in PDF, E-book and XML, respectively, for readers' convenience. It has been accessible https://www.wmo.int/cycloneguide/. It can be downloaded chapter-wise or in full in PDF format. The book was distributed to the Panel Members in a USB key, which also includes the book <<Seamless Prediction of the Earth System: From Minutes to Months>> (WMO-No. 1156) organized by WWRP.

1.4.1.5. The Panel was informed that through the agreement established between WMO and China Scholarship Council (CSC), opportunities now exist to train experts at Nanjing University of Information Science and Technology (NUIST), and a number of experts have already benefitted from this arrangement. Members are therefore encouraged to work with WMO, with this aim of taking advantage of this and similar opportunities.

1.4.1.6. Tropical Cyclone (TC) Forecasting competencies

WMO representative introduced the concept of tropical cyclone forecast competency. The brief summary of the concept is given below.

1.4.1.6.1. The Panel noted that the Executive Council at its 66th Session stressed the need for, and urged the Secretariat to support the, development of TC forecasting competencies in all tropical cyclone basins by regional tropical cyclone committees under the initiative of RSMCs. Implementation of tropical cyclone competencies is an essential component of improving service delivery as it sets common global recommended practises providing a safety net of "our staff are trained to at least the minimum recommended standards" and providing a leverage for members to obtain funding of "we need to train our staff to at least the minimum recommended standards" to provide quality services. Development and implementation of a competency framework is part of a quality approach to ensuring service delivery as it requires parallel reviews of policies and forecasting processes and procedures to be successful.

1.4.1.6.2. The Panel also noted that Members in RAI, RA IV and RA V and the ESCAP/WMO Typhoon Committee have already undertaken considerable work in the development and implementation of tropical cyclone forecasting competencies at national and regional level. The Panel was informed that RSMC New Delhi had developed a set of tropical cyclone forecasting competencies, and circulated among the Panel Members a draft version of the tropical cyclone forecasting competencies for the Panel. The Panel is invited to discuss further this document and provide recommendations to implement these

Dr. Mohapatra, Head, RSMC, New Delhi made a presentation on the draft document on tropical cyclone forecast competency for PTC region under the leadership of RSMC New Delhi. The document is given in the Appendix-VIII.

1.4.1.6.3. The Panel agreed that TC forecast competency document be circulated by PTC to all the Member countries requesting for comments / feedback by 31st October, 2017. On the receipt of the feedback RSMC New Delhi will finalize the document and send to WMO and PTC by 30th November 2017.

1.4.2. BANGLADESH

Tropical Cyclone forecasters have been sent to RSMC New Delhi for attachment training. Forecasters are encouraged to pursue research work on track prediction of Tropical Cyclone and storm surge.

1.4.3. India

The representative of India informed the Panel that the Human Resource Development has been one of the prime thrust areas of capacity building in IMD to keep pace with the latest trends in weather monitoring and forecasting.

Meteorological Training Institute (MTI) at IMD Pune acts as a WMO recognised regional training centre. Like previous years, MTI Pune conducted various training programmes in 2016. The course curricula of various training courses have been modified keeping in view the latest developments. The institute conducted Refresher courses (Five days to fifteen days to cover latest developments in the concerned field globally) for Aviation Meteorology, NWP etc and International WMO sponsored Training on Instrument maintenance & Calibration was conducted in the month of Nov-Dec 2016. The institute imparted training for participants from 53 countries on various aspects.

In addition, RSMC New Delhi conducted its regular cyclone training programme. Various other divisions of IMD such as Satellite Meteorological Division, Radar Division and NWP Division conducted training programmes in their respective areas for national and international participants. Advanced refresher courses in Aviation meteorology and WMO course on Instrument maintenance & calibration was conducted in 2016-2017. Three Advanced Refresher Courses on, NWP, Radar Meteorology, Radar Technology and Communication and is planned during 2017-18. E-learning method in training programme has been introduced for some courses by MTI Pune. Initiative is being taken up for distant learning programme through virtual classroom facilities and sharing of digital content of lectures in broadcast mode.

The Human Resource Development has been one of the prime thrust areas of capacity building in IMD to keep pace with the latest trends in weather monitoring and forecasting. Meteorological Training Institute (MTI) at IMD Pune acts as a WMO recognised regional training centre. Like previous years, MTI Pune conducted various training programmes in 2016. The course curricula of various training courses have been modified keeping in view the latest developments.

1.4.3.1 Regular Courses on General Meteorology

S.No.	Departmental/Non Departmental courses	Duration	Training centres	Eligibility Criteria
1.	Advanced Met. Training Course (Non-Departmental)	1 Year	Pune	B.Sc*. (with Physics or Maths as main subject) /M.Sc./B.E./ B.Tech.
2.	Forecasters Training course	6 months	Pune	B.Sc. (with Physics or Math as main subject) and after successful completion of Intermediate Met. Training course
3.	Intermediate Training course including one month on the Job training.	3 months	Pune, Delhi, Kolkatta & Chennai centres.	B.Sc. (with Physics or Maths as main subject) after successful completion of Basic Met. Training course.
4.	Integrated Meteorological Training course.	4 months	Pune , Delhi, Chennai and Kolkata	Fresh recruited Scientific Asst.with B.Sc.(Phy., Math/ BE/B. Tech. qualification
5	LA's Modular Course	2 Months	Delhi & Kolkotta.	Departmental Met. Attendant who have passed SSC and working in same cadre for 5 years

1.4.3.2 Other Trainings

- Training Programs, Seminars and Workshops are conducted to operational forecasters for improvement of forecast skills in real-time forecast. Capacity Development of personnel from IMD, NCMRWF, IAF, Indian Navy, Coast Guard, NDMA, Indian Army, ICAR, DRDO, Universities, Research Institutes and other National/International Organizations was undertaken.
- Imparted training from 53 countries in the area of instrument, cyclones, climate, forecasting and general meteorology.
- In addition, RSMC New Delhi conducted its regular cyclone training programme.
- Various other divisions of IMD such as Satellite Meteorological Division, Radar Division and NWP Division conducted training programmes in their respective areas for national and international participants.
- E-learning in training programme has been introduced for some courses of IMD. Initiative is being taken up to introduce distance learning through virtual classroom facilities in IMD's training programme.
- Two refresher courses viz. on tropical cyclones and climate science have been organized in 2015.

1.4.3.3. Future Plans:

- Five Advanced Refresher Courses viz. Aviation Meteorology, Radar Meteorology, Radar Technology, Communication and IS and NWP have been planned to be conducted during 2016-17.
- To upgrade the infrastructure of training institute & Trainees Hostel, action is in progress.
- Revision of the syllabus /Course contents of the different training courses is in progress.
- e-Learning method in training programme is already introduced by MTI. Action towards introduction of distance learning in the IMD's training programs by the provision of virtual class room facilities is already initiated. Under this proposal, provision is also there to share the digital content of the lectures in broadcast mode between centres through internet based software.
- One year ab-initio training for Group A officers (direct recruit) of the department to be conducted in this year.
- Action towards publication of lecture notes in respect of Integrated Meteorological Training Course is in progress.

1.4.4. Myanmar

The representative of Myanmar informed that in order to improve the earthquake monitoring system and enhance technique for research activities in Seismological field, Department of Meteorology and Hydrology-DMH, Ministry of Transport and Communications had collaborated with German Research Centre for Geosciences (GFZ) and held the International Training Course on "Seismology, Seismic Data Analysis, Hazards Assessment and Risk Mitigation" at Aureum Palace Hotel in Nay Pyi Taw from 26 September to 21 October 2016.

DMH is also collaborating with Yangon and Dagon Universities since 1993-94 for the provision of higher education (B.Sc (Hons) in Meteorology and Hydrology) to their staff. In 2016-2017, 1st year intake is (10) females in Meteorology and (2) females in Hydrology, 2nd year intake is (3) females and 3rd year intake is (5) females in Meteorology.

- He further informed that Hydrology grade (III) training held at Yangon DMH office from 19.12.2016 to 24.2.2017 and eleven (11) in-service personnel of DMH attended this training.
- Capacity building Training on utilizing of CUMSERV and Geoclim was held on from 3-5 January, 2017.
- At the eve of WM Day on 23th March, 2017, DMH organized the research papers reading session with participation from Universities, relevant departments and DMH officials.
- Training on Synoptic Observation and how to fill-up in Pocket Register (PR) for the observers was held on 6th to 10th March 2017.

- Country training on advance flood forecasting HEC-HMS model by the technical assistance of RIMES was held in June 2017. This training was attended (16) participants from DMH and (3) participants from Irrigation of Water Utilization and Management department.
- Flood Simulation drill was held in Kalay township, Sagaing Region on 8-9 August 2017, to reduce the flood disaster for community under the project of "Developing a Methodology for Flood Forecasting for the Select River Basin in Myanmar" in 2015-2017, which is financially support by the Norwaygian Foregin Affairs and technical support by ADPC.

1.4.5. Oman

The representative of Oman inforemd that 7th WMO Center of Excellence in Oman has conducted the 12th Session of Satellite Application Course (SAC) for Middle East countries in cooperation with Eumetsat.

Other important Workshops, Seminars, Researches and Training Courses attended by the Met personnel during the year 2016 are as follows:

Workshop/Seminar/Training/Research Course	Country	No. of Persons
PhD. In Dust Modelling	Australia	1
EUMETSAT Satellite Application Course	Oman	5
Auto weather Station	Slovakia	8
Forecasting Tropical Cyclone Tracks	Japan	1
Airport Weather System	Finland	8
Weather Radar	South Africa	6
FFG System	USA	2

During the year 2016, the Ministry of Regional Municipalities and Water Resources arranged for both local and overseas training and workshops. The training Program: Operation and instillation of Rainfall weather stations Telemetry gauge, Monitoring, processing and analysis of water Resource Data , Flash Flood Forecasting Model.

1.4.6. Pakistan

For the capacity building of PMD in the field of meteorology, hydrology, seismology, climate sciences and related disciplines maximum efforts are being made for seeking higher education and training opportunities abroad for PMD scientists in these fields since 2006. So far, twenty-nine (29) officers have joined back to PMD after completion of their higher studies (MS/PhD) from some reputeable institutions in UK, Canada, Norway, Sweden, China, Korea, Russian Federation and Thailand.

- During September 2016, one PMD scientist joined back to PMD after completion of his Master degree in 'Flood Disaster Risk Reduction' from the International Centre for Water Hazard and Risk Management (ICHARM), Japan under generous support by JICA/Government of Japan while two (02) scientists are still doing the same program in Japan with the support of UNESCO under their ongoing project with PMD.

- During 2017, one scinetist joined back to PMD after completion of Post-Doc in Meteorology from Environemnt Canada. In addition, one more scientist joined back to PMD after doing MS (Meteorology) from Nanjing University of Information Science and Technology (NUIST), China. He was awarded fellowship by the NUIST.
- During 2017, one scientist proceeded to China for undertaking Ph.D (Meteorology) programme at (NUIST), China under award of fellowship by the WMO.
- Three (03) PMD officers have still been doing their Ph.D at the Chinese Academy of Sciences (CAS), China. These scientists have been awarded scholarship by the CAS for their PhD. Two (02) more officers are undertaking their Ph.D in Meteorology and Hydrometeorology at the University of Hamburg, Germany and the University of Arizona, USA respectively since 2013 under scholarship program. In addition, four (04) officers have been doing their 3-years Ph.D Meteorology program at KAU, Saudi Arabia since 2014. Three out of four are expected to join back PMD in September / October 2017. Beisdes this one more scientist doing his 3-years M.Sc (Hydrology) at Russian State Hydrometeorlogical University, St. Petersburg, Russian Federation under award of WMO Fellowship since 2015.
- During 2016-2017 around 60 fellowships were availed by PMD scientists for attending short-term trainings/ workshops/ seminars abroad. These fellowships were offered mainly by CMA, WMO, ICIMOD, ICTP, IOC-UNESCO, JICA, UNESCO, UNESCAP, APCC, RIMES etc.
- During 2017, upon request of Department of Meteorology, Sri Lanka, six (03) Met personnel have been accommodated in 78th (BIP-MT, Mid Level) Preliminary Meteorology Course at IMG, Karachi schedule to commence at IMG Karachi w.e.f. 15th September, 2017 for 18 weeks duration.
- A training workshop on downscaling Global Climate Models for Future Projections of climate in Pakistan was organized by PMD from 2-6 May 2016 in collaboration with RIMES at PMD Headquarters, Islamabad. This training was part of capacity building of local researchers/students from different universities and organizations from all over Pakistan. The objective of the training program was to disseminate the skills acquired by PMD professionals from RIMES, Thailand to the local researchers for their capacity building on Generation and Application of Downscaled Climate Change Projections. The training workshop was meant to train the participants in downscaling the regional climate data from modern CMIP5 models for having future scenarios for different socio-economic sectors of Pakistan.

1.4.7. Sri Lanka

1.4.7.1. 23 short-term training opportunities for meteorological personnel were received during the year 2016 which sponsored by WMO, JICA, KOICA, RIMES organizations as well governments of India, China and Pakistan etc. In addition three Master programmes in Korea were received for meteorologists during 2016. The meeting of the SASCOF-8 was held in Colombo during 25-26th April 2016. A training on preparation of seasonal forecasts during 19 – 23 April and the meeting of the climatological service users was held during 27-28 April alongwith this forum. A training workshop on presumption of future behaviour of meteorological parameters in Sri Lanka, caused by climatic changes was conducted by RIMES from 24 - 28 May 2016, 07 Meteorologists and research assistants were participated. The results of study were submitted on 16th August 2016 to around 30 institutions to whom these calculations in regard to Sri Lanka would be useful. In addition,

a training for meteorologists on lightning detection was provided by Finish Meteorological Institute and VAISALA under Severe Storm Warning Services for Sri Lanka (SSWSS)" collaborative project .

Separate NWP group was established to improve the performance of Weather Research and Forecasting (WRF) Model. They group was able to assimilate the data and now the results were used for day today forecasting along with other model outputs.

Around 23 researches were conducted by the department in related to El Nino/La Nina MJO, some case studies regards to heavy rainfall and landslide incidents, strom surge and climate change issues . The department was able to publish a meteorological Journal during 2016.

1.4.7.2. Awareness Activities

A seminar was conducted to observe the World Meteorological Day, which held on 23rd March 2016, with the participation of public officials, journalists and school students under the theme of this year "Let's Face a warm dry and wet future"**.** One day seminar named "Monsoon Dialogue" was conducted even before the onset of South West monsoon season for the main stakeholders of meteorological and climatological services in order to provide awareness regarding the potential weather conditions, changes and disasters in the monsoon times. Long-term forecasts at research level were made in it in regard to the potential rainfall in South West monsoon times. The Department has provided resource persons to awareness programmes conducted for academics, researchers, policy makers, teachers and school children in regard to climatic changes**.** Training was provided to 5870 (military/university students and other) persons through awareness programmes on meteorology, climatology and lightning accidents and exhibits were provided to 15 school exhibitions and contributed to enhance the knowledge on Meteorology by providing training to 75 children and officials to do demonstrations in exhibitions. Two workshops were conducted to provide awareness to the volunteers who measure the rainfall in southern province covering Matara, Galle and Hambantota districts and in Uva Province covering Badulla and Moneragala districts. 18 new rain gauages and 45 measuring cylinders were distributed in the aforesaid workshops and a manual was provided to all institutions to educate the officers continuously on how to obtain data.

1.4.8. Thailand

Thai Meteorological Department (TMD) sent officials to attend in the trainings supported by WMO as below:

- GURME Training Workshop, 7-10 April 2015, Malaysia.
- Attachment Training at RSMC Tokyo 2015, 22 – 31 July 2015 JMA Headquarters, Tokyo Japan.
- International Training Workshop on Tropical Cyclone Forecasting, 3 – 14 August 2015, New Delhi, India.

- Training of Trainers Course on climate Field Schools (ToT on CFS) and Workshops on the Global Framework for Climate Services for Asia-Pacific Countries (GFCS Workshop), 25 – 28 August 2015,Citeko Indonesia.
- Training on Meteorological Disaster Management for Official from Developing Countries, WMO RTC Beijing, 7 – 18 September 2015.
- The Common Alerting Protocol (CAP) Jump-Start Training Session and CAP Implementation Workshop, 22, 23-24 September 2015, Rome, Italy.
- International Short-term Course on Flood Forecasting and Warning for South and Southeast Asia, 26 October – 1 September 2015, Roorkee, India.
- Fourth Capacity Building Workshop of the Data Buoy Cooperation Panel (DBCP) for the North pacific Ocean and its Marginal seas (NPOMS-4), Busan, Republic of Korea, 2-4 September 2015.
- Group Fellowship Training on Instrument Maintenance and Calibration, Nanjing, China, 2– 27September 2015.
- Training on Regional Satellite data usage, designed Specifically for satellite data users in RAII, 9,13 Nov. 2015, JMA, Tokyo, Japan, 9 – 13 November 2015.
- 8th International Workshop on Tropical Cyclones (IWTC-VIII) and 3rd International Workshop on Tropical Cyclone Landfall Processes (IWTCLP-III), 2 – 10 December 2015, Jeju, Republic of Korea.
- Training on Tropical Cyclones Forecasting and Warning, 7 – 11 December 2015, RTC Nanjing,China.

(i) During 2015, the Thai Meteorological Department (TMD) in cooperation with the World Meteorological Organization (WMO) organized a two- week Training Workshop entitled "Severe Weather Forecasting Demonstration Project (SWFDP) Regional Subproject for the Bay of Bengal and Southeast Asia Training Workshop on Severe Weather Forecasting and Warning Services" at the Thai Meteorological Department (TMD) in Bangkok from 14 to 25 September 2015,

(ii) The Thai Meteorological Department (TMD) in cooperation with the Japan International Cooperation Agency (JICA) Office in Bangkok and the Thailand International Cooperation Agency (TICA) organized a Training course on Hydrology (Advance Flood Forecasting, Flash Flood Forecasting, Remote Sensing and GIS) for the Myanmar Officials from 18 January to 17 February 2016, at TMD Headquarters, Two Staffs of RID joined the Training for WGH AOP4 on Operational system for Urban Flood Forecasting and Inundation Mapping (OSUFFIM), held in Sun Yat-Sen University Guangzhou, China, 15 November to 14 December 2015.

(iii) TMD cooperation with the Japan Aerospace Exploration Agency (JAXA) which was the qualitative precipitation estimation (QPE) from satellite to estimation rainfall, monitoring and warning, supported hydrology (the Royal Irrigation Department: RID, the Electricity Generating Authority of Thailand: EGAT, the Department of Water Resources: DWR and so all).

(iv) December 2015, 2 Staffs of RID joined the Training for WGH AOP4 on Operational system for Urban Flood Forecasting and Inundation Mapping (OSUFFIM), held in Sun Yat-Sen University Guangzhou, China.

1.4.9. Recommendations

1.4.9.1. Members requested WMO to organize training on interpretation of satellite, Radar and NWP model products including ensemble prediction system to enhance the capability of the region on TC forecasting and monitoring services.

1.4.9.2. The Panel recommends WMO to consider to organize the training in 2018 in accordance with the decision of RA II in its 16th Session held in Abu Dhabi, UAE in February 2017.

1.5. RESEARCH and publication

1.5.1. ACTIVITIES OF WMO

1.5.1.1. The Panel noted that WMO's World Weather Research Programme (WWRP) had developed in 2016 the programme's Implementation Plan for 2016-2023. This plan provides guidance on WWRP activities for the said period and was developed around four major challenges that have been identified by WMO's Commission for Atmospheric Sciences. The Four challenges namely: High-Impact Weather, Water, Urbanization and New Technologies are well aligned with the needs, challenges and results outlined in the WMO Strategic Plan for 2016-2019. It will be an important contribution to WMO fulfilling its mission to support Members in their work and meeting their commitments. The Plan provides a framework for the operational and academic research communities in different disciplines and countries to work together to advance weather science for the benefit of society. It is a valuable resource not only for experts related to WWRP but for anyone dealing with environmental prediction matters. The WWRP Implementation Plan is available online at: https://www.wmo.int/pages/prog/arep/wwrp/new/documents/WWRP_IP_JN161711_final_April_2017.pdf

1.5.1.2. The WWRP Working Group on Tropical Meteorology Research (WGTMR) is one of six WWRP working groups. The WGTMR aims to identify and support the research initiatives of National Meteorological and Hydrological Services (NMHSs) on tropical cyclones and monsoons.

1.5.1.3. The Panel noted that two WWRP/WGTMR research projects on tropical cyclones are currently ongoing:

a) Typhoon Landfall Forecast Demonstration Project (TLFDP) (2010-2021)
(Lead: Eastern China Regional Meteorological Center/CMA)
b) Understanding and Prediction of Rainfall Associated with Landfalling Tropical Cyclones (UPDRAFT) (2015-2020)
(Lead: CMA and Nanjing University)

1.5.1.4. The Panel was pleased to note that the Working Group on Tropical Meteorology Research (WGTMR) has been supporting and actively coordinating with the Tropical Cyclone Programme (TCP) and the Typhoon Committee (TC) on integrating the TC project: "Experiment on Typhoon Intensity Change in the Coastal area (EXOTICCA) with the two on-going WWRP projects mentioned in 5.4.2 (TLFDP and UPDRAFT). Plans are underway to organize on 8 December 2017 a one day tripartite Project Progress Meeting in Macau, China.

1.5.1.5. The Panel noted that WWRP in 2016 reviewed and supported two research proposals namely CyTron: Cyclones Tropicaux de l'OceanIndieN (Tropical Cyclones in the Indian Ocean) and Innovative Research on Natural Hazards (ReNovRisk). Both research proposals are highly relevant to the research priorities and work programme of WWRP which could lead to improving predictions especially on landfalling tropical cyclones, a high-impact weather event and strengthen regional cooperation.

1.5.1.6. The research paper "Asymmetric response of tropical cyclone activity to global warming over the North Atlantic and western North Pacific from CMIP5 model projections" has been published and is now available at:http://www.nature.com/articles/srep41354. The Chair of WGTMR's Tropical Cyclone Panel, Professor Johnny Chang, is one of the authors of this paper. The Lead author of the paper is Dr Doo-Sun R. Park of Seoul National University. The paper provides this summary:Based on statistical method, tropical cyclone (TC) passage frequency will decrease over the North Atlantic, but will increase over the western North Pacific in future climate conditions. An ensemble mean of CMIP5 models projects an increase in TC activity in the western North Pacific, which is owing to enhanced subtropical deep convection and favorable dynamic conditions therein in conjunction with the expansion of the tropics and vice versa for the North Atlantic.

1.5.1.7. Dr Phil Klotzbach, Chairperson of WGTMR's Expert Team on Seasonal Tropical Cyclone Forecasts has created a global real-time monitoring website which not only provides real-time global tropical cyclone statistics but also features extensive basin-wide archives of tropical cyclone statistics for each global TC basin.
The Website address is: http://tropical.atmos.colostate.edu/Realtime/

1.5.1.8. Available on the WGTMR website for download is the paper on Tropical Cyclone Intensification: Prediction and Mechanisms written by Chris Davis and Johnny Chanwhich is Chapter 14 of the book: Seamless Prediction of the Earth System: From Minutes to Months

1.5.1.9. The Barcelona Supercomputing Center (BSC), Colorado State University (CSU) and XL Catlin have launched a new website to track seasonal hurricane forecasts and the evolution of hurricane activity. Seasonal Hurricane Predictions brings together forecasts from major centers that specialize in hurricanes, with information dating back to 1996. It also offers extensive information to promote understanding of the factors that contribute to these meteorological phenomena, which can have devastating consequences, and to help explain why different models produce different predictions.The website is an initiative of WGTMR's Expert Team on Seasonal Tropical Cyclone Forecasts. Phase II of this initiative will include tropical cyclones in the Western North Pacific Basin.

1.5.1.10. The WGTMR is organizing a one-day Workshop on Tropical Meteorology in Hong Kong, China on 21 September 2017. The workshop is co-organized with Professor Gabriel Lau and hosted by The Chinese University of Hong Kong.

1.5.1.11. WWRP is organizing the Fourth International Workshop on Tropical Cyclone Landfall Processes (IWTCLP-4) in Macau, China from 5-7 December 2017. The theme for the fourth workshop in the series is " Tropical Cyclone Landfall Impacts: Transitioning from Observations and Modeling to Greater Understanding and Better Forecasts."

1.5.1.12. Steps have been taken to organize the Ninth International Workshop on Tropical Cyclones (IWTC-9) in Honolulu, Hawaii, USA in late November or early December 2018. Organized by TCP and WWRP, the workshop is held every four years. The ninth workshop in the series will be co-chaired by Dr Michael Brennan (National Hurricane Center) and Professor Yuqing Wang (University of Hawaii).

1.5.1.13. Members of the Panel are urged to actively participate in the above-mentioned workshops. Operational and research meteorologists from Members of the Panel on Tropical Cyclones who will not need WMO support to participate at the IWTCLP-4 and IWTC-9 should, in a timely manner, inform Dr. Taoyong Peng, Chief of TCP of their intent to attend the aforementioned workshops.

1.5.2. India

India Meteorological Department remained involved in extensive research activities. The major achievements during 2016 were:

a) Publication of quarterly journal Mausam
b) Publication of reports on Forecast Demonstration Projects on Cyclones, Thunderstorms etc.
c) Annual reports on cyclonic disturbances
d) Conduct of national and international seminars, conferences and workshops.
e) WMO's SWFDP over Bay of Bengal implemented w.e.f 2 May 2016.
f) Project TCRAIN: A Tropical Cyclone Rainfall Analytical tool for the North Indian Ocean – TCRAIN that depicts rainfall characteristics of 59 Tropical Cyclones over North Indian Ocean during the period 2000-2015 was developed based on TRMM data by CWRC, RMC Chennai and the application is hosted in the web at the URL: www.cwrcimdchennaitcrain.in
g) TC Structure over north Indian Ocean
h) TC energy metrics over North Indian Ocean
i) TC life cycle over North Indian Ocean
j) Translational speed and direction of movement of cyclones over North Indian Ocean
k) TC forecast accuracy over North Indian Ocean

1.5.2.1 Current Status

Research works pertaining to statistical, climatological and dynamical aspects of Tropical Cyclones of North Indian Ocean are undertaken regularly. Some recent efforts are listed below:

1.5.2.2. TCRAIN Project

A Tropical Cyclone Rainfall Analytical tool for the North Indian Ocean – **TCRAIN** that depicts rainfall characteristics of 59 Tropical Cyclones over North Indian Ocean during the period 2000-2015 was developed based on TRMM data by CWRC, RMC Chennai and the application is hosted in the web at the URL: www.cwrcimdchennaitcrain.in. The necessary software for generation of percentage frequency distribution of rain rates, azimuthally averaged radial profiles of rain rates and quadrant-wise mean rain rates around a cyclone centre and with respect to the direction of movement of the cyclone using 3hrly TRMM data was developed in-house. The products are generated for different stages of intensity of the system viz., (i) Depression, (ii) Cyclonic Storm and (iii) Severe Cyclonic Storm and above during its growth as well as decay for all the **59** cyclones would serve as valuable inputs for research on rainfall associated with Tropical Cyclones of the North Indian Ocean.

1.5.2.3 Research Papers

The following research papers were published:

1.5.2.3.1. Papers published in books/reports

1. **M Mohapatra, 2017,** Monitoring and Forecasting of Tropical Cyclones over North Indian Ocean, In Advanced Numerical Modeling and Data Assimilation Techniques for Tropical Cyclone Prediction, Ed. UC Mohanty and SG Gopalakrishnan, Co-published by Capital Publishers, New Delhi and Springer, Germany, 409-447 pp.
2. RP Sharma, **M Mohapatra**, 2017 Rapid Weakening of Very Severe Cyclonic Storm 'Lehar'–A Case Study, In Tropical Cyclone Activity over the North Indian Ocean, Ed. **M.Mohapatra,** B.K. Bandyopadhyay and L.S. Rathore, 2017, Xo-published by Capital Publishers, New Delhi and Springer, Germany, 131-147
3. **M Mohapatra**, 2017, Tropical Cyclone Track, Structure and Intensity Changes at Landfall, In Tropical Cyclone Activity over the North Indian Ocean, Ed. **M.Mohapatra,** B.K. Bandyopadhyay and L.S. Rathore, Co-published by Capital Publishers, New Delhi and Springer, Germany, 97-116
4. SVJ Kumar, SS Ashthikar, **M Mohapatra**, 2017, Life Period of Cyclonic Disturbances Over the North Indian Ocean During Recent Years, In Tropical Cyclone Activity over the North Indian Ocean, Ed. **M.Mohapatra,** B.K. Bandyopadhyay and L.S. Rathore, Co-published by Capital Publishers, New Delhi and Springer, Germany, 181-198
5. DP Nayak, **M Mohapatra**, 2017, Rapid Movement of Cyclone Viyaru Just Before Landfall-A Case Study, In Tropical Cyclone Activity over the North Indian Ocean, Ed. **M.Mohapatra,** B.K. Bandyopadhyay and L.S. Rathore, Co-published by Capital Publishers, New Delhi and Springer, Germany, 149-163
6. PS Chinchole, **M Mohapatra**, 2017, Some Characteristics of Translational Speed of Cyclonic Disturbances Over North Indian Ocean in Recent Years, In Tropical Cyclone Activity over the North Indian Ocean, Ed. **M.Mohapatra,** B.K. Bandyopadhyay and L.S. Rathore, Co-published by Capital Publishers, New Delhi and Springer, Germany, 165-179
7. B Sabade, **M Mohapatra**, 2017, Very Severe Cyclonic Storm MADI over Bay of Bengal, 6–13 December 2013: A Diagnostic Study, In Tropical Cyclone Activity over the North Indian Ocean, Ed. **M.Mohapatra,** B.K. Bandyopadhyay and L.S. Rathore, Co-published by Capital Publishers, New Delhi and Springer, Germany, 117-130
8. LS Rathore, **M Mohapatra**, B Geetha, 2017, Collaborative Mechanism for Tropical Cyclone Monitoring and Prediction over North Indian Ocean, In Tropical Cyclone Activity

over the North Indian Ocean, Ed. **M.Mohapatra,** B.K. Bandyopadhyay and L.S. Rathore, Co-published by Capital Publishers, New Delhi and Springer, Germany, 3-27.

9. M Sharma, **M Mohapatra**, 2017, Standard Operation Procedure for Tropical Cyclone Vital Parameters over North Indian Ocean, In Tropical Cyclone Activity over the North Indian Ocean, Ed. **M.Mohapatra,** B.K. Bandyopadhyay and L.S. Rathore, Co-published by Capital Publishers, New Delhi and Springer, Germany, 367-381
10. K Ray, **M Mohapatra**, K Chakravarthy, SS Ray, SK Singh, AK Das, 2017, Hydro-Meteorological Aspects of Tropical Cyclone Phailin in Bay of Bengal in 2013 and the Assessment of Rice Inundation due to Flooding, In Tropical Cyclone Activity over the North Indian Ocean, Ed. **M.Mohapatra,** B.K. Bandyopadhyay and L.S. Rathore, Co-published by Capital Publishers, New Delhi and Springer, Germany, 29-43
11. **M Mohapatra**, AK Srivastava, S Balachandran, B Geetha, 2017, Inter-annual Variation and Trends in Tropical Cyclones and Monsoon Depressions Over the North Indian Ocean, In Observed Climate Variability and Change over the Indian Region, Ed. M. Rajeevan and Shailesh Nayak, published by Springer, Germany, 89-106

1.5.2.3.2. Books edited:

1. Tropical Cyclone Activity over North Indian Ocean, Ed. **M.Mohapatra,** B.K. Bandyopadhyay and L.S. Rathore, 2017, Xo-published by Capital Publishers, New Delhi and Springer, Germany, 365 pp.
2. Monsoon 2016- A report, Ed PCS Rao, DS Pai and **M Mohapatra**, 2017, Published by India Meteorological Department, Pune, 374pp.
3. Monsoon-2017- A report, Ed O.P. Sreejith, DS Pai and **M Mohapatra**, 2018, Published by India Meteorological Department, Pune

1.5.2.3.3. Papers published in Reviewed National & International Journals

1. S Goyal, A Kumar, M Mohapatra, LS Rathore, SK Dube, R Saxena, 2017, Satellite-based technique for nowcasting of thunderstorms over Indian region, Journal of Earth System Science 126 (6), 79
2. S Goyal, M Mohapatra, P Kumari, SK Dube, K Rajendra, 2017, Validation of Advanced Dvorak Technique (ADT) over north Indian Ocean, MAUSAM 68 (4), 689-698
3. N Kumar, AK Jaswal, M Mohapatra, PA Kore, 2017, Spatial and temporal variation in daily temperature indices in summer and winter seasons over India (1969–2012), Theoretical and Applied Climatology 129 (3-4), 1227-1239
4. DR Pattanaik, M Mohapatra, AK Srivastava, A Kumar, 2017, Heat wave over India during summer 2015: an assessment of real time extended range forecast, Meteorology and Atmospheric Physics 129 (4), 375-393
5. Randall S Cerveny, Pierre Bessemoulin, Christopher C Burt, Mary Ann Cooper, Zhang Cunjie, Ashraf Dewan, Jonathan Finch, Ronald L Holle, Laurence Kalkstein, Andries Kruger, Tsz-cheung Lee, Rodney Martínez, M Mohapatra, DR Pattanaik, Thomas C Peterson, Scott Sheridan, Blair Trewin, Andrew Tait, MM Abdel Wahab, 2017, WMO Assessment of Weather and Climate Mortality Extremes: Lightning, Tropical Cyclones, Tornadoes, and Hail; Weather, Climate, and Society 9 (3), 487-497

6. N Kumar, M Mohapatra, AK Jaswal, 2017, Meteorological features associated with unprecedented precipitation over India during 1st week of March 2015, Journal of Earth System Science 126 (5), 62
7. DR Pattanaik, M Mohapatra, 2017, Active North-East Monsoon Over India During 2015–An Assessment of Real Time Extended Range Forecast, Current Science, 112 (11), 2253-2262
8. M Mohapatra, B Geetha, M Sharma, 2017, Reduction in uncertainty in tropical cyclone track forecasts over the North Indian Ocean, Current Science 112 (9), 1826
9. M Mohapatra, VV Kumar, 2017, Interannual variation of tropical cyclone energy metrics over North Indian Ocean, Climate Dynamics, 48, 1431-1445
10. PLN Murty, J Padmanabham, T Srinivasa Kumar, N Kiran Kumar, V Ravi Chandra, SSC Shenoi, M Mohapatra, 2017, Real-time storm surge and inundation forecast for very severe cyclonic storm 'Hudhud', Ocean Engineering, 131, 25-35
11. S Goyal, M Mohapatra, A Kumar, SK Dube, K Rajendra, P Goswami, 2016, Validation of a satellite-based cyclogenesis technique over the North Indian Ocean, Journal of Earth System Science 125 (7), 1353-1363
12. DR Pattanaik, M Mohapatra, AK Srivastava, A Kumar, 2016, Heat wave over India during summer 2015: an assessment of real time extended range forecast, Meteorology and Atmospheric Physics, 1-19
13. S Goyal, M Mohapatra, SK Dube, P Kumari, I De, 2016, Mesoscale convective systems in association with tropical cyclones over Bay of Bengal, Natural Hazards 82 (2), 963-979
14. D.R. Pattanaik, M. Mohapatra; 2016; Seasonal Forecasting of Tropical Cyclogenesis over the North Indian Ocean; Journal of Earth System Science; 125, 231-250; DOI:10.1007/s12040-016-0663-4
15. Naresh Kumar, Ashok K Jaswal, M Mohapatra, Prasann A. Kore, 2016, Spatial and temporal variation in daily temperature indices in summer and winter seasons over India (1969–2012), Theoretical and Applied Climatology, 124,
16. M. Mandal, K. S. Singh, M. Balaji, M. Mohapatra; 2016; Performance of WRF-ARW model in real-time prediction of Bay of Bengal cyclone 'Phailin'; Pure and Applied Geophysics; 173, 1783-1801, DOI:10.1007/s00024-015-1206-7

1.5.2.4. Participation in Seminar / Symposium / Conference

1. Dr. M. Mohapatra, Scientist G (Services) participated in the 1st meeting of Indo-Russia joint commission for cooperation in the field of Disaster management on 22nd March, 2016 at New Delhi and presented the Early warning system of IMD.
2. Dr. M. Mohapatra, Scientist G (Services) participated in the Ministerial Segment of 72nd Annual Session of UN-ESCAP held at UN Conference Centre, Bangkok during 17-19 May, 2016.
3. Dr. M. Mohapatra, Scientist G (Services) participated in a Twittter conference programme as an expert on cyclones and floods organised by National Disaster

Management Authority at New Delhi to respond to the queries raised by public through twitter online on 27th May, 2016.

4. Dr. S. C. Sahu, Scientist 'F' attended a meeting of the State Executive Committee constituted under the Disaster Management Act 2015 at Secretariat, Bhubaneswar on 9th June, 2016.
5. Dr. M. Mohapatra, Scientist G (Services) participated in the meeting to discuss the draft proposal for the renewed and expanded SAARC Disaster Management Centre (SDMC) at National Disaster Management Authority on 15th June, 2016.
6. Dr. P. K. Nandankar, Scientist 'F' attended a meeting on "Hazard Risk Vulnerability Analysis in Pune" held at Collector's Office, Pune on 16th June, 2016.
7. Dr. M. Mohapatra, Scientist G (Services) participated in the meeting under the chairmanship of Shri R. K. Jain, Member, NDMA on 1st July, 2016 at NDMA Bhawan, New Delhi to discuss the preparations for the 2nd Meeting of the BRICS Ministers for Disaster Management in August, 2016.
8. Dr. M. Mohapatra, Scientist G (Services) participated in training programme on "Disaster Risk Reduction Strategies for Sustainable Development Planning & Policy Instruments" during 17-18 February, 2016 at New Delhi organised by National Institute of Disaster Management (NIDM).
9. Regional Training Workshop for capacity development in coastal multi hazard early warning system was jointly organised by IMD & Indian National Centre for Ocean Information Services (INCOIS), Hyderabad and sponsored by UN-ESCAP at Hyderabad during 19-23 September, 2016. During the workshop, Dr. M. Mohapatra, Scientist G (Services)delivered a lecture on "Cyclone Warning Services of IMD", Dr. D. R. Pattanaik, Scientist 'E' delivered a lecture on Severe Weather Forecast Demonstration Project and Role of RSMC and Dr. Naresh Kumar, Scientist 'D' delivered a lecture on Thunderstorm & Heat Wave Warning on 20th September, 2016.

1.5.2.5. Other Publications

- Annual RSMC Report on Cyclonic Disturbances
- Annual Tropical Cyclone Operation Plan (TCP-21)
- WMO/ESCAP Panel News
- Annual Report of Cyclone Warning Division, IMD and Ministry of Earth Sciences (MoES), Government of India
- News Letters : IMD and MoES
- Preliminary reports of cyclonic disturbances

1.5.3. Pakistan

The representative of Pakistan informed the Panel that Pakistan Meteorological Department (PMD) is also committed to promote research activities in the field of meteorology, hydrology, climate change, geophysics and other related disciplines for

improving meteorological services for the benefit of the people. As part of its efforts, PMD started publication of its biennial research journal namely "Pakistan Journal of Meteorology" in 2004. During 2016, PMD published two issues (No. 24 and 25) of "Pakistan Journal of Meteorology". These issues contain 12 research papers which were contributed by the scientists of PMD in addition to foreign researchers. Scientists of PMD also contributed (both as lead authors and co authors) in around ten (09) research papers which have been published in various national and international journals like Climate Dynamics, Natural Hazards, and Pakistan Journal of Meteorology and /or presented at international scientific conferences and have been published in the proceedings of these conferences/ seminar.

1.5.4. Sri Lanka

The representative of Sri Lanka informed the Panel that around 23 researches were conducted by the department in related to El Nino/La Nina MJO, some case studies regards to heavy rainfall and land lide incidents, storm surge and climate change issues. The department was able to publish a Meteorological Journal during 2016.

1.6. Publications

1.6.1. Panel News

- Panel News letter of PTC is a bi-annual document, which is issued after every six months. During 2016-2017 two (02) publications of PTC newsletter "Panel News" Issue No. 42, 43 were published and the same were uploaded / distributed among PTC Members and other concerned.

- The PTC Secretariat requested the Panel Member countries to carefully review the current Panel News issues, and send their views/comments to PTC Secretariat for further improving the quality of the Panel News.

- PTC Secretariat requested the respected Panel Members to provide their contributions in the form of news material related to development activities, science news, training workshops, research reports etc. in their respective countries to PTC Secretariat through their Panel News Correspondents so that next issues of the Panel News can be published timely. PTC Secretariat requested Panel Members to send their contribution by 31 October 2017 for 44th Edition.

1.6.2. Annual Cyclone Review-2016

Dr, M Mohapatra, Head, RSMC, New Delhi informed that Annual Cyclone Review has been completed and been sent to WMO for publication. The Panel appreciated Dr M. Mohapatra, Chief Editor of the Annual Cyclone Review and also the National Editors.

1.6.3. Annual Report on cyclonic distrurbances over north Indian Ocean

Dr. M Mohapatra, Head, RSMC, New Delhi informed that Annual Report on cyclonic disturbances over the North Indian Ocean during 2016 has been completed and been published. The same is also available in RSMC, New Delhi website under the heading, publications.

1.7. REVIEW OF THE TROPICAL CYCLONE OPERATIONAL PLAN

1.7.1 The Panel appreciated Dr. M. Mohapatra of RSMC New Delhi for his valuable services extended in updating the Operational Plan of the PTC. List of Important Addresses and Telephone Numbers Connected with Tropical Cyclone Warning in the Panel Countries (ANNEX V-A-1 of the WMO/Tropical Cyclone Programme Report No. TCP-21, edition 2016) which was re-established by Dr. Mohapatra, rapporteur of Tropical Cyclone Operational Plan (TCOP) in 2016, with the support of the PTC Secretariat and in response to the recommendation of the Panel made at the 43rd Session in New Delhi, India.

1.7.2 The PTC Secretariat requested the Panel Members to make a careful review of TCOP available at www.rsmcnewdelhi.imd.gov.in and inform to the RSMC New Delhi about their input / feedback, if any, before 30th September 2017. Panel requested Dr M Mohapatra to act as Rapporteur for the year 2017 to update the Operational Plan of PTC.

1.8. Coordinated Technical Plan (2016-19) and Annual Operational Plan (2016)

1.8.1. The Panel reviewed the coordinated technical plan 2016-2019 of the five components. It adopted the CTP 2016-2019 as shown in the Chapter IV.

1.8.2. The Panel considered the 2017-2018 Annual Operating Plan (AOP) of the five components. It adopted the 2017-2018 AOPs as shown in the Chapter V.

1.8.3. Panel decided to continue with the same working group experts on Meteorology, Hydrology, DRR as constituted in 2016 for the period of 2017-19.

1.8.3.1. The working groups should submit their report by 31 October 2017 for the year 2016 and 17. In case of no response, the Panel may write to PRs of the concerned country. PTC will write to the working group experts (Chairman and members) enclosing coordinated technical plan and annual operating plan alongwith the terms of reference for the working groups.

1.8.4. Due to delay in conduct of the 44th Session of PTC, it isrecommended that the annual operating plan adopted in PTC-44 session will be applicable for 2017 and 2018.

1.9. PTC SECRETARIAT

1.9.1 Secretary of PTC conveyed thanks to the Panel on the confidence that Panel reposed on him and Pakistan with regard to the hosting of the PTC Secretariat.

1.9.2 PTC Secretariat briefed the Panel about its activities during the inter-sessional period. The Panel expressed its satisfaction with the work of the PTC Secretariat. The summary of the activities of PTC Secretariat is given in **CHAPTER VI**

1.9.3 Upon request of the PTC Secretariat, the Panel agreed to provide US$ 4,000 to support the activities of the PTC Secretariat 2017.

1.10 SUPPORT FOR THE PANEL'S PROGRAMME

1.10.1. PTC Trust Fund

1.10.1.1. The WMO representative presented to the Panel the final statement for 2016 of the PTC Trust Fund. The Panel endorsed the statements. A detailed financial report of the Trust Fund as of 31 December 2016 as submitted by WMO to the Panel is given in **(Appendix-II).**

1.10.1.2. The Panel encouraged the PTC Members and others, if any, to contribute to the PTC Trust Fund on voluntarily basis.

1.10.1.3. The Panel agreed to the participation of Secretary of PTC in the 74th Session of ESCAP through PTC Trust Fund.

1.10.1.4. The Panel reaffirmed that the Panel on Tropical Cyclones Trust Fund (PTCTF) should be used for achieving self-reliance of the Panel and thus be used not only for the provision of institutional support but also as funding support to the representatives of the Panel Members attending training events and conferences.

1.10.1.5. The Panel endorsed the use of the Trust fund for 2017 for the following specific purpose:

1. Support to the two weeks attachment training at RSMC, New Delhi for per diem (lump sum) for three (03) participants (US$ 6000)
2. Support to the one week attachment training on storm surge in India for per diem (lump sum) for six (06) participants (US$ 6000)
3. Support to the PTC Secretariat for its operating expenses and running of the PTC website (US$ 4,000)

1.10.2. Resources and Support

A document provided by the WMO Development and Regional Activities Department (WMO/DRA) has been presented to the Panel and is given in **Appendix-III**.

1.10.3. Review of the Terms of Reference (ToRs) of the Working Groups and Secretariat of the Panel

The ToRs of the WGs and the PTC Secretariat were presented by the Vice-Chair of PTC and were endorsed by the Panel members as given in **Appendix-IV and V**.

1.10.3.1. Reports of Working Groups

1.11 Other issues:

1.11.1 Tropical Cyclone (TC) Forecasting competencies

This agenda item was moved to 5.4 on Training. The outcomes of the discussion and recommendation was also recorded there.

1.11.2. Development of TC impact-based forecasting products

The Panel was presented Decision 10 of 68th session of WMO Executive Council on development of impact-based tropical cyclone forecasting and warning products to enhance the capability of National Meteorological and Hydrological Services to provide tropical cyclone forecasting and warning services with multi-hazard approach. The decision requires that the new products be developed and corresponding training opportunities be provided, under the initiative of Regional Specialized Meteorological Centres dealing with tropical cyclones, in collaboration with Members with experience in impact-based tropical cyclone forecast and warning services, to assist other Members in accelerating their implementation of impact-based tropical cyclone forecasts and warnings. In this connection, the Panel requested RSMC New Delhi to lead the development of the new products, and the Members to collaborate with RSMC New Delhi in the process.

1.11.3 Global Multi-Hazard Alert System (GMAS)

4.1.x The Panel was presented by WMO Secretariat on the Decision 3 of the WMO EC-69 (Decision 3 (EC-69)) that urges Members, regional associations, technical commissions and technical programmes to participate in and contribute to the development of WMO GMAS. The panel discussed about the GMAS and recognized its importance to Members, to United Nations agencies, and other sectors of the international communities. Considering that tropical cyclones are the most disastrous weather phenomenon and should become an important part of GMAS, the Panel urged the Members to contribute to the development of GMAS, and requested RSMC New Delhi to take a leading roles in coordination of technical specifications on the GMAS.

1.12. DATE AND PLACE OF THE FORTY-FOURTH SESSION

Myanmar is supposed to host PTC Session in 2018 and Oman in 2019. However, PR of Myanmar has expressed readiness to host the session in 2019. As at this moment, no member agreed to host the next PTC session in 2018, the Panel requests Secretary PTC in consultation with WMO and ESCAP to contact members of the Panel to find host for next session.

1.13. ADOPTION OF THE REPORT

The report of the forty-fourth session was adopted at 13:20 hours on Thursday 14th September 2017.

1.14. CLOSURE OF THE SESSION

The session closed at 13:30 hours on Thursday 14th September, 2017.

CHAPTER-II

CYCLONIC ACTIVITIES OVER NORTH INDIAN OCEAN DURING 2016

A. Annual Activity

There were 10 cyclonic disturbances (CD) i.e. depressions and cyclones over the north Indian Ocean (NIO) & adjoining land regions during 2016 against the long period average (LPA) of 11.5 disturbances per year based on data of 1961-2015. Out of 10 CDs, 4 intensified into tropical cyclones against the normal frequency of 4.5 cyclones per year over north Indian Ocean (NIO) based on LPA. It included including 3 cyclonic storms (CS) and one very severe cyclonic storm (VSCS). These cyclones are:

- ***Cyclonic storm, Roanu over Bay of Bengal (17-21 May)***
- ***Cyclonic storm, Kyant over Bay of Bengal (21-28 October)***
- ***Cyclonic storm, Nada over the Bay of Bengal (29 November-02 December)***
- ***Very severe cyclonic storm, Vardah (06-13 December)***

i. Thus, there was no cyclone over the Arabian Sea and all the four cyclones developed over the Bay of Bengal

ii. The cyclonic activity over the NIO was near normal during 2016. The activity during post-monsoon and pre-monsoon seasons was also near normal with the formation of 3 and 1 cyclones during these seasons respectively.

iii. There was one severe cyclonic storm or higher intensity storm (Maximum sustained wind speed (MSW) ≥ 48 kts & above) over NIO in 2016 against the average of 2-3 such storms.

iv. All the cyclones during 2016 had recurving tracks. While cyclone Roanu had anti-cyclonic recurvature, cyclone Kyant, Nada and Vardah had cyclonic recurvatures.

v. Cyclone, Roanu developed from a depression over southwest BoB off Sri Lanka coast on 17th May. It moved initially northwards and then north-northeastwards skirting Indian coast and crossed Bangladesh coast near latitude 22.6° N and longitude 91.6° E, to the north of Chittagong around 1000 UTC of 21st May with MSW of 45 kts.

vi. The Cyclonic Storm (CS) Kyant developed on 21st October with the formation of a depression (D) over eastcentral Bay of Bengal (BOB). Initially, it moved east-northeastwards towards Myanmar coast and steadily intensified into a deep depression (DD) on 23rd morning. Thereafter, it changed its direction of movement and recurved west-northwestwards. It intensified into a CS in the morning of 25th over eastcentral BOB. Thereafter, it again changed its direction of movement and moved west-southwestwards towards westcentral BOB off Andhra Pradesh coast. It maintained its intensity till midnight of 26th and thereafter weakened gradually becoming DD in the early hours 27th and D in the same evening. It weakened into a well marked low pressure area over westcentral BOB off Andhra Pradesh coast in the morning of 28th.

vii. Cyclone Nada formed from a depression that formed over southeast BOB in the evening of 29th November. It moved initially northwestwards and intensified gradually into cyclonic storm (CS) "Nada" over southeast BoB in the morning of 30th. It maintained its intensity till the evening of 1st December while moving west-northwestwards. It weakened into a deep depression (DD) in the noon of 1st December and further into a depression in the same midnight. Continuing to move west-northwestwards, it crossed

north Tamil Nadu coast near Nagapattinam (about 20 km south of Karaikal) during 0400-0500 hours IST of 2nd December. Continuing to move westwards, it further weakened into a well marked low pressure area over interior Tamil Nadu in the forenoon of 02nd Dec. 2016.

viii. The last cyclone, Vardah formed from a depression (D) that developed over southeast Bay of Bengal (BOB) in the afternoon of 6th December. Moving northwestwards initially and northwards thereafter, it intensified into a deep depression (DD) in the midnight of 7th December, into a cyclonic storm (CS) "Vardah" in the morning of 8th and into a severe cyclonic storm (SCS) in the midnight of 9th. It then moved west-northwestwards and intensified further into a very severe cyclonic storm (VSCS) over westcentral and adjoining south BOB in the evening of 10th December. It then moved nearly westwards and reached its peak intensity of about 130 kmph on 11th December evening and maintained the same intensity till noon of 12th December. It weakened into an SCS and crossed north Tamil Nadu coast near Chennai during 1500-1700 hrs IST of 12th December 2016 with a wind speed of 100-110 kmph gusting to 120 kmph. After the landfall, the SCS moved west-southwestwards and weakened into a CS in the evening, into a DD in the midnight of 12th and into D in the early morning of 13th. Continuing its west-southwestwards movement, it weakened into a weIl marked low pressure area in the forenoon of 13th December.

ix. Thus, there were only two landfalling cyclones over the north Indian Ocean in 2016 against normal of 3 such cyclones per year based on long period average based on 1961-2015.

x. Only one cyclone (Vardah) crossed India coast against the normal of about 2 such cyclones per year.

Details of the cyclonic disturbances formed over the north Indian Ocean and adjoining land areas are given in Table 2.1-2.4. The tracks of these disturbances are shown in Fig. 2.1.

Table 2.1 Brief statistics of cyclonic disturbances over NIO and adjoining land areas during 2016:

1.	Cyclonic Storm, **ROANU**, over Bay of Bengal (17-22 May, 2016)
2.	Depression over Arabian Sea (27-29 June, 2016)
3.	Land Depression (6-7 July, 2016)
4.	Deep Depression over Bay of Bengal(9 - 12 Aug, 2016)
5.	Deep Depression over Bay of Bengal (16 - 21 Aug, 2016)
6.	Cyclonic Storm, **KYANT**, over Bay of Bengal (21 – 28 Oct 2016)
7.	Depression over Bay of Bengal (02-06 Nov, 2016)
8.	Cyclonic Storm, **NADA**, over Bay of Bengal (29 Nov- 02 Dec 2016)
9.	Very Severe Cyclonic Storm, **VARDAH**, over Bay of Bengal (06 – 13 Dec, 2016)
10.	Depression over Arabian Sea (17-18 Dec, 2016)

Table 2.2 Some Characteristic features of cyclonic disturbances formed over north Indian Ocean and adjoining region during 2016

S. No.	Cyclonic storm/	Date, Time&	Date, Time (UTC) Place	Estimated lowest	Estimated	Max T. No.

	Depression	**Place of genesis (Lat. N/long E)**	**(Lat./Long.) of Landfall**	**central pressure, Time & Date (UTC) & Lat°N/long° E**	**Maximum wind speed (kt), Date & Time**	**Attained**
1	Cyclonic Storm (CS) Roanu over the Bay of Bengal (17-22 May, 2016)	17th May 2016, 0300 UTC over Sri Lanka and adjoining areas of Gulf of Mannar & southwest BoB (11.0/81.0).	Weakened into a well-marked low pressure over Myanmar and adjoining Nagaland & Manipur at 0300 UTC on 22nd May 2016	983 hPa at 2100 UTC on 20th May 2016 near (20.7/88.4)	45 knots at 1800 UTC on 20th May 2016 near	T 3.0
2	Depression over Arabian Sea (27-29 June, 2016)	27th Jun 2016, 0900 UTC over northeast Arabian Sea (AS) (21.5/64.5)	Weakened into a well-marked low pressure over northwest and adjoining west-central Arabian Sea at 0300 UTC on 29th June 2016	996 hPa at 0900 UTC 27th Jun 2016 near (21.5/64.5)	25knots at 0900 UTC of 27th Jun 2016	T 1.5
3	Land Depression (6th- 7th July 2016)	06th Jul 2016, 0300 UTC over north Madhya Pradesh and neighbourhood (24.8/81.5).	Weakened into a Well marked low pressure area over northeast Madhya Pradesh and neighbourhood at 0300 UTC on 07th July 2016	996 hPa at 0300 UTC 06th Jul 2016 near (24.8/81.5)	25 knots at 0300 UTC of 06th Jul 2016.	-
4	Deep Depression (09-12 Aug, 2016) over Bay of	09th Aug, 2016, 0900 UTC over coastal areas of west	Weakened into a Well marked low pressure area over south Bihar	994 hPa at 0300 UTC 10thAug, 2016 near (23.0/89.4)	30 knots at 0300 UTC 10thAug, 2016	T1.5

	Bengal	Bengal and neighbourhood (22.0/88.5)	and neighborhood on 13th morning, 2016			
5	Deep Depression (16-21 Aug, 2016) over Bay of Bengal	16th Aug, 2016, 1200 UTC over northwest Bay of Bengal and neighbourhood (21.0/89.0)	weakened into a well marked low pressure area, over east Rajasthan & adjoining west Madhya Pradesh by 0000 UTC of 21st Aug, 2016.	994 hPa at 0900 UTC 17thAug 2016 near (21.6/88.4)	30 knots at 0900 UTC 17thAug 2016	T1.5
6	Cyclonic Storm, KYANT Over bay of Bengal (21st Oct – 27th Oct, 2016)	26th Oct 2016, 0000 UTC over eastcentral Bay of Bengal (13.5/88.5).	Weakened into a well-marked low pressure area over west central Bay of Bengal off Andhra Pradesh coast on 28th morning.	988 hPa at 0300 UTC on 25th Oct 2016 near (17.0/91.2)	40 knots at 0300 UTC on 25th Oct 2016	T 2.5
7	Depression over the Bay of Bengal (2nd – 6th Nov. 2016)	2nd Nov 2016 at 1800 UTC over central and adjoining southeast Bay of Bengal (12.7/88.0).	Weakened into a well marked low pressure area over southeast Bangladesh & adjoining northeast Bay of Bengal and lay as a low pressure area over southeast Bangladesh and neighbourhood on 7thmorning.	996 hPa at 1800 UTC on 2nd Nov 2016 (12.7/88.0)	25 knots at 1800 UTC on 2nd Nov 2016.	T1.5
8	Cyclonic	29th Nov	weakened into	988 hPa at	40 knots	T 2.5

	Storm "Nada" over the Bay of Bengal (29th Nov. – 2nd Dec. 2016)	2016, 1200 UTC over southeast Bay of Bengal (6.5/87.5)	a well marked low pressure area over interior Tamil Nadu & neighbourhood on 2nd.	0300 UTC 30th Nov, 2016 near (8.2/85.3)	at 0300 UTC 30th Nov, 2016	
9	Very Severe Cyclonic Storm 'VARDAH' over the Bay of Bengal (6th -13th Dec. 2016).	06th Dec 2016, 0900 UTC over southeast Bay of Bengal (8.5/91.0)	weakened into a Well marked low pressure area over north interior Tamil Nadu and adjoining south interior Karnataka at 0300 UTC of 13th Dec 2016.	984 hPa at 1200 UTC 10th Dec 2016 near (13.2/86.4)	65 knots at 1200 UTC 10th Dec 2016	T 4.5
10	Depression over Arabian sea (17-18 Dec 2016)	17th Dec 2016 at 0300 UTC over southwest Arabian Sea near (11.0/62.5).	weakened into a well marked low pressure area over southwest Arabian Sea in the forenoon of 18th Dec 2016	994 hPa at 0300 UTC 18th Dec, 2016 near (9.4/56.8)	25 knots at 0300 UTC 17th Dec 2016.	T 1.5

Table 2.3 Statistical data relating to cyclonic disturbances over the north Indian Ocean during 2016

A) Monthly frequencies of cyclonic disturbances(C I .≥1.5)

S. No	Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.	D						↔					↔	↔
2.	DD								⇔				
3.	CS					↔					↔	↔	
4.	SCS												
5.	VSCS												↔

6.	Land Dep.							⇔					

⇔ Peak intensity of the system

B) Life time of cyclonic disturbances during 2016 at different stages of intensity

S.No.	Type	Life Time in (Days)
1	D	17 days 12 hours
2.	DD	09 days 12 hours
3.	CS	07 days 09 hours
4.	SCS	01 day
5.	VSCS	01 days 21 hours
	Total Life Time in(Days)	37 days 25 hours

C) Frequency distribution of cyclonic distribution with different intensities based on satellite assessment

CI No (≥)	**≥1.5**	**.≥2.0**	**.≥2.5**	**.≥3.0**	**.≥3.5**	**.≥4.0**	**.≥4.5**	**.≥5.0**	**≥5.5**	**≥6.0**
No of Disturbances	10	6	4	2	1	1	-	-	-	-

D) Basin-wise distribution of cyclonic distribution

Basin	**Number of cyclonic disturbances**
Bay of Bengal	7
Arabian Sea	2
Land depression	1

Table 2.4. Cyclonic disturbances formed over the north Indian Ocean and land areas of India during 1997-2016

Year	**Basin**	**D**	**DD**	**CS**	**SCS**	**VSCS**	**ESCS**	**SuCS**	**Total**
1997	BOB	1	4	1	1	1	0	0	8
	ARB	1	0	0	0	0	0	0	1
	Land	0	0	0	0	0	0	0	0
	Total								**9**
1998	BOB	0	3	0	1	2	0	0	6
	ARB	0	1	1	1	1	0	0	4
	Land	1	0	0	0	0	0	0	1
	Total								**11**
1999	BOB	2	2	1	0	1	0	1	7
	ARB	0	0	0	0	1	0	0	1
	Land	1	0	0	0	0	0	0	1
	Total								**9**
2000	BOB	1	1	2	--	2	0	0	6

	ARB	0	0	0	0	0	0	0	0
	Land	1	0	0	0	0	0	0	1
	Total								**7**
2001	BOB	2	0	1	0	0	0	0	3
	ARB	0	0	2	0	1	0	0	3
	Land	0	0	0	0	0	0	0	0
	Total								**6**
2002	BOB	1	1	2	1	0	0	0	5
	ARB	0	0	0	0	0	0	0	1
	Land	0	0	0	0	0	0	0	0
	Total								**6**
2003	BOB	2	2	0	1	1	0	0	6
	ARB	0	0	0	1	0	0	0	1
	Land	0	0	0	0	0	0	0	0
	Total								**7**
2004	BOB	2	0	0	0	1	0	0	3
	ARB	0	2	0	3	0	0	0	5
	Land	2	0	0	0	0	0	0	2
	Total								**10**
2005	BOB	2	3	4	0	0	0	0	9
	ARB	2	0	0	0	0	0	0	2
	Land	1	0	0	0	0	0	0	1
	Total								**12**
2006	BOB	5	2	1	0	1	0	0	9
	ARB	0	1	0	1	0	0	0	2
	Land	1	0	0	0	0	0	0	1
	Total								**12**
2007	BOB	3	4	1	0	1	0	0	9
	ARB	0	1	1	0	0	0	1	3
	Land	0	0	0	0	0	0	0	0
	Total								**12**
2008	BOB	1	2	3	0	1	0	0	7
	ARB	1	1	0	0	0	0	0	2
	Land	1	0	0	0	0	0	0	1
	Total								**10**
2009	BOB	0	2	2	1	0	0	0	5
	ARB	2	0	1	0	0	0	0	3
	Land	0	0	0	0	0	0	0	0
	Total								**8**
2010	BOB	2	1	0	2	1	0	0	6

	ARB	0	0-	1	0	1	0	0	2
	Land	0	0	0	0	0	0	0	0
	Total								**8**
2011	BOB	2	2	0	0	1	0	0	5
	ARB	1	2	1		0	0	0	4
	Land	1	0	0	0	0	0	0	1
	Total								**10**
2012	BOB	0	2	1	0	0	0	0	3
	ARB	0	1	1	0	0	0	0	2
	LAND	0	0	0	0	0	0	0	0
	Total								**5**
2013	BOB	3	0	1	1	3	0	0	8
	ARB	0	1	0	0	0	0	0	1
	Land	1	0	0	0	0	0	0	1
	Total								**10**
2014	BOB	2	2	0	0	1	0	0	5
	ARB	0	0	1	0	1	0	0	2
	Land	1	0	0	0	0	0	0	1
	Total								0
2015	BOB	1	1	1	0	0	0	0	3
	ARB		2	1	0	0	2	0	5
	Land	2	2		0	0	0	0	4
	Total								**12**
2016	BOB	1	2	3	0	1	0	0	7
	ARB	2	0	0	0	0	0	0	2
	Land	1	0	0	0	0	0	0	1
	Total								**10**

D: Depression, **DD:** Deep Depression, CS**:** Cyclonic Storm, **SCS:** Severe Cyclonic Storm,
VSCS: Very Severe Cyclonic Storm, **SuCS:** super Cyclonic Storm,
BOB: Bay of Bengal, **ARB:** Arabian Sea

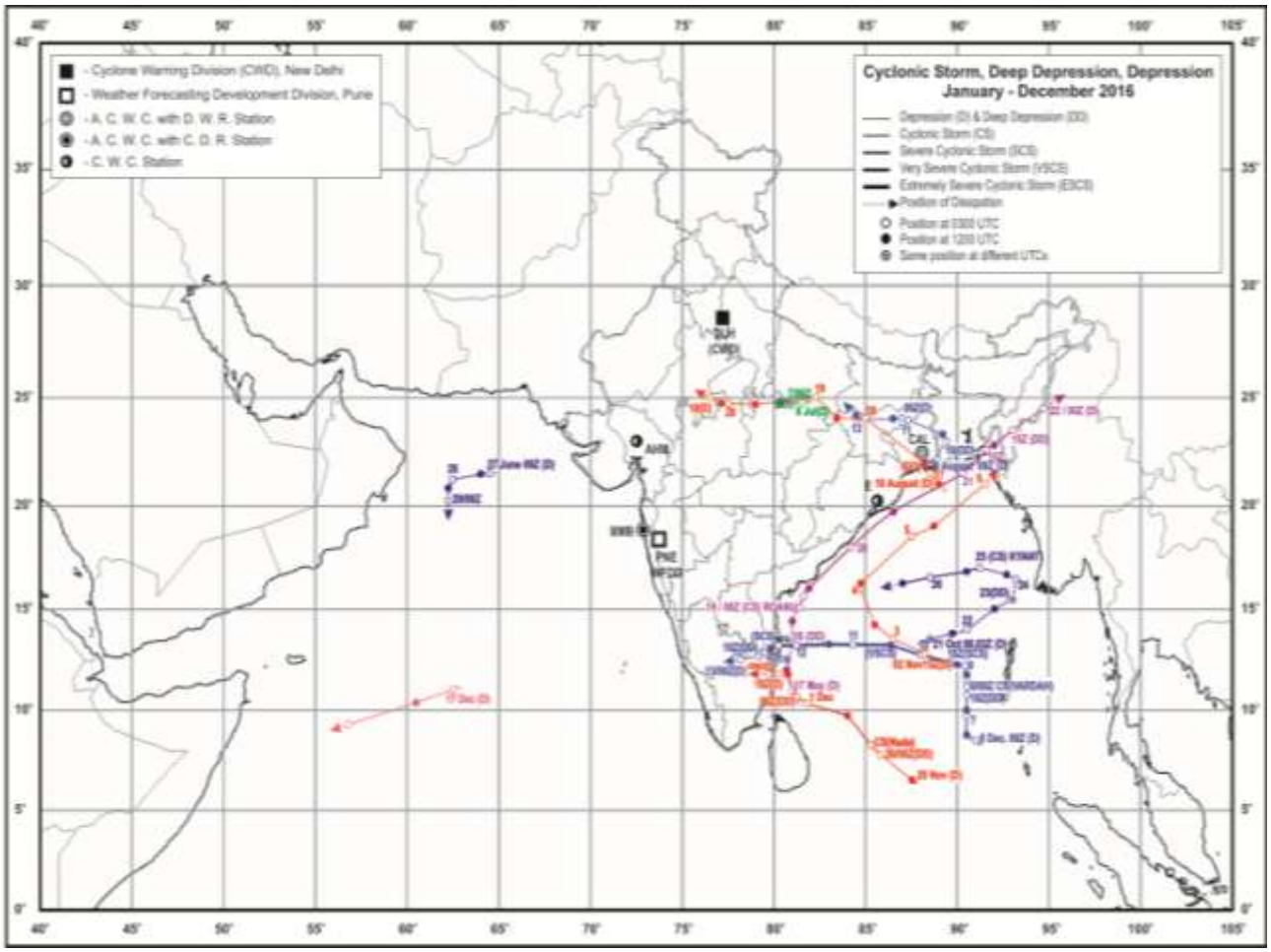


Fig. 2.1. Tracks of the cyclonic disturbances over the north Indian Ocean and adjoining land regions during the year, 2016

Detailed reports on these systems are available in the Annual Report on Cyclonic Disturbances during 2016 at the link http://www.rsmcnewdelhi.imd.gov.in/images/pdf/publications/annual-rsmc-report/rsmc-2016.pdf

B. Action Taken Report of Panel on 2015 cyclone season

(i) Panel urged the importance of improving the observations in the ocean and along the coast.

(ii) Panel requested WMO to intervene to reduce the cost of radiosonde for least developed countries and also for developed countries to improve upper air observations.
Action: The Panel was informed that infrastructure is mainly the responsibility of the members. However it is understood that some members encountered difficulty in procuring

the RS instruments due to high price. The Panel recommends WMO to consider to be engaged on the issue to reduce the cost of radiosonde for least developed countries and also for developed countries to improve upper air observations. However, after the deliberations it was recommended that PTC may write a letter to President of WMO RA-II on the issue for possible intervention. President RA-II also requested all members to share the information on the type of RS instruments, gas and accessories used and their cost among the countries and to RA-II so as to enable members to choose the cheapest and qualitative RS instruments. Further it was recommended that PTC may prepare and send a proposal to Green Climate Fund (GCF) for supporting augmentation of the observation in the region.

(iii). Panel urged that a table containing number of ship observations taken by the member countries may also be included.
Action: At NCMRWF, India, monthly observation monitoring statistics is generated. For north Indian Ocean, the count for the monthly mean ship pressure observation per day over Indian Ocean is as follows :

Month	Ship (mslp) North Indian Ocean	Month	Ship (mslp) North Indian Ocean
January 2016	393	Novermber 2016	663
February 216	452	December 2016	707
March 2016	457	January 2017	457
April 2016	454	February 2017	621
May 2016	383	March 2017	696
June 2016	436	April 2017	680
July 2016	529	May 2017	648
August 2016	642	June 2017	640
September 2016	635	July 2017	633
October 2016	572	August 2017	659

(iv). Panel requests WMO to intervene in institutionalization the sharing of TCP and TC data.
Action: Sharing of non-GTS data between any two countries is possible only through bilateral/multi-laterial arrangements. However, the data related to tropical cyclones and typhoons like track, intensity, genesis and frequency etc. is available in RSMC, New Delhi and Tokyo websites.

(v) Panel recommends that it would be very helpful if the algorithms of satellite products related to the Tropical Revolving Storms are available. Panel requests WMO to discuss with satellite owners in this regards.
Action: President of RA-II is requested to write to satellite owners to make available to PTC countries the algorithms of satellite products related to the Tropical Storms for better interpretation and utilization of products, as well as data assemilation as different satellites differ from each other.

(vi) Panel emphasizes the need of Microwave data and products of Tropical Storms even

at the initial stage of genesis. Panel requests WMO to make arrangements with US Navi NRL and other service providers.
Action: President of RA-II is requested to make arrangements with US Navy NRL and other service providers through CGMS.

(vii) Aircraft based observations of WMO observation system should be transmitted to WMO GTS to provide high quality vertical profile.
Action : Monthly average number of observationsReceived at NCMRWF in 24 are given below

(viii). RADAR data as metadata should go into the WMO observational system as more than 80 countries have already participated.
Action: The President of RA II informed the Panel that a website is being developed for RA-II region to display all the radar products in Asia.

With respect to Meta Data all members are quested to provide the same to WMO focal point for the purpose. The representative of India informed the Panel that he Radar Meta Data have been prepared. It is in the process of being sent to WMO.

(ix). Myanmar urges the member countries to share their expertise with financial support and give training on telecommunication, satellite and RADAR.
Action: Representative of Myanmar informed the Panel that the country has made arrangement for augmentation of observational network. However, WMO may organize and support the training on telecommunication, satellite and RADAR.

(x). Member countries may do the cyclone hazard mapping as is done in India.
Action: A few countries have carried out hazard mapping. Other countries may like to do the similar mapping. India representative informed that data on tropical cyclone are available in the RSMC website. Any technical support for the purpose of the cyclone hazard mapping can be provided, if needed by the member countries.

(xi) To understand, interpret and convey the warnings correctly, a training should be held in capacity building of the users and media.
Action: Member countries informed the Panel regarding the organization of such meetings and workshops within their NMHSs. Member countries are encourged to communicate the details of such activities to Chairperson of PTC for preparation of a consolidated report by 31st October 2017. Further, it was recommended that member countries may continue such activity to enhance better utilisation of forecast and warning products by users and media.

C..Report of Members on the impact of tropical cyclones

i. India

The representative of India informed the Panel that out of four cyclones developed over the Bay of bengal and Arabian Sea during 2016, only one cyclone, viz., very severe cyclonic storm (VSCS), Vardah crossed Indian coast (near Chennai, Tamil Nadu). Cyclone Vardah wreaked havoc in the remote islands of Andaman like Diglipur, Rangat and Billy ground that witnessed a flood-like situation due to torrential rains. Landslides were reported along the Andaman Trunk Road, while several houses and crops have been damaged in

areas located in the northern and central Andaman. There was no power in several areas for two days due to the snapping of power cables. More than 1,400 tourists were stranded on the Havelock and Neil Islands of the Archipelago. However, no casualty was reported from Andaman & Nicobar Islands. The cyclone prompted evacuation of 16000 people. 24 deaths related to the cyclone have been reported in the state of Tamil Nadu and 2 deaths in adjoining areas of Andhra pradesh. Cyclone Vardah caused colossal damage to infrastructure like roads, bridges, reservoirs, tanks, drinking water supply, school & public health buildings, electrical installations, habitats such as huts & houses, crops, cattle losses in Tamil Nadu. Severe Crop damages occurred in Tiruvallur, Kanchipuram, Vellore and Tiruvannamalai districts of north Tamil Nadu. There was damage to paddy, groundnut, blackgram, greengram and coconut causing a loss of nearly 33 % in these districts in an area of 34206.13 Hectare.

ii. Myanmar

The representative of the Myanmar informed the Panel that during 2016, 13 lpas, 7 deans intensified further and 4 naming cyclonic storms as Roanu in May, Kyant in Oct , Nada in Oct to Dec and Vardah in Dec. No crossing to Myanmar coast in 2016. Esp CS Roanu, after crossing as land dean, it was continued to cross NW of Myr and then weakened as lpa. it was effected by heavy ref, flash floods, tornadoes and landslides in NW of Myr. CS Kyant was per ulnar track. 1st tracking was approaching to deltaic areas and then recurred to NW wards. Media were pointed out due to over estimated in storm surge FC that did not happen in delta areas. If CS was cries sing to delta, storm surge will be occurred up to fc height about 3 to 4 m .Local authority as Relief and resettlement Dept. explained in DRR and CCA meeting , 1 m was raised in that area. More or less impacts were occurred during storm formation in BOB and Andaman Sea even though cyclone did not cross to Myr coasts. During 2017 as of today, 8 lpas, 4 depn and 2 became naming cyclonic storms as Maarutha in April and Mora in May. CS Maarutha was crossed near Thandwe, Rakhine coast.After land depn, it was happened more serious in Rakhine, Chin, Magway and Bago regions. flash flood was ocurred in Mann Chaung that is one estuary of Ayeyarwady river in Central(dry zone). DMH has observed new max ref recorded in the whole country starting from Jan to August in 2017. Storm warning did identify as color code by National Disaster Management Committee-NDMC .People in Myanmar are noted well before, during and after storm in BOB and Andaman Sea. Information and warning rely on RSMC for BOB and Andaman Sea 1st. For the remnant of Ty and disturbance on East, DMH always rely on TMD.RSMC should be issued the warning and info in time . EW requested to provide uploaded and updated in time esp E of 90 dog east longitude .And then storm surge new version by RSMC, IMD, IIT need to provide to DMH.

iii Pakistan

The representative of Pakistan informed the Panel that there was no cyclonic activity in the Arabian Sea during 2016. However, two depressions formed in the Arabian Sea (27-29 June, 2016) and (17-18 December, 2016).

iv Oman

The representative of Oman informed the Panel that no cyclonic disturbance formed in the Arabian Sea during 2016.

v Sri Lanka

The representative of the Sri Lanka presented the report on cyclongenesis activities during 2016, which is summarized below:

The first cyclone affected the Sri Lankan weather during the year 2016 was "ROANU" as a low pressure area. It developed to the southeast of Sri Lanka in the southwest bay of Bengal on 10th and gradually intensified into a cyclone "ROANU, causing extremely heavy rain over Northern, western, Central, North-western and Eastern provinces during 13-16th resulting in massive landslides in western part of central highland and severe flooding in Kelani river catchments in Colombo district. At least 104 persons are known to have died and 99 persons are still missing, the majority due to a landslide in Aranayake, Kegalle District, which devastated three villages. An estimated 301,602 persons have been affected by this disaster. There were three cyclones (KYANT,NADA and VARDHA) formed in the Bay of Bengal during latter part of the year from October to December 2016 and these systems suppressed the usual inter-monsoon activity as well as northeast monsoon rain over Sri Lanka enhancing prevailed drought condition in the country, Particularly in the rain shadow areas during the southwest monsoon season.

CHAPTER-III

Publications

A book entitled "Tropical Cyclone Activity over north Indian Ocean" edited. **M.Mohapatra,** B.K. Bandyopadhyay and L.S. Rathore and Co-published by Capital Publishers, New Delhi and Springer, Germany **was released during 2017. The Contents the book are given below:**

CHAPTER-IV
COORDINATED TECHNICAL PLAN (CTP): 2016-2019

4.1. 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.

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 CTP (2009-2011) was developed by the PTC Policy Working Group chaired by Dr. Qamar-uz-Zaman Chaudhry, Secretary of PTC and adopted by the PTC during its 36th Session (Muscat, Oman, 2-6 March, 2009)..

The present CTP (2016-2019) is an updated version of previous Coordinate Technical Plans and has also taken into consideration the WMO Strategic Plan 2016-2019 and the Strategic Plan for the Enhancement of National Meteorological and Hydrological Services in Regional Association II (2012-2015).

4.1.1 Panel Region

Currently, the Panel is composed of nine Members; Bangladesh, India, Maldives, Myanmar, Oman, Pakistan, Sri Lanka, Thailand and Yemen.

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 present and 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.

4.1.2. Vision and mission of the Panel

4.1.2.1.Vision of the Panel

To promote and coordinate the planning and implementation of the multi hazard early warning based Disaster Risk Reduction system to attain sustainable development measures through minimizingloss and damage caused by tropical cyclones and associated meteorological, hydrological and other ocean hazards in the Bay of Bengal and the Arabian Sea.

4.1.2.2. 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 information dissemination 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.*
f. *To encourage and carry out capacity building.*

4.1.3 Priorities of the Panel

The Panel agreed that the following are priority issues:

a. Maintenance of existing system and further development of land, Ocean and atmosphere 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, high waves, flash/urban floods, tsunamis etc.;
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 and technology transfer for early warning dissemination and response at the national and community levelsto 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 and climate change impacts. Member countries to encourage and promote research on Multi hazards associated with tropical cyclones

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. Facilitation of tropical cyclone disaster risk assessment at the country level, especially along the coast, delta, and urban areas where risks are the highest to reach sustainable development goals
j. 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;
k. Strengthening information exchange with various disaster-related information systems in the region;
l. Strengthening partnerships with relevant international and regional bodies, such as UN-ISDR, UNDP, UNESCO/IOC, UNEP, ESCWA,ASEAN, SAARC, IFRC, ADRC, ADPC, ICHARM, JICA, KOICA, TICA, USAID, ADB, ICAO, RIMES, BIMSTEC and WB;
m. Enhanced public & private partnership including industries, non-governmental organisations (NGOs) etc. for awareness, feedback and information dissemination etc. aiming to disaster risk reduction (DRR);
n. Enhancement of resource mobilization activities for implementation of CTP.

4.1.4 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.

4.1.4.1 Meteorology

4.1.4.1.1. 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 land, Ocean &atmosphere observing systems 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.

4.1.4.1.2. 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.

4.1.4.1.3. 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 theirforecasting 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.

4.1.4.2. 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, Yemen, 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.

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.

4.1.4.3 Disaster Risk Reduction

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. The Disaster Risk Reduction component of the CTP will aim at reducing tropical cyclone disaster risks at the community level by enhancing the local and institutional capacities to cope with the risks.

4.4.3.1. 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, Myanmar or to Bangladesh and a few of them emerge into Arabian Sea after crossing the Indian Peninsula and Sri Lanka. A few tropical cyclones form in the Arabian Sea and move to the north affecting the western part of India, southern Pakistan, Yemen 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. Quantification of associated risks might help to plan appropriate DRR actions.

4.4.3.2. Regional technical coordination on tropical cyclones

Regional cooperation and coordination in disaster prevention and mitigation among the Members are gaining importance in the region. India 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. Mechanism may be set up to foster tele conference (audio/video) for consultation among members and RSMC, New Delhi.

4.1.4.3.3. Inter Regional Co-operation on Tropical Cyclones

Real time exchange of information, data and products between RSMC, New Delhi and RSMC, Tokyo for monitoring and prediction of tropical cyclones to be institutionalised. WMO may co-ordinate this co-operation. The archived informations, data and products also to be exchanged for R& D purposes.

4.1.4.3.4. Risk assessment and management

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.

Risk level needs to be evaluated based on the tropical cyclone forecast over a region utilizing the past climatology. The assessed risk level needs to be communicated to the disaster managers for suitable actions at their levels. Post-disaster risk assessment based

on loss and damage survey is also essential to identify the gaps and improve the risk assessment for the future.

4.1.4.3.5. Linkages with International framework initiatives

Activities of the Panel on Tropical Cyclones may be linked appropriately with the important initiatives such as the ESCAP/WMO Typhoon Committee, International Network for Multi-Hazard Early Warning Systems (IN-MHEWS) established at the Third United Nations Conference on Disaster Risk Reduction in March 2015, and the Climate Risk Early Warning System (CREWS) launched at the Conference of the Parties of the United Nations Framework for Climate Change in December 2015. In this regard, WMO and ESCAP may extend institutional support the Panel on Tropical Cyclones.

4.1.4.4. 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.

RSMC New Delhi, Indian National Centre for Ocean Information Services (INCOIS), Hyderabad and academic institutions to support 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:

- Forecasting of tropical cyclone intensity and track, and associated storm surge, inland flooding and coastal inundation
- Observing and processing data and interpretation of outputs from regional centres;
- Information and communication technology (ICT);
- Equipment maintenance;
- Provision of weather services for the public, including service-oriented media/communication skills;
- Provision of weather services for aviation and shipping, including marketing of services and liaison with clients;
- Provision of climate information services;
- Application of NWP products;
- Nowcasting of severe weather; and
- High level and middle management skills.
- Climate change impacts on tropical cyclones and associated phenomenon
- Maintenance of competency standards
- Training through fellowships, seminars and workshops with assistance from outside the region needs to be also intensified.

4.1.5 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:

4.1.5.1. 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.

4.1.5.2 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.

In the Panel region, efforts have to be continued under CTP for attachment training on country specific advanced storm surge forecasting and inundation modelling.

4.1.5.3 Hindu Kush-Himalayan Hydrological Cycle Observing System (HKH-HYCOS) Phase II project

The Hindu Kush-Himalayan Hydrological Cycle Observing System (HKH-HYCOS) Phase II project, which was funded by the government of Finland, was successfully completed on December 31, 2015. HKH-HYCOS Phase III project proposal has been prepared and is being circulated to potential donors.

4.1.5.4. Mekong-HCOS project

The Mekong-HCOS project was successfully completed on 30 November 2012. The project was financially supported by the Agence Francaise de Developpement (AFD). AFD is further supporting additional efforts with the Mekong River Commission on extending the MRC-HYCOS network and improving its sustainability, as well as improving data usage based on statistical hydrological analyses

4.1.5.5. WMO's Severe Weather Forecasting Demonstration Project (SWFDP)

At present, several SWFDP regional subprojects are in progress including in Southern Africa, South Pacific, Eastern Africa, Southeast Asia, Bay of Bengal, and Central Asia. One of the main objectives of SWFDP is to improve forecasting and warning services for hazardous weather in participating countries through efficient use of the'Cascading forecasting process' of GDPFS centres (i.e. Global to Regional to National) and by making best use of the available NWP products and satellite information, and through improved coordination of NMHSs with targeted users including disaster management and civil protection authorities and media. The development planning for SWFDP-Bay of Bengal was initiated in 2012 with participation of six countriesnamely: Bangladesh, India, Maldives, Myanmar and Sri Lanka and Thailand. Since then a steady progress has been made towards SWFDP-Bay of Bengal development and implementation.The contributing global centres are: IMD, JMA, UKMO, NOAA/NCEP and ECMWF. As one of the contributing global centres, IMD is also supported by National Centre for Medium Range Weather Forecasting (NCMRWF) and Indian National Centre for Ocean Information Services (INCOIS) for NWP and marine related products respectively. The password-protected subproject website has been developed by RSMC New Delhi in 2015.Based on Members' interest in SWFDP and considering potential benefits which it could bring to the NMHSs in South Asia, the subproject has been extended to three more countries in the region including Bhutan, Nepal and Pakistan. Most of the Panel Members are also participating countries of SWFDP-Bay of Bengal. The pilot phase commenced on 2nd May, 2016 with issue of regional severe weather guidance by RSMC, New Delhi.

4.1.5.6. 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 MekongRiver Basin in collaboration with MRC. Other areas under development for the implementation of the project are south Asia, 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. The first Steering Committee meeting held at New Delhi recommended to link flash flood guidance provided by regional flash flood guidance centresfor south Asia with SWFDP-BOB.

4.1.5.7. 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.

4.1.6. WMO Programmes and other Regional/International Programmes in support of the Panel Members

4.1.6.1. WMO Programmes

The major WMO Programmes concerned are the World Weather Watch (WWW), the World Climate Programme (WCP), Tropical Cyclone Programme (TCP), PWS (Public Weather Service), DPFS (Data Processing and Forecasting System), MMO (Marine Meteorology and Oceanography), DRR (Disaster Risk Reduction), SP (Satellite Program), AEM (Aeronautical Meteorology), HWR (Hydrology and Water Resources), RAP (Regional Office for Asia and the Pacific), ETR (Education and Training), WWRP (World WeatherResearch Programme), Global Framework for Climate services (GFCS).

4.1.6.2. 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);

UNDP; 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; (BIMSTEC);Regional Integrated Multi- hazard Early Warning System (RIMES);(ADPC); and the Regional Organization for the Protection of the Marine Environment (ROPME).

4.1.7. Agreements and conventions

Members are encouraged 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); Sustainable Development Goals 2015-2030; Hyogo Framework for Action 2005-2015; Sendai Framework for Disaster Risk reduction (2015-2030); 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 and most recent and important Paris agreement on Climate Change 2015.

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.

4.2. DEVELOPMENT OF COORDINATED TECHNICAL PLAN

4.2.1 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 establishan 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:

- 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;

- 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;

- 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;

- 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
- 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.

4.2.2 Institutional Arrangement

Coordinated Technical Plan needs institutional arrangements for successfulimplementation. 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.

4.2.2.1 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.

4.2.2.2 Duration of the Coordinated Technical Plan

Coordinated Technical Plan is to cover a four-year term to keep pace with the financial periods of WMO (4 years) and ESCAP (2 years). The present Coordinated Technical Plan, therefore, covers the period from 2016- to 2019 to coincide with the financial periods of WMO and ESCAP as mentioned above. Coordinated Technical Plan is a live document and continue to be reviewed and updated by the PTC every four years.

4.2.2.3. 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.

4.2.2.4. Steps for the implementation of the Coordinated Technical Plan

The steps for implementing the Coordinated Technical Plan include:

a. Panel, WMO and ESCAP, through cooperative efforts to assist and/or support the implementation of the Coordinated Technical Plan;
b. 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.

4.2.3 Reporting

As part of implementation of the Coordinated Technical Plan, Members will report on progress on the implementation of the Plan to the PTC at annual sessions.

4.3. EXPECTED RESULTS AND STRATEGIC ACTIONS

4.3.1 Meteorology

4.3.1.1 Expected Result 1

- Developed capabilities of Members to produce and provide impact based forecasts and risk based warnings of tropical cyclones, storm surges and associated hazards

This is expected to be achieved based on thedevelopment 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.

4.3.1.2 Strategic Actions

1-a To further improve and expand the observing system of surface, upper-air, ship, buoy, aircraft, radar and satellite observations in the Member countries.

1-b To ensure the real-time operational use of the WMO Information System (WIS) for operation-critical data exchange through dedicated telecommunication means of the GTS, andthrough broadband Internet access for Data Discovery, Access and Retrieval service.

1-c To further increase accuracy, timeliness and usefulness of tropical cyclone forecasts and warnings.

1-d To develop capacity of member countries for providing impact based forecasts and risk based warnings

1-e To extend the operational use of ensemble prediction techniques and probabilistic forecasts for more effective disaster risk assessment and management.

1-f To continue 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-g To ensure the operational use of the recently established 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

4.3.2 Hydrology

4.3.2.1 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.

4.3.2.2 Strategic Actions

2-a To further improve regional cooperation in real time monitoring and exchange of relevant data and information, forecast/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 further improve management of water resources, including assessment of surface and ground water resources in relation to cyclonic disturbances;

4.3.3 Disaster RiskReduction (DRR)

4.3.3.1 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 risk reduction in the region will be improved through establishment of institutional and legal frameworks at country level involving improved multi-hazard early warning and Decision support Systems (DSS) of vulnerability and community based disaster risk management (CBDRM) initiatives aiming at enhanced public awareness, and participation of stakeholders to be more effective. These are expected to be achieved through improvement in standard procedures on DRR and exchange of national and international experiences and information on disaster management among the Members.

4.3.3.2 Strategic Actions

3-a To improve regional cooperation in policies and strategies on DRR, especially those related to tropical cyclones, coastal hazards and other extreme weather events.

3-b To establish a regional information system to support development of policies and strategies on DRR as well as interfacing the national level systems by creating an updatedcomprehensive database on disaster information and best practices on DRR.

3-c To further enhance public awareness and appreciation of the impacts of tropical cyclones and other extreme weather events, for possible mitigation and response actions through effective communication with the media prior to, during, and after suchevents.

3-d To further strengthen 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 DRR information exchange through networking by making available disaster preparedness and mitigation information through Internet web sites, involving web GIS tools and other means.

3-f To enhance disaster risk management, especially those related to cyclone-related disaster preparedness by developing and implementing pilot projects on multi-hazard disaster risk management programmes into the development plan of the Panel Members in the next four years.

4.3.4 Training

4.3.4.1 Expected Result 4

- Development of a strategic approach to capacity building with a regional perspective

Trainingactivities 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.

4.3.4.2 Strategic Actions

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 remote sensing data including satellite and 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 and other multi-hazard risk reduction related programmes.

To set up a small group of its Members to develop a draft training plan. The training plan could identify the training needs and available opportunities as well as the gaps that will need to be addressed to support the successful implementation of the Coordinated Technical Plan.

4-f To develop TC Forecasting Competency as per recommendation of EC-65 & EC-66.

The Panel noted that the Executive Council at its 66th session stressed the need for, and urged the Secretariat to support the, development of TC forecasting competencies in all tropical cyclone basins by regional tropical cyclone committees under the initiativeof RSMCs. Implementation of tropical cyclone competencies is an essential component of improving service delivery as it sets common global recommended practises providing a safety net of "our staff are trained to at least the minimum recommended standards" and providing a leverage for members to obtain funding of "we need to train our staff to at least

the minimum recommended standards" to provide quality services. Development and implementation of a competency framework is part of a quality approach to ensuring service delivery as it requires parallel reviews of policies and forecasting processes and procedures to be successful.

The Panel also noted that Members in RAI, RA IV and RA V and the ESCAP/WMO Typhoon Committee have already undertaken considerable work in the development and implementation of tropical cyclone forecasting competencies at national and regional level. The Panel was informed that RSMC New Delhi had developed a set of tropical cyclone forecasting competencies, and circulated among the Panel Members a draft version of the tropical cyclone forecasting competencies for the Panel. The Panel is invited to discuss further this document and provide recommendations to implement these competencies.

4.3.5 Research

4.3.5.1 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.

4.3.5.2 Strategic Actions

5-a To assess the impact of climate change on tropical cyclones in the region.

5-b To further improve monitoring capabilities to characterize physical and dynamical characteristics of tropical cyclones.

5-b To further improve regional NWP models for tropical cyclone track, Intensity and structure predictions.

5-c To develop and further improve the 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.

5-e To identify research issues and develop research proposals for technical and funding support

4.3.6 Partnership

4.3.6.1 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.

4.3.6.2 Strategic Actions

a To promote exchange of information and data among Members and with regional bodies to enhance regional cooperation in the five components: meteorology, hydrology, DRR, training and research.

b To enhance cooperation with other regional bodies, organizations, service providers and sectors for more effective provision of the forecasts and warnings.

c To develop and implement joint projects in the areas of the above five components and resource mobilization.

4.3.7 Management and Governance

4.3.7.1 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.

4.3.7.2 Strategic Actions

a To further improve the coordination and decision making process of the Panel.

b To enhance effectiveness in implementation of CTP and AOPs.

c To continue to ensure effective and collaborative relationships among working groups of Meteorology, Hydrology and DRR.

d To further improve coordinated technical planning process as well as monitoring and evaluation.

4. 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 Actions of each of the expected results. The AOP will be prepared and adopted at the annual PTC sessions and the detailed actions and performance indicators are subject to revision by PTC during its sessions.

4.5. CONCLUSION

Coordinated Technical Plan (CTP) for the WMO/ESCAP Panel on Tropical Cyclones for the Bay of Bengal and Arabian Sea (2016-2019) 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 Sendai Framework for Disaster Risk Reduction (2015-2030) adopted during the World Conference on Disaster Reduction in 2015 , the WMO Strategic Plan and the Strategic Plan for the Enhancement of National Meteorological and Hydrological Services in Regional Association II (2012-2016).

CHAPTER-V
Annual Operating Plan for 2017-18

Coordinated Technical Plan (CTP) for the WMO/ESCAP Panel on Tropical Cyclones - Annual Operating Plan for 2017-2018		
Expected Result	**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, wave radar and satellite observations in the Member countries.	To strengthen of the cooperative relationship with the Airlines for development of the regional Aeronautical Meteorological Data Relay (AMDAR) programme (WMO).
	1-b To implement and operate adequate Members' connection to the WMO Information System (WIS) for operation-critical data exchange through dedicated telecommunication means.	Members to implement plans to deploy WIS functionality.
	1-c To increase accuracy, timeliness and usefulness of tropical cyclone forecasts and warnings.	1) To establish and enhance the communication between the operational forecasters in RSMC and the Members (RSMC, PTC-S). 2) To develop collaborative links with the Severe Weather Forecasting Demonstration Project and the Coastal Inundation Forecasting Demonstration Project of WMO (Members, RSMC, BMD, PTC-S, WMO) 3) To promote the use of Common Alerting Protocol (CAP) in partnership with WGDRR (WMO, Members). 4) To implement TC Landfall Forecast FDP (RSMC, Members) 5) To prepare an assessment report on the current status and needs of the Members with respect to data, products, analytical and forecasting procedures.(Working Group on

		Meteorology in association with RSMC, New Delhi) 6) To arrange the training on Dvorak's technique, microwave imageries & products and application of Ensemble Prediction System (EPS) for tropical cyclone monitoring and prediction with the support of WMO. 8) WMO/PTC may facilitate training on the utilization of INSAT-3D data and products including RAPID and Nowcasting toolsamong the Member countries. (in conjuction with some other training activity of WMO).
ER-2 (Hydrology) Enhanced capabilities of Members to provide better hydrological forecasts and assessments.	1-d 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. 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.	RSMC New Delhi may inform the Panel Member countries about the changes/upgradation in their telecommunication systems so that necessary measures taken by the members. 1) To develop and implement regional information exchange strategy during 2017-2018. 2) To organize regional workshops on data transmission mechanisms with special reference to water related hazards. 3) To collaborate with Commission for Hydrology (CHy) and RA-II to carry out the activity on action 1 and 2.
	2-b To improve flood forecasts and warnings particularly in deltaic and coastal areas by coupling storm surge forecasts with river flow forecasting.	1) To develop delta hydraulic models for river forecasting by coupling any hydrodynamical 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 associated flood hazard and risk maps in the line as

		mentioned above. 3) To organize workshops for enhancing the capabilities of the countries (in conjuction with WMO training etc.)
	2-c To enhance regional capabilities relating to urban floods/ riverine flood risk reduction in delta and coastal regions through continued interaction with the member countries and user agencies.	1) To undertake flood hazard mapping at least in one major delta/coastal area in each country during the next four years. 2) To organize workshops for capacity building (in conjuction with WMO training activity etc). 3) To collaborate and share experiences with Typhoon Committee (WMO, ESCAP, PTC-S)
ER-3 (DRR) Enhanced capabilities of Members to promote tropical cyclone disaster resilient communities through providing guidance on multi-hazard early warning dissemination and response mechanism.	3-a To improve regional cooperation in policies and strategies on DRR, especially those related to tropical cyclones, coastal hazards and other extreme weather events.	▪ ESCAP, WMO and PTC to organize capacity development training programme for PTC member countries particularly in the areas of impact based forecasting, risk based warning. ▪ ESCAP and WMO to work with PTC membercountries for developing regional component of International Network of Multi Hazard Early Warning System (IN-MHEWS)
	3-b To establish a regional information system to support development of policies and strategies on DRR as well as interfacing the national level systems by creating an updated comprehensive database on disaster information and best practices on DRR.	▪ To strengthen regional cooperation on DRR information exchange through networking by making available disaster preparedness and mitigation information through Internet web sites, involving web GIS tools and other means.The web link may be provided to GMAS. WMO will provide a guideline to the member countries. ▪ ESCAP to support PTC

		member countries for attending regional co-operation related activities including IN-MHEWS, Asian Pacific Centre for Development of Disaster Information Management (APDIM).
	3-c To improve public awareness and appreciation of the impacts of tropical cyclones and other extreme weather events, for possible mitigation and response actions through effective communication with the media prior to, during, and after such events. 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.	ESCAP to support strengthening multi stake holders forum such as monsoon forums, national climate outlook forums in PTC member countries. ESCAP to continue supporting the initiatives such as Common Alerting Protocol (CAP) in PTC member countries.
	3-e To improve disaster risk management, especially those related to cyclone-related disaster preparedness by developing and implementing pilot projects on multi hazard disaster risk management programmes into the development plan of the Panel Members in the next four years.	WMO and ESCAP to support piloting a standard methodology project on impact based forecasting and risk based warning in PTC member countries.
ER-4 (Training) Training plan for capacity building with a regional perspective.	4-a An expert group of members (Bangladesh, India, Maldives & Sri Lanka)as constituted by 43rd WMO/ESCAP PTC session to prepare draft training plan from 2017-2019.	▪ Expert Group (Sri Lanka, Oman and Thailand)to produce a training plan including prioritized list of training needs and opportunities of PTC Members through a survey and advise WMO for reporting, planning and implementation purposes. PTC will write to member countries regarding

		constitution of expert group and requesting for nomination of experts and focal persons. ▪ The plan to be submitted to PTC Secretariat by end of December 2017. PTC will forward the report to WMO with a request to organize training as per the plan.
	4-b To arrange training programmes on the use of NWP model products and their application in Cyclone (track and intensity) and storm surge prediction.	▪ To continue the attachment training programme in RSMC, New Delhi for cyclone forecasters. ▪ PR of India with WMO to arrange training on storm surge forecasting in India for the PTC member countries. ▪ To continue to organize a training programme at INCOIS, Hyderabad in India on utilization of Ocean data and wave forecasting. ▪ ESCAP to continue supporting training programme for information dissemination and media co-ordination in multi-hazard early warning system.
	4-c To arrange training programmes on the use of Satellite and Doppler Weather Radar (DWR)data & products in Cyclone forecasting as well as DWR callibration and maintenance 4-d To arrange training programmes on information dissemination tools and media coordination during disasters and their effectiveness on "human response".	
	4-e To exchange visits of experts among Member countries to share their experiences and expertise on cyclone & related disaster management aspects.	-
	4-f 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 research.	5-a To produce regional assessment of the impact of climate change on tropical cyclones.	To collect data/materials/papers from the Member countries which are relevant to the regional assessment.

	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, DRR, 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 DRR.	-
	7-d To improve coordinated technical planning process as well as monitoring and evaluation.	-

CHAPTER-VI

Activities of PTC Secretariat during the Intersessional Period 2015-2016

The activities of PTC Secretariat during the intersessional period 2015-2016 are given below

1. Pursuant upon the organization of 3rd Joint Session of the WMO/ESCAP Panel on Tropical Cyclones (PTC) and ESCAP/WMO Typhoon Committee (TC) (***WMO/ESCAP/PTC-42 Session*** | ESCAP/WMO/TC-47 Session) in Bangkok, Thailand, from 9 to 13 February 2015. PTC Secretariat collected input/feedback from the Panel Member countries and other participating international organizations under the auspicious of WMO and ESCAP and arranged / compiled the PTC-42 final report.
2. In order to enhance the visibility of the of activities of the WMO/ESCAP Panel on Tropical Cyclones beyond the Panel region and to increase its Membership, PTC Secretariat extended invitation to UAE, Qatar and Yemen for participation in the 3rd Joint Session of PTC/TC (Bangkok, Thailand, 9-13 February, 2015). Yemen showed interest for the membership of PTC. PTC Secretariat, under the guidance of WMO, extend full coordinated with Yemen for its membership to Panel on Tropical Cyclones, and extend invitation for attending PTC-43 as an observer.
3. PTC Secretariat collected contributions from Member countries for PTC Newsletters and published PTC Newsletter "Panel News" (Issue No.39, 40) and distributed the e-version issue among the PTC Member countries, WMO, UN-ESCAP and other international organizations.
4. As per decision of 3rd Joint Session of WMO/ESCAP Panel on Tropical Cyclones (PTC) and ESCAP/WMO Typhoon Committee (TC) (Bangkok, Thailand from 9-13 February, 2015), the Japan Meteorological Agency (JMA) organized Attachment Training for three tropical cyclone forecasters one each from PTC Member countries Bangladesh, Maldives, and Myanmar. The Attachment Training was held at RSMC, Tokyo, Japan from 22 to 31 July, 2015. Financial support in lieu of travel and per diem for the participants was arranged through JMA's VCP Fund maintained by WMO. PTC Secretariat, upon WMO's advice, extended invitation to the concerned PTC Member countries for inviting nominations for the attachment training.
5. With the support of the Panel, Secretary of PTC represented PTC at Seventy-first Session of ESCAP (Phase-II) (Bangkok, Thailand from 25-29 May, 2015). The opportunity was also used to share PTC programmes and activities, and to highlight the cooperation of PTC with the other regional body of WMO/ESCAP Typhoon Committee (TC) in joint SSOP project. At the platform of ESCAP, the Secretary of PTC made the following statement:
    a. *"The WMO/ESCAP Panel on Tropical Cyclones (PTC) is working to strengthen regional cooperation among countries affected by tropical cyclones in the Bay of Bengal and the Arabian Sea. This year, a particular highlight of our work is the Joint Session held in cooperation with the ESCAP/WMO Typhoon Committee (TC) and hosted by ESCAP here in Bangkok in February this year. This was the first time in 18 years that such a joint session was held. In this session, the PTC and the TC agreed on mechanism for future cooperation, including joint projects and human capacity building trainings. We are now*

working to take this positive outcome forward, in cooperation with ESCAP, WMO and Regional Specialized Meteorological Centres."

6. Panel on Tropical Cyclones Secretariat closely collaborated with the Typhoon Committee in the implementation of joint project "Synergized Standard Operating Procedures (SSOP) for Coastal Multi-Hazards Early Warning System (SSOP)" funded by ESCAP Multi-Donor Trust Fund for Tsunami, Disaster and Climate Preparedness in Indian Ocean and South East Asia. The beneficiary countries include Bangladesh, Cambodia, China, India, Lao PDR, Malaysia, Maldives, Myanmar, Pakistan, Philippines, Sri Lanka, Thailand and Viet Nam. Under this project Manual on SSOP has been developed, the same has been circulated to the Panel Member countries.

7. Concerning to the updation of Tropical Cyclone Operational Plan (TCP-21) for 2015 version, PTC Secretariat collected feedback from PTC Member countries to assist Rapporteur of the Operation Plan in the early issuance of TCP-21 2015 version.

8. In connection to the organization of 43rd Session of WMO/ESCAP Panel on Tropical Cyclones (New Delhi, India from 2-6 May, 2016), PTC Secretariat extended invitation to the Panel Member countries for seeking nomination of their representatives. Invitations were also extended to international organizations like Typhoon Committee, IOC-UNESCO, ICAO, CMA, and Tohoku University, UN-ESCAP, IFRC, RIMES towards their participation as an observer at the PTC-43.

9. As per decision of 3rd Joint Session of WMO/ESCAP Panel on Tropical Cyclones (PTC) and ESCAP/WMO Typhoon Committee (TC) (Bangkok, Thailand from 9-13 February, 2015), the Japan Meteorological Agency (JMA) is organizing Attachment Training for three tropical cyclone forecasters one each from PTC Member countries Oman, Pakistan and Sri Lanka). The Attachment Training will be held at RSMC, Tokyo, Japan from 15 to 26 August, 2016. Financial support in lieu of travel and per diem for the participants was arranged through JMA's VCP Fund maintained by WMO. PTC Secretariat, upon advice by WMO, extended invitation to the concerned PTC Member countries for inviting suitable nominations for the attachment training.

APPENDIX-I

STATEMENT OF PTC SECRETARIAT ACCOUNTS (TO BE REPLACED)

(2015- 2016)

Sr. No.	**Opening Balance and Receipts**	**Amount (PKR)**
1.	Balance after 42nd Session of PTC	64,545/-
2.	Amount received during the intersessional period (US$ 4000/- equivalent to PKR 418,000/- @US$ 1 = 104.5 PKR)	418,000/-
	Total	482,545/=
	Expenditures	
1.	Services for compilation work of Panel News (Issues No. **39th and 40th**).	40,000/-
2.	Honorarium to Meteorologist-PTC Secretariat @ US$150/= per month (equivalent to Pak Rupees) (for the period from July 2014 to April 2016).	336600/-
3.	Stationery, and other miscellaneous items	10000
4.	Purchase of Colour Toner for Laser Jet printer	Nil
	Total	386600
	Net Balance in hand	95,945

Appendix-II
Final Statement of Panel's Trust Fund

WMO OMM

World Meteorological Organization
Organisation météorologique mondiale
Organización Meteorológica Mundial
Всемирная метеорологическая организация
المنظمة العالمية للأرصاد الجوية
世界气象组织

Secrétariat
7 bis, avenue de la Paix – Case postale 23
CH-1211 Genève 2 – Suisse
Tél.: +41 (0) 22 730 81 11
Fax: +41 (0) 22 730 81 81
wmo@wmo.int – www.wmo.int

PANEL ON TROPICAL CYCLONE TRUST FUND

Trust Fund 421313

Interim Statement of Income and Expenditure
For the period 1 January to 31 December 2016
Amounts in US dollars

1.	Balance of fund at 1 January 2016			63,915
2.	Income:			
2.1	Contributions:			
2.1.1	Pakistan (16 March 2016)	3,000		
2.1.2	Maldives (26 April 2016)	3,000		
2.1.3	Thailand (10 August 2016)	3,000		
2.1.4	Pakistan (18 November 2016)	3,000		
2.1.5	Sri Lanka (1 December 2016)	3,000		
2.1.6	India (2 December 2016)	3,000		
2.1.7	Oman (8 December 2016)	3,000		
2.1.8	Total contributions		21,000	
2.2	Interest		18	
2.3	Total revenue			21,018
3.	Total available funds during reporting period			84,933
4.	Expenditure:			
4.1	Direct project costs:			
4.1.1	Travel cost for RASHADU ZZAMAN, Training on Operation Tropical Cyclone Forecasting at RSMC New Delhi, New Delhi, India, 14-30 September 2016	2,036		
4.1.2	Travel cost for AKRAM, 43rd Session of WMO/ESCAP/PTC, New Delhi, India, 2-6 May 2016 (Activity no. 80073)	207		
4.1.3	Total direct project costs		2,243	
4.2	Indirect project costs			
4.2.1	Unrealized loss on currency exchange	a/ 2,582		
4.2.2	Support costs (13%)	292		
4.2.3	Bank charges	67		
4.2.4	Total indirect project costs		2,941	
4.3	Total project expenditure			5,184
5.	**Balance of fund at 31 December 2016**			**79,749**

a/ WMO's official currency is the Swiss Franc (CHF). Accordingly, all transactions completed in currencies other than the CHF are converted to Swiss Francs at the United Nations Operational Rate of Exchange (UNORE) in force on the day of the transaction. Project account balances (in CHF) are translated to applicable donor reporting currencies based on UNOREs in force at the end of the month to facilitate reporting to donors. As the Swiss Franc has been appreciating against the US Dollar (the reporting currency for the Panel on Tropical Cyclone Trust Fund), foreign exchange gains resulted from conversion of net asset balances from CHF to USD as of the reporting date. This explains the foreign exchange gain. It should be noted that the gain was not realized as of the reporting date, i.e. they were not actual, as they resulted from (a) revaluing the Fund's assets and liabilities as of that date, and (b) converting the resulting CHF balances to US$.

The financial statement has been prepared on the accrual basis of accounting in accordance with the International Public Sector Accounting Standards (IPSAS).

Certified correct:

Luckson Saeira
Chief, Finance Division
16 January 2017

Appendix -III
Resources and Support

Documents 1

MHEWS SIDS / S E Asia	Canada	10 M CAD	2016- 2019

Document 2

1. Project: Installation of Himwari Cast Receiving and Processing Systems

Geographic region: East Asia, Pacific

Donor	Japan Meteorological Agency (JMA)
Trust Fund Code(s)	420280
Grant	CHF 741,546
Governance	Project Executive(s) Kuniyuki Shida (SPM/RC), Ayşe Altunoğlu (H/PCU)
Focal Point	Ryuji Yamada (PM/RAP)
Duration	January 2015 – March 2016
Received funds	CHF 714,546
Project implementation (%)	90%
Budget implementation (%)	90% *(note: payment to the vendor is imminent – services received and payment will be made in February 2016)*

Summary

Procurement and installation of the new Japanese HimawariCast Receiving and Processing systems in nine (9) countries: Bangladesh, Cambodia, Federated States of Micronesia, Myanmar, Palau, Papua New Guinea, Thailand, Tuvalu and Viet Nam. Additionally, skills development of staff of the relevant NMHSs in the recipient countries to enable them to sustainably operate the installed systems.

Key highlights (covering reporting period)

- The equipment for the project was shipped to all 9 recipient countries;
- The supplier installed the systems in 8 countries (Bangladesh, Cambodia, Federated States of Micronesia, Myanmar, Palau, Thailand, Tuvalu and Viet Nam) during October-December 2015;
- Due to the delay in the customs clearance and tax exemption process in Papua New Guinea (PNG), the installation of the system has not taken place in this country;
- However, a series of discussions with the Meteorological Services in PNG has given assurance that the equipment will be released from customs early 2016.

Actions to be taken

- Given that almost all recipient countries have received the equipment, WMO to prepare 'Transfer of Title' to ensure that the equipment becomes legally the property of the respective recipient country, thus, giving full ownership for the operation of the system;;
- Follow up with the Meteorological Services of PNG to ensure that equipment is released from customs as early as possible;

- Hold discussions with the donor, JMA, regarding their intension of requesting the addition of more recipient countries (country identification; funding is available in the Trust Fund);
- Prepare final narrative and financial report on the project expected to be completed in March 2016;
- Prepare a draft WMO press release on the project and the recipient countries (focusing on the impact based forecasting potential offered by the system).

2. Project: Installation of a Doppler radar system in Sri Lanka

Geographic region: Asia

Donor	Government of Sri Lanka
Trust Fund Code(s)	421109
Grant	USD 2,931,480
Governance	Project Executive Robert Masters (D/DRA)
Focal Point	Kuniyuki Shida (SPM/RC)
Duration	May 2007 - December 2016
Received funds	USD 2,931,480
Project implementation (%)	60%
Budget implementation (%)	52 %

Summary

Procurement and installation of a Doppler weather radar system for the Department of Meteorology of Sri Lanka.

Key highlights (covering reporting period)

- No highlights for this reporting period.

Actions to be taken

- Pending the receipt of the response from the Ministry of Disaster Management and taking into consideration that the new Minister and the Secretary of the Ministry of Disaster Management were appointed in October 2015 after the general election in the country in August and Prof. Taalas assumed the post of SG of WMO on 1 January 2016, a new WMO letter to the Secretary of the Ministry of Disaster Management will be sent in January 2016 to expedite the response from Sri Lanka;
- The Ministry of Disaster Management will send an official letter to WMO confirming that the damaged equipment should be repaired using the remaining funds in the Trust Fund;
- Once agreed by Sri Lanka and WMO, the current PO will be revised to accommodate proposed actions.
- DOM will send the equipment back to the factory of EEC for inspection. EEC will submit the cost proposal to WMO;
- EEC will repair the damaged equipment and send the equipment back to DOM with some replacements;
- The radar system will be installed at the radar site;
- In parallel, the relevant authorities of Sri Lanka including DOM should conduct the construction work to repair the damage road leading to the radar site.

APPENDIX-IV
TERMS OF REFERENCE OF THE PTC WORKING GROUP ON METEOROLOGY (WGM)

In order to coordinate efforts in the implementation of various programmes and activities related to meteorology with the aim to better support the socio-economic development process in the PTC region and to help accomplish the strategic goals and objectives as mentioned under the Meteorological Component of the Coordinated Technical Plan of the WMO/ESCAP Panel on Tropical Cyclones (PTC) for the Bay of Bengal and the Arabian Sea, the PTC has established the Working Group on Meteorology (WGM) as decided during 39th Session of PTC (Myanmar, 5-9 March, 2012) with the following Terms of Reference and operational modalities.

Terms of Reference

The WGM will promote cooperation among the Members in the implementation of various programmes and activities under the Meteorological Component of the PTC's Coordinated Technical Plan with the aim to support the socio-economic development process and enhance cooperation among the Members in all the five major components towards this end. The WGM is expected to advise and assist the PTC in:

- Identifying priority issues and areas of cooperation in the Meteorological Component;
- Promoting and facilitating the exchange of experiences and knowledge on the latest developments and techniques related to the above issues and areas;
- Coordinating and implement priority activities and programmes of the PTC aiming at strengthening capacity of the Members in meteorology;
- Mobilizing resources to carry out priority activities of the PTC related to the Meteorological Component;
- Developing Annual Operating Plan (AOP) for meteorology and reporting on the activities under the AOP;
- Reporting overall progress in the implementation of the Meteorological Component of the PTC's Coordinated Technical Plan;
- Recommending to the PTC's priority areas, programmes and activities for cooperation in meteorological research by related experts of the Members; and
- Performing any other task as assigned by the PTC.

Membership

The WGM consists of the following members:

- Mrs. Sunitha Devi, India as Chairperson
- Mr. Khalid Ahmed Al-Wahaibi, Oman as Vice-Chair
- Mr Ali Shareef, Maldives as Vice-Chair
- Members of other 6 countries

The PTC invites WMO and ESCAP to continue their involvement in the work of WG-M. The PTC also requests the other concerned agencies to participate in the activities of WGM. The term of service on the WGM is 1 year, which shall be automatically extended for similar durations unless modified or terminated by the PTC.

Operation modalities

In view of the limited financial resources of the PTC Trust Fund, the WG-M is expected to perform its work through email and other means. The WGM shall hold meeting during the annual Session of PTC. The WG-M members, however, may also meet during the inter-sessional period, if so necessary.

Reporting requirements

The Chairperson of the WGM is required to report to the PTC on overall progress in the implementation of the Meteorological Component of the Coordinated Technical Plan as well as on the activities with regards to the AOP for meteorology through the PTC Secretariat to the PTC Chairperson and the PTC Members for their consideration under the framework of the PTC. This report may also include recommendations related to priority activities to be undertaken in the coming years.

TERMS OF REFERENCE OF THE PTC WORKING GROUP ON HYDROLOGY (WGH)

In order to coordinate efforts on the implementation of various programmes and activities related to hydrology with the aim to better support the socio-economic development process in the PTC region and to help accomplish the strategic goals and objectives as mentioned under the Hydrological Component of the Coordinated Technical Plan of the WMO/ESCAP Panel on Tropical Cyclones (PTC) for the Bay of Bengal and the Arabian Sea, the PTC has establishedWorking Group on Hydrology (WGH), as decided during 39th Session of PTC (Myanmar, 5-9 March, 2012) with the following Terms of Reference and operational modalities.

Terms of Reference

The WGH will promote cooperation among the Members in the implementation of various programmes and activities under the Hydrological Component of the PTC's Coordinated Technical Plan with the aim to support the socio-economic development process and enhance cooperation among the Member in all the five major components towards this end. The WGH is expected to advise and assist the PTC in:

- Identifying priority issues and areas of cooperation in the Hydrological Component;
- Promote and facilitating the exchange of experiences and knowledge on the latest developments and techniques related to the above issues and areas;
- Coordinating and implement priority activities and programmes of the PTC aiming at strengthening capacity of the Members in hydrology and water resources;
- Mobilizing resources to carry out priority activities of the PTC related to the Hydrological Component;
- Developing Annual Operating Plan (AOP) for hydrology and reporting on the activities under the AOP;
- Reporting overall progress in the implementation of the Hydrological Component of PTC's Coordinated Technical Plan;
- Recommending to the PTC's priority areas, programmes and activities for cooperation in hydrological research by related experts of the Members; and
- Performing any other task as assigned by the PTC

Membership

All Member countries will be represented at the WGH.

Pakistan, Myanmar, Bangladesh will be the Chair and Vice-chairs of the WGH respectively. The PTC invites WMO and ESCAP to continue their involvement in the work of WGH. The PTC also requests to other concerned agencies to participate in the activities of WG-H.

The term of service on the WGH is 1 year, which shall be automatically extended for similar durations unless modified or terminated by the PTC.

Operation Modalities

In view of the limited financial resources of the PTC Trust Fund, the WGH is expected to perform its work through email and other means. The WG members shall meet if necessary.

Reporting Requirements

The Chairperson of the WGH is required to submit annual report on WGH activities with regards to the implementation of Coordinated Technical Plan through PTC Secretariat to the PTC Chairperson and the PTC Members for their consideration under the framework of the PTC. This report will include recommendations related to priority activities to be undertaken in the coming years.

TERMS OF REFERENCE OF THE PTC WORKING GROUP ON DRR (WGDRR)

In order to coordinate efforts on the implementation of various activities under the Disaster Risk Reduction (DRR) Component to better support the socio-economic development process in the Panel on Tropical Cyclones (PTC) Area and to help accomplish the DRR related goals and objectives in the Coordinated Technical Plan (CTP) 2009-2011, PTC established the Working Group on Disaster Prevention and Preparedness, later renamed to the Working Group on Disaster Risk Reduction (WGDRR), with the following Terms of Reference and operational modalities.

Terms of Reference

The WGDRR will promote cooperation among the PTC Members in the implementation of activities under the DRR Component of the PTC's Coordinated Technical Plan to support the socio-economic development process and enhance cooperation among the Members inall the five components towards this end, the WGDRR is expected to advise and assist the PTC:

- Identifying priority issues and areas of cooperation in the DRR Component;
- Promoting and facilitating the exchange of experiences and knowledge on the latest developments and techniques related to the above issues and areas;
- Coordinating and implementing priority activities of the AOP and programmes of the PTC aiming at strengthening capacity of the Members in DRR;
- Mobilizing resources to carry out priority activities of the PTC related to the DRR Component;
- Monitoring and evaluating overall progress in the implementation of the DRR Component of the Coordinated Technical Plan;
- Recommending to the PTC priority areas, programmes and activities for cooperation in DRR research by experts of the Members;
- Promoting measures for more effective cooperation with other components of work of the Panel, including the development of the conceptual framework on multi-hazard early warning systems and public outreach programs; and,

- Reporting overall progress in the implementation of the DRR component of the CTP.

Membership

The WGDRR will consist of the following members:

- Mr. Adthaporn Singhwichai, Thailand; as Chairperson
- Mr. Captain Faisal, Oman; as Vice Chairperson
- Members of other 7 countries

The PTC invites ESCAP and WMO to continue their involvement in the work of WGDRR. The PTC also requests the other concerned agencies to participate in the activities of WGDRR.

The term of service on the WGDRR is 1 year, which shall be automatically extended for similar durations unless modified or terminated by the PTC.

Operation modalities

In view of the limited financial resources of the PTC Trust Fund, the WGDRR is expected to perform its work through email and other means. The WG members shall meet if necessary.

Reporting requirements

The Chairperson of the WGDRR is required to submit an annual report on DRR activities with regards to the implementation of Coordinated Technical Plan through the PTC Secretariat to the PTC Chairperson and the PTC Members for their consideration under the framework of the PTC. This report will include recommendations related to priority activities to be undertaken in the coming years.

APPENDIX-V

TERMS OF REFERENCE FOR THE PANEL ON TROPICAL CYCLONES SECRETARIAT

The Panel on Tropical Cyclones (PTC) Secretariat will coordinate the Panel's programme in close consultation with the WMO and ESCAP Secretariats. The PTC Secretariat will report to the Panel at regular intervals on the progress of the work so far undertaken. Specifically, to the extent that its available resources permit, the PTC Secretariat shall:

(1) Assist the Members as administrative, documentary, and information centre of the Panel on Tropical Cyclones;

(2) Implement the PTC decisions and coordinate and monitor the implementation of the PTC Annual Operating Plan;

(3) Maintain close contact with the Panel Members and other relevant organization by correspondence and coordination to carry out all matters related to implementation of recommended programmes;

(4) Follow up decisions of Panel meetings and related activities such as those concerning other regional tropical cyclone bodies, or the General Component of the WMO Tropical Cyclone Programme (TCP) with assistance from WMO;

(5) Manage the operation and promote the use of the PTC website;

(6) Participate and organize the annual session of the Panel with assistance and guidance from WMO/ ESCAP including documentation;

(7) Process and take necessary action promptly on correspondence from Panel Members, WMO, and other sources;

(8) Enhance visibility of the PTC in cooperation with Panel Members including editing and publishing of PTC news Letter;

ANNEX VI

SUPPORT FOR THE PANEL'S PROGRAMME

International Network for Multi-Hazard Early Warning Systems (NM-HEWS) in Asia and the Pacific
(Submitted by UN-ESCAP)

In the last decade, the Asia-Pacific region had 1,624 reported disasters. From these, approximately 400,000 people lost their lives, and around 1.4 billion were suffered.[23] Disasters continued to undermine hard-won development gains across the region, and impacts of disasters constitute a serious threat to the attainment of the Sustainable Development Goals (SDGs), and thus, in the Asia-Pacific, building resilience to disasters is not a matter of choice.

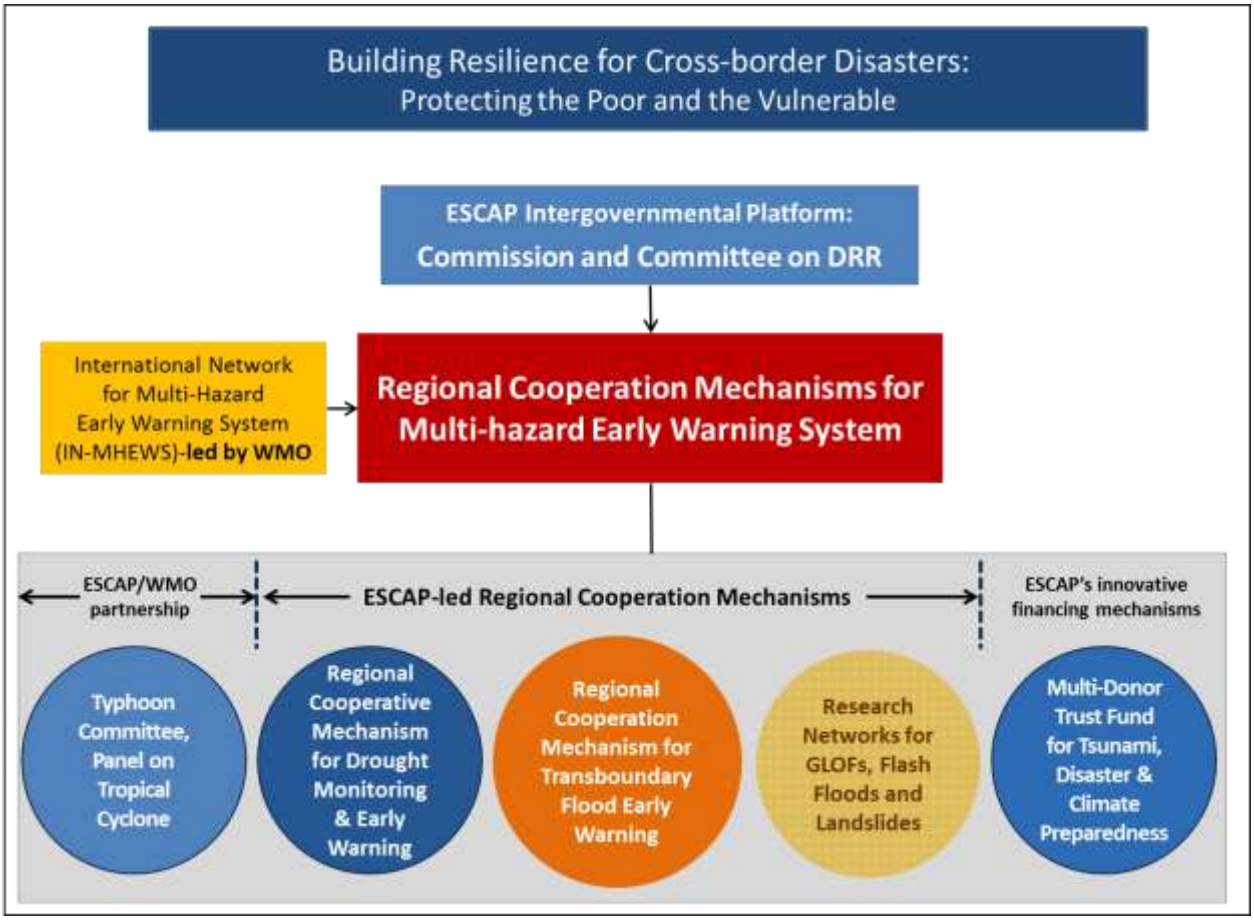
Establishing proper early warning systems is a critical element in protecting our development gains, and the *Sendai Framework for Disaster Risk Reduction 2015-2030*(the Sendai Framework) recognizes the importance of early warning systems (EWS) in reducing the disaster risk. These early warning systems should cover multi-hazards considering the cascading impacts of natural hazards and climate change. Accordingly, the Sendai Framework calls for enhancing and strengthening multi- hazard early warning systems (MHEWS).

In response to this call, the **International Network for Multi- Hazard Early Warning Systems (IN- MHEWS)** is being established as a multi- stakeholder partnership that will facilitate the sharing of expertise and good practices for MHEWS. As a broad-based networking initiative on early warning, IN-MHEWS is not meant to be an operational network of MHEWS. Instead, it will exemplify the importance of multi-stakeholder cooperation in MHEWS as a way to advocate the implementation and/or improvement of multi-hazard early warning systems, to compile and disseminate lessons learned regarding early warning systems, and to increase the efficiency of investments in MHEWS for societal resilience.

Member States of ESCAP also recognized the need to strengthen people-centred multi-hazard early warning systems and requested the ESCAP secretariat to work on multi-hazard early warning systems at the regional level through the Commission resolution 71/12 adopted in May 2015. Accordingly, ESCAP outlined a concept multi-hazard early warning system as the regional component of WMO-led IN-MHEWS, based on ESCAP's experience in regional mechanisms including

- Panel on Tropical Cyclones,
- Typhoon Committee, and
- Regional Drought Mechanisms and Multi-donor Trust Fund on Tsunami, Disaster and Climate Preparedness.

ESCAP's new initiatives on regional cooperation mechanism for flood forecasting and early warning in transboundary river basins, and putting in place a research network(s) for flash floods, GLOFS and landslides highlight its ongoing efforts towards strengthening multi-hazard regional early warning systems in the region (Figure).



ESCAP with partners has also developed the tools for multi-sectoral impact assessment of slow-onset disasters - which were used for 2015/2016 El Nino Impact Outlook in Asia and the Pacific.

Under the agenda item 9.4, the concept will be presented for the discussion with PTC member Countries.

Annexure-VII

COORDINATION WITH OTHER ACTIVITIES IN THE PANEL REGION

Coordination within WMO Tropical Cyclone Programme

1. The Panel was presented by WMO representative about activities under, and those requiring coordination through, TCP. It appreciated the comprehensive presentation, and thanked WMO support to endeavours of the Panel.

2. The Panel was informed by the WMO Secretariat about decisions of the 17th WMO Congress and sessions of Executive Council, which govern the Tropical Cyclone Programme to arrange and take necessary actions particularly for the following:

- to expand and consolidate further the regionally coordinated systems to cover all Members prone to tropical cyclones;
- to enhance the capacities of Members to provide more accurate forecasting and warning services which are impact-based and in multi-hazard approach (which was also a decision of EC-66);
- to improve forecasting and warning capabilities of Members through advances in sciences and technologies, and capacity development; and
- to reduce damage and loss of lives through the above institutionalized activities and arrangements, and in step with the developmental goals of the Sendai Framework, in particular Global Targets 1, 2, and 7 .

3. The Panel was further informed by the WMO Secretariat about decisions made by the 68th session of WMO Executive Council (EC-68). Under the initiative of the Tropical Cyclone Regional Specialized Meteorological Centres (RSMC)/TCWC, and in collaboration with Members with experience in impact-based tropical cyclone forecasting and warning services, new products be developed and corresponding training opportunities be provided to assist Members in accelerating their implementation of impact-based tropical cyclone forecasts and warnings (Decision 10).

4. The Panel was presented by WMO Secretariat on the Decision 3 of the WMO EC-69 (Decision 3 (EC-69)) that urges Members, regional associations, technical commissions and technical programmes to participate in and contribute to the development of WMO GMAS (Global Multi-hazard Alert System).

The panel discussed about the GMAS and recognized its importance to Members, to United Nations agencies, and other sectors of the international communities. Considering that tropical cyclones are the most disastrous weather phenomenon and should become an important part of GMAS, the Panel urged the Members to contribute to the development of GMAS, and requested RSMC New Delhi to take a leading roles in coordination with TCP and RA II.

5. The Panel was informed that the scope of activities of the regional Tropical Cyclone Committees had been expanded through involvement with the WMO's cross-cutting projects such as the Severe Weather Forecasting Demonstration Project (SWFDP), Coastal Inundation Forecasting Demonstration Project (CIFDP) and Disaster Risk Reduction projects for Early Warning Systems in Regions I, II, IV and V. Those Committees' annual/biennial sessions serve as venues for information sharing for the projects and their technical plans have incorporated collaborative actions with those projects. Wider cross-cutting project coverage is further needed to reach all the Member countries of the regional TC committees. In addition, a synergistic relationship with other UN agencies and international/regional entities has also been developed.

Annexure-VIII

Tropical Cyclone Forecasting Competencies

What it it? Why are we doing it? Why is important?

WMO/ESCAP PTC Region(Bangladesh, India, Maldives, Myanmar, Pakistan, Sultanate of Oman, Sri Lanka, Thailand and Yemen) Tropical Cyclone Forecasting Competencies
WMO/ESCAP PTC Tropical Cyclone Forecasting Competencies are a set of proposed competencies aiming to provide a baseline competence standard to effectively address the job performance of the Tropical Cyclone Forecaster (TCF). These competencies, like other WMO competencies being developed, seek a competence framework that identifies the knowledge, skills and attitudes that must be demonstrated. They have been devised to be consistent with the actual work in meteorological services(NMSs) and are is essential for defining: 1. What is required to do the job; 2. The development of the most appropriate training for tropical cyclone forecasters and, 3. To demonstrate that forecasters working with tropical cyclones can do the job. The competencies are designed to use and build upon general weather forecasting and forecast preparation skills, general synoptic analysis techniques, analysis skills and the knowledge and interpretation of Numerical Weather Prediction (NWP) model output.
WMO/ESCAP PTC consists of a wide variety of Ness and these differences guide the eventual competency framework. This led to a proposed framework to deal with variations in activities and services, taking into account the necessary competencies needed and depending on the tasks each service will undertake. The framework suggests that WMO/ESCAP PTC NMSs be broken up into the following three(3) categories: 1) TCFs suited with the necessary skills and equipment to provide guidance for other services to downscale. This was one of the primary roles of RSMC New Delhi. 2) TCFs that downscaled the guidance from the RSMC New Delhi or other sources to tailor forecasts for their areas of responsibility. The role of most of the forecast offices in WMO/ESCAP PTC . 3) TCFs that work from forecasts provided by services that downscaled the guidance. In this case the primary role was the interpretation of the provided forecast for use in an advisory capacity to the emergency services, local media etc. Primarily Public Weather Services (PWS) of the countries.

Format of the Framework

The framework is provided under the following headings:

Category: Determine the type of meteorological service and the job responsibility of TCF within that category.

Unit Descriptor: a competency unit relevant to TCFs working within a particular category, providing the operational tropical cyclone services. Activities include:

- Analyzing synoptic environment and determine TC position, intensity and structure.
- Forecasting TC track, intensity and structure.
- Determining potential weather impacts on at risks areas
- Formulating policy and issue TC products.
- Communicating relevant information

The details of the unit descriptor describe the aspects of competency recommended for an effective TCF. The specific performance criteria and background knowledge and skills for a given category reflect required and roles and responsibilities of the service provided by that tropical cyclone office.

Another important section of the framework is the national variations, which recognizes the national requirements among services in WMO/ESCAP PTC which may require specific attention. These may be the result of general geography or social consequence such as communication language etc.

It is expected that the role of a TCF will change as technology changes and as more is required from users. Therefore, as with other competencies a process of continuous improvement is expected.

1.0 Category 1. TCFs providing guidance for other services to downscale

Unit Descriptor

1.1 This competency unit is relevant to TCFs working in a TC warning office. It covers the provision of operational TC services at an unsupervised level. It includes:

- TC analysis and continuously monitor, analyze the area of responsibility for TCS development
- Forecast and warn of TC development, change in intensity and associated hazards ;
- determining the potential weather and storm tide impacts;
- formulating policy and issuing of products; and
- Communicating/delivering briefings, interviews and presentations.

1.2 Analyze broad scale environment and determine TC position, intensity and structure.

Description

1.2.1 A range of observational information is analysed to interpret the broad scale environment, the position, intensity and structure of the tropical circulation.

Performance criteria

1.2.2 Analyzes the synoptic environment to assess the likely influence on the disturbance in a range of situations.

1.2.3 Determines location of centre and current movement in accordance with standard procedures in a range of situations.

1.2.4 Determines intensity in accordance with standard procedures in a range of situations.

1.2.5 Determines structure in accordance with standard procedures in a range of situations.

1.2.6 Background knowledge and skills

1.2.7 Knowledge of:

- local cyclone policy and operating procedures;
- observation networks;
- capabilities and limitations of different observational data types;
- TC structure dynamics and conceptual models;
- synoptic factors that affect the intensity including shear, ocean temperatures, upper-level flow, stability, landfall, vorticity and low to mid-level moisture;
- strengths and limitations of Dvorak technique, ADT, AMSU intensity estimation, SATCON and other intensity analysis guidance;
- Strength and limitations of Radar products for location and intensity estimation

1.2.8 Skills in:

- using data viewing software and other applications in the forecast process;
- interpreting observations, weather radar and satellite derived information such as scatterometry and cloud drift winds;
- interpreting satellite imagery including water vapour, visible, infra-red, and microwave for TC analysis;
- using Dvorak technique for cyclone centre location and intensity estimation;
- using Radar products for cyclone centre location and intensity estimation
- estimating the intensity from a number of inputs;
- interpreting wind shear from shear analyses and prognoses;
- assessing the environment for motion, intensity and structural changes;
- interpreting deterministic and probabilistic NWP guidance material;
- interpreting multi model ensemble and grand global ensemble techniques

1.3 Forecast TC track, intensity and structure.

Description

1.3.1 A range of information including numerical weather prediction NWP and objective aids in

addition to an understanding of conceptual synoptic forecast approaches are used to forecast the track, intensity and structure in warning products that are issued in accordance with documented procedures.

Performance criteria

1.3.2 Interprets NWP-predicted broad scale environment to assess the likely influence on the disturbance in a range of situations.
1.3.3 Determines forecast track in accordance with standard procedures in a range of situations.
1.3.4 Determines forecast intensity in accordance with standard procedures in a range of situations.
1.3.5 Determines forecast structure in accordance with procedures and timelines in a range of situations.

Background knowledge and skills

1.3.7 Knowledge of:

- local cyclone policy and forecast process;
- relative strengths and limitations of NWP in predicting cyclone movement, structure and intensity;
- synoptic factors that affect TC motion and intensity;
- consensus track forecasting techniques;
- Intensity forecasting methods including conceptual models of decay;
- Interpretation of Satellite, Radar and coastal observations for TC track and intensity forecasting

1.3.8 Skills in:

- evaluating model predictions against observed conditions to (i) assess the most likely forecast environment for motion and intensity changes and (ii) to find out models w.r.t. better initial conditions
- interpretation of Satellite & Radar observations for TC track, intensity and structure forecasting;
- interpreting NWP guidance material including ensemble output to determine forecast uncertainty;
- using software systems (Tropical Cyclone Module) to determine forecast parameters;

1.4 Determine potential weather impacts on at risks areas

Description

1.4.1 The impacts of high winds, rainfall, waves and storm surge are determined for key locations/areas according to appropriate thresholds and including estimates of uncertainty.

Performance criteria

1.4.2 Forecast extent of cyclonic winds (e.g. squall, gales, storm force) and onset times for key locations/areas using available guidance in a range of situations.
1.4.3 Forecast rainfall using available guidance in a range of situations and liaise with Hydrology to determine potential flooding.
1.4.4 Forecast waves and swell using standard techniques.
1.4.5 Forecast storm tide potential considering various track and intensity scenarios and confidence levels (worst case, most likely, alternate track/intensity).
1.4.6. Forecast coastal inundation (height and area) considering various track, intensity scenarioes and confidence level

Background knowledge and skills

1.4.6 Knowledge of:

- local cyclone policy and operating procedures;
- potential impacts in a range of synoptic situations;
- wave and storm surge theory;
- local climatology of cyclogenesis, track, intensity and landfall;
- Storm tide and coastal inundation theory and warning techniques;
- The level of threat posed by storm surge heights and coastal inundation.

1.4.7 Skills in:

- using software to determine range of impacts;
- interpreting NWP guidance material;
- assessing rainfall potential including eTRaP, consensus model guidance and probabilistic rainfall guidance;
- determining onset, extent and associated uncertainties of weather phenomena (heavy rain, gail/squally wind, storm surge and coastal inundation) forecasting;

1.5 Formulate policy and issue TC products.

Description

1.5.1 Local forecast production systems are used to produce and disseminate a range of products according to local operating procedures.

Performance criteria

1.5.2 Liaise effectively with internal staff in the development of tropical cyclone policy and the impact on other services.

1.5.3 Formulates TC policy in accordance with procedures in a range of situations.

1.5.4 Determines the appropriate key messages for general and technical audiences in a range of situations.

1.5.5 Issues the range of TC products in accordance with procedures and timelines in a range of situations.

Background knowledge and skills

1.5.6 Knowledge of:

- local cyclone policy and operating procedures;
- user needs and significant impact thresholds;
- product styles and standards;

1.5.7 Skills in:

- using appropriate software (TC module) to produce warning products;
- communicating with colleagues to arrive at policy decisions;
- internal time management to produce the range of products on time;
- compiling policy, products and key messages for different audiences;
- converting technical concepts into concise and easy to understand language;

1.6 Communicate relevant TC information to internal and external stakeholders.

Description

1.6.1 TCFs are required to communicate information to internal and external users appropriate to their needs.

Performance criteria

1.6.2 Logically structured briefings and presentations to contain relevant, accurate and complete information.

1.6.3 Delivers briefings, presentations and interviews to suit the intended audience explaining technical information in concise, clear and easy to understand language.

Background knowledge and skills

1.6.4 Knowledge of:

- principles of effective communication, including presentation and interviews;
- presentation and meeting formats and requirements;
- Legislation, regulations, policies, procedures and guidelines relating to workplace communication in the public sector such as privacy, confidentiality, freedom of information.

1.6.5 Skills in:

- compiling policy, products and key messages for different audiences;
- converting technical concepts into concise and easy to understand language;
- facilitating and engaging in communication exchanges;
- Using equipment for structured briefing presentations and interviews to suit the intended audience explaining technical information in concise, clear and easy to understand language.

2.0 Category 2. TCFs who downscaled the guidance from the RSMC or other sources to tailor forecasts for their areas of responsibility

Unit Descriptor

2.1 This competency unit is relevant to TCFs working either under the supervision of a senior forecaster or in a forecasting office that receives guidance from an RSMC. It includes:

- Accessing and interpretation of TC products and services;
- Understanding the forecast process and technical components of the forecast inputs (Radar and satellite interpretation (including Dvorak technique etc.), Scat Sat, Ascat, NWP models etc but is not expected to perform the technical analysis themselves;
- Using technical forecast to determine potential impacts;
- Producing local forecast products based on technical forecast from RSMC;
- Conducting briefings to local user groups -media & emergency services and provide TC information in response to enquiries
- Providing support to senior TC forecaster or feedback to RSMC as appropriate.

2.2 Access and interpret TC products and services.

Description

2.2.1 Guidance products from RSMC and other agencies are appropriately accessed and interpreted. Technical information including satellite, Radar and other observational information are interpreted in the context of the guidance products.

Performance criteria

2.2.2 Ability to access the range of appropriate information including forecasts from RSMC and other agencies.

2.2.3 Ability to interpret technical forecast guidance in order to assess impact potential upon forecast region of responsibility.

2.2.4. Ability to interpret observational products and satellite and radar information appropriately.

Background knowledge and skills

2.2.5 Knowledge of:

- local cyclone policy and operating procedures;
- observation networks for the area of responsibility;
- capabilities and limitations of different observational data types;
- TC structure dynamics and conceptual models;
- synoptic factors that affect the intensity including shear, ocean temperatures, upper-level flow, stability, landfall, vorticity, low to mid-level moisture; divergence and convergence etc.
- strengths and limitations of Dvorak technique, ADT, AMSU intensity estimation, SATCON and other intensity analysis guidance;

2.2.6 Skills in:

- Interpreting official forecast products from official agencies;
- using data viewing software and other applications in the forecast process;
- interpreting observations, weather radar, satellite and satellite- derived information at a general level;
- assessing the environment for impact on the TC at a general level;
- interpreting NWP guidance material;

2.3 Determine potential weather impacts on/at risks areas

Description

2.3.1 The impacts of high winds, rainfall, waves and storm surge/ coastal inundation are determined for key locations/areas according to appropriate thresholds and including estimates of uncertainty.

Performance criteria

2.3.2 Forecast extent of cyclonic winds (e.g. squalls, gales, storm force) and onset times for key locations/areas using available guidance in a range of situations.

2.3.3 Forecast rainfall using available guidance in a range of situations and liaise with Hydrology to determine potential flooding.

2.3.4 Forecast waves and swell and storm tide/coastal inundation potential using standard techniques and guidance material.

Background knowledge and skills

2.3.5 Knowledge of:

- local cyclone policy and operating procedures;
- potential impacts in a range of synoptic situations;
- wave and storm surge theory and warning techniques;
- The level of threat posed by storm surge heights.
- Rainfall theory and warning techniques
- Downscaling the RSMC forecast products (rainfall, wind, storm surge etc.) at key locations/areas

2.3.6 Skills in:

- using software to determine range of impacts;
- interpreting RSMC/ NWP guidance material;
- determining onset, extent and associated uncertainties of weather phenomena (like rainfall, wind etc.);
- storm surge forecasting;
- Flood forecasting.

2.4 Formulate policy and issue forecast products

Description

2.4.1 Local forecast production systems are used to produce and disseminate a range of products according to local operating procedures.

Performance criteria

2.4.2 Liaise effectively with internal staff in the development of tropical cyclone policy and the impact on other services.

2.4.3 Formulates policy in accordance with procedures in a range of situations.

2.4.4 Determines the appropriate key messages for general and technical audiences in a range of situations.

2.4.5 Issues the range of TC products in accordance with procedures and timelines in a range of situations.

Background knowledge and skills

2.4.6 Knowledge of:

- local cyclone policy and operating procedures;
- user needs and significant impact thresholds;
- product styles and standards;

2.4.7 Skills in:

- communicating with colleagues to arrive at policy decisions;
- using appropriate software to produce notification products;

- internal time management to produce the range of products on time;
- compiling policy, products and key messages for different audiences;
- converting technical concepts into concise and easy to understand language;

2.5 Communicate relevant TC information to internal and external stakeholders.

Description

2.5.1 TCFs are required to communicate information to internal and external users appropriate to their needs including responding to enquiries.

Performance criteria

2.5.2 Logically structured briefings and presentations to contain relevant, accurate and complete information.

2.5.3 Delivers briefings, presentations and interviews to suit the intended audience explaining technical information in concise, clear and easy to understand language.

2.5.4 Responds to requests for information appropriately.

Background knowledge and Skills

2.5.5 Knowledge of:

- principles of effective communication, including presentation and interviews;
- presentation and meeting formats and requirements;
- Legislation, regulations, policies, procedures and guidelines relating to workplace communication in the public sector such as privacy, confidentiality, freedom of information.

2.5.6 Skills in:

- compiling key messages for different audiences;
- converting technical concepts into concise and easy to understand language;
- facilitating and engaging in communication exchanges;
- Using audio/visual equipment for presentations.

3.0 Category 3. TCFs who worked from forecasts provided by RSMC/National Storm Warning Services. In this case the primary role is coordination with emergency services, local media etc (*Forecast offices in WMO/ESCAP Panel countries that has trained forecaster(s)*)

Unit Descriptor

3.1 This competency unit is relevant to TCFs working in a non-forecasting office that receives information and guidance from a forecast office. It includes:

- Accesses and interprets TC products and services;
- Understands forecast process and technical components of the forecast inputs (Radar, satellite interpretation including Dvorak technique etc), Scat Sat, Ascat, etc but is not expected to perform the technical analysis themselves;
- Uses technical forecast to determine potential local impacts;
- Conducts briefings to local user groups -media & emergency services and provide TC information in response to enquiries
- Provide support and or feedback to Forecast Office as appropriate.

3.2 Access and interpret TC products and services.

Description

3.2.1 Guidance products from forecast office and other agencies are appropriately accessed and interpreted. Technical information including Radar, satellite and other observational information are interpreted in the context of the guidance products.

Performance criteria

3.2.2 Access the range of appropriate information including forecasts from RSMC and other agencies.

3.2.3 Interpret technical forecast guidance to assess potential local impact.

3.2.4 interpret observational and satellite information appropriately.

Background knowledge and skills

3.2.5 Knowledge of:

- local cyclone policy and operating procedures;
- observation networks for the area of responsibility;
- capabilities and limitations of different observational data types;
- TC structure dynamics and conceptual models;
- synoptic factors that affect the intensity including shear, convergence, divergence, ocean temperatures, upper-level flow, stability, landfall, vorticity and low to mid-level moisture etc.;
- strengths and limitations of Dvorak technique, ADT, AMSU intensity estimation, SATCON and other intensity analysis guidance;

3.2.6 Skills in:

- Interpreting official forecast products from official agencies;
- using data viewing software and other applications in the forecast process;
- interpreting observations, weather radar, satellite and satellite- derived information at a general level;
- assessing the local environment for impact on the TC at a general level;

3.3 Determine potential weather impacts.

Description

3.3.1 The impacts of high winds, rainfall, waves and storm surge are interpreted for key locations according to appropriate thresholds and including estimates of uncertainty.

Performance criteria

3.3.2 To interpret the extent of cyclonic winds (e.g. squall, gales, storm force) and onset times for key locations/areas using available guidance in a range of situations.

3.3.3 To use available information to determine potential flooding and give guidance on the impact of rainfall in a range of situations.
3.3.4 To use available information to give guidance on the impact of forecast waves, swell and storm tide and coastal inundation potential.

Background knowledge and skills
3.3.5 Knowledge of:
- local cyclone policy and operating procedures;
- potential impacts in a range of synoptic situations;
- wave and storm surge theory and warning techniques;
- The level of threat posed by storm surge heights and coastal inundation.
- Rainfall theory and warning techniques;
- Downscaling the RSMC forecast products (rainfall, wind, storm surge) at location/area level

3.3.6 Skills in:
- using software to determine range of impacts;
- interpreting forecast office and RSMC/ NWP guidance material;
- determining onset, extent and associated uncertainties of weather phenomena like rainfall, wind etc.;
- Downscaling the RSMC forecast products (rainfall, wind, storm surge) at location/area level

3.4 Communicate relevant TC information to internal and external stakeholders.

Description
3.4.1 TCFs are required to communicate information to internal and external users appropriate to their needs including responding to enquiries.

Performance criteria
3.4.2 Logically structured briefings and presentations to contain relevant, accurate and complete information.
3.4.3 Delivers briefings, presentations and interviews to suit the intended audience explaining technical information in concise, clear and easy to understand language.
3.4. 4 Responds to requests for information appropriately.

Background knowledge and skills
3.4.5 Knowledge of:
- principles of effective communication, including presentation and interviews;
- presentation and meeting formats and requirements;
- Legislation, regulations, policies, procedures and guidelines relating to workplace communication in the public sector such as privacy, confidentiality, freedom of information.

3.4.6 Skills in:
- compiling key messages for different audiences;
- converting technical concepts into concise and easy to understand language;
- Facilitating and engaging in communication exchanges; using equipment for presentations/briefings.

REGIONAL/NATIONAL VARIATIONS

Regional/national variations referred to within the document may include but are not limited to the following:,

- Agreed and documented criteria and thresholds
- The range of weather phenomena
- Appreciation of the types and use of forecast guidance
- Designated offices responsible for advice on tropical cyclones
- Regional regulations
- Boundaries of forecast and warning areas
- Communication language(s)
- Communications technology for forecast and warning transmission, and for weather briefing
- Forecast database(s) utilized – gridded/text/graphical/digital, etc.