WORLD METEOROLOGICAL ORGANIZATION

AND

UNITED NATIONS ECONOMIC AND SOCIAL COMMISSION

FOR ASIA AND THE PACIFIC

WMO/ESCAP PANEL ON TROPICAL CYCLONES

FORTY-THIRD SESSION

New Delhi, India

(2 - 6 May 2016)

Final Report

GENERAL SUMMARY OF THE WORK OF THE SESSION

1. ORGANIZATION OF THE SESSION

The forty-third session of WMO/ESCAP Panel on Tropical Cyclones (PTC) was hosted by India Meteorological Department in New Delhi, India, from 2 to 6 May 2016. The session was attended by 60 participants from the six Members of the PTC, namely Bangladesh, India, Maldives, Oman, Sri Lanka and Thailand. It was also attended by the representatives of World Meteorological Organization (WMO), United Nation Economic and Social Commission for Asia and the Pacific (UN-ESCAP), and observers from ICAO, RIMES, member from the WMO/WWRP WGTMR. The list of the participants is given in **ANNEX 1.I**.

1.1 Opening of the PTC 43rd Session

The opening ceremony of 43rd Session of WMO/ESCAP Panel on Tropical Cyclones (PTC) was held during 1000 to 1130 hours IST of 2nd May, 2016 at New Delhi.

The ceremony started with welcome address by Dr. M. Mohapatra, Head Regional Specialised Meteorological Centre, New Delhi. At the outset, Dr. Mohapatra welcomed Dr. M. Rajeevan, Secretary, Ministry of Earth Sciences (MoES), Government of India; Dr. L. S. Rathore, Director General of Meteorology, India Meteorological Department (DGM, IMD); Dr. S.D. Attri, Deputy Director General of Meteorology (Organisation); Dr. Shamika Sirimanne, Director, Information and Communications Technology and Disaster Risk Reduction Division, UN-ESCAP; Dr. Xu Tang, Director, Weather and Disaster Risk Reduction Service Department, WMO; Mr. Ali Shareef, Chairman, PTC; Dr. Anne-Claire Fontan, WMO/TCP; representatives from UN-ESCAP & ICAO, delegates from WMO/ESCAP Panel member countries. Dr Mohapatra outlined the objective and expected outcome of the Session. He highlighted that the Session aimed to improve tropical cyclone monitoring, prediction and warning system as well as multi-hazard early warning systems over the North Indian Ocean including Bay of Bengal and Arabian Sea region for effective disaster management. The session also aimed at exploring sources of technical and financial support and sharing knowledge and experience among member countries.

Dr. L. S. Rathore, DGM, IMD presided over the function. In his address, Dr. Rathore highlighted the historical perspectives leading to the development of WMO/ESCAP Panel on Tropical Cyclones. He also discussed about the role of RSMC, New Delhi. He mentioned the success achieved in tropical cyclone forecasting during these years resulting in significant decrease in track and landfall forecast errors at par with other international centres and increase in forecast lead period up to 5 days with outlook up to 3 days. The delegates were told that during 2011-15, the track forecast errors have been 98 & 146 km for 24 & 48 hours lead period against 141 & 247 km respectively during 2006-10. The landfall forecast error has been 56 & 93 km against 99 & 100 km for 24 & 48 hours lead period respectively. He informed that IMD received National Award for accurate forecast of tropical cyclone Phailin. The United Nations appreciated the performance of RSMC New Delhi in its audit report for the year 2015.

Dr. Tang, WMO representative in his opening remarks highlighted the activities of WMO in the region. He placed on record the appreciation of WMO for RSMC, New Delhi for providing accurate tropical cyclone advisories with sufficient lead time to member countries. He stressed upon the need to reduce risk from disasters for sustainable development. He highlighted the decision and requirement of Congress 17 regarding contribution of tropical cyclone global and regional coordination and services to WMO DRR priority in its Strategic Plan 2016-2019. He assured that WMO through its Tropical Cyclone Programme will continue to make every effort in supporting the work of the Panel. Dr. Tang encouraged the panel members to participate in the International Conference on Multi Hazard Early Warning System (IC-MHEWS) in early 2017 with the assistance from WMO and ESCAP.

Dr. Shamika Sirimanne representative UN-ESCAP in her address stressed upon the need of urban flood risk management, implementation of measures to minimize gaps between meteorology, hydrology & DRR, and to develop capacity for impact based forecasting. She highlighted the need to make use of Synergised Standard Operating Procedure (SSOP) and its regular updation for effective early warning system. In order to promote collaboration between PTC and the ESCAP/WMO Typhoon Committee members, she proposed a joint side-event at the 7th Asian Ministerial Conference on Disaster Risk Reduction (AMCDRR) which will be held in New Delhi in this November. The delegates were told that ESCAP will continue extending support towards capacity building in the region. The house was informed that ESCAP is organising a joint training on multi-hazard warning systems in collaboration with INCOIS, Hyderabad and RSMC, New Delhi and that ESCAP will lead regional implementation of the International Network for Multi-Hazard Early Warning Systems (IN-MHEWS) led by WMO.

Mr. Shareef, Chairman PTC, drew attention towards the track errors in the Arabian Sea region vis-a-vis the Bay of Bengal, post landfall flooding in inland areas of different countries, role of climate change in tropical cyclone activity over the region. He encouraged the Session to explore the scope of co-operative institutional and community involvement in early warning, sustainability and development of regional early warning system.

Dr. M. Rajeevan, Secretary, Ministry of Earth Sciences, Government of India, inaugurated the 43rd Session of WMO/ESCAP Panel on Tropical Cyclones.
During his speech, he appreciated RSMC, New Delhi for significant improvements in tropical cyclone monitoring and forecasting. He informed that MoES is preparing a Strategy document with a Vision for next 10 years (2025) and urged upon the delegates to send suitable recommendations which can be incorporated in this document. Stressing upon the enhancement of observational network, he informed that in addition to the existing INSAT-3D, INSAT-3D (R) and Scat. Sat will be launched by India during 2016 and INSAT-3D (S) in 2017. These satellites would augment the observational data for monitoring of tropical cyclones over the region. He also informed about enhanced Doppler Weather Radar network along the border of India, which would also help Panel member countries in weather monitoring and that the Ocean based data and products from INCOIS, Hyderabad will continue to be available to the countries in this region. IMD and INCOIS are working together to implement coupled HWRF model with resolution of 3 km and GFS model will be run with higher resolution of 25 km. To increase the lead time of forecast of cyclogenesis, the Ministry is working to operationalise the extended range forecast through IMD and IITM, Pune. He stressed upon introducing the probablistic forecast of location specific heavy rainfall, winds and storm surge. In view of the global warming issues and its impact on tropical cyclones, Dr. Rajeevan suggested to consider the impact of climate change while planning for the early warning system. With reference to the challenges in the prediction of tropical cyclones intensity, he urged upon the delegates to utilise the Ocean Thermal Energy in the prediction scheme, which has got the potential to provide better intensity forecast. Further, Ocean data assimilation especially the salinity data should be taken up by modeling group to improve the cyclogenesis and intensity forecast.
At the end, he thanked upon the organisers for giving him an opportunity to inaugurate this Session.

Dr. S. D. Attri, Deputy Director General of Meteorology (Organisation) extended the Vote of Thanks.

1.1.1 Inauguration of the pilot phase of Severe Weather Forecast Demonstration Project over the Bay of Bengal (SWFDP-BoB) and Release of Cyclone Related Publications.

Dr. M. Rajeevan, Secretary, Ministry of Earth Sciences, Government of India, inaugurated the pilot phase of Severe Weather Forecast Demonstration Project over the Bay of Bengal (SWFDP-BoB). Severe Weather Forecast Demonstration Project (SWFDP) is an ambitious project taken up with the joint initiative of India Meteorological Department (IMD) and World Meteorological Organisation (WMO). The objective of the project is to monitor, predict and warn the public and the Disaster Managers against the Severe Weather namely heavy rain, strong wind, storm surge and high waves. RSMC New Delhi will be the regional centre to provide daily Regional Severe Weather Guidance to the member countries including Bangladesh, India, Bhutan, Nepal, Pakistan, Afghanistan, Sri Lanka and Maldives. It is a 3-tier cascading process involving various NWP centres at global levels, RSMC New Delhi, at regional levels and the National Meteorological centres of the member countries. The project also stresses upon the Public Weather Services and liaison with Disaster Managers, Media and others for effective management of severe weather over the region.

On this occasion, he officially released following books:

- Tropical Cyclone Activity over the North Indian Ocean
- Report on Cyclonic Disturbances over the North Indian Ocean during 2015

1.2 Election of the Chairman and Vice-chairman

Dr. L. S. Rathore of India Meteorological Department, India was elected as Chairperson and Mr. Ali Shareef of Maldives Meteorological Service, Maldives was elected as Vice-Chairperson of the Panel, to hold their posts until the next session. Mr Siri Ranjith Jayasekera of Department of Meteorology, Sri Lanka was elected as Chairperson of the drafting committee of 43rd Session.

1.2.1. Yemen as a Member of the Panel

WMO informed the Panel that Yemen has requested to be a Member of the Panel. After the deliberations, it was unanimously decided to include Yemen in the Panel. Thus Yemen is the 9th country of the Panel.

1.3 Adoption of the agenda

The Panel adopted the agenda as given in **ANNEX 1.II.**

1.4 Working arrangements

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

2. FOLLOW-UP ACTION ON PTC-42

2.1 The Panel reviewed the recommendations of the forty-second session and the follow up actions as given in a table available in **ANNEX 2.I.**
Regarding support to Maldives for telecommunication (para 5.1.3), IMD shall provide all possible assistance required by Maldives or any other centre under the area of responsibility connected on GTS through mutual co-ordination. IMD has the expertise and can suggest communication system suitable for centres within the area, if required. For the purpose, a feasibility study on the existing set up and future requirementis to be carried out at site. IMD can also impart training on meteorological telecommunication to officers from these countries as per their needs and mutually agreed schedule.

2.2 The representative of WMO informed the Panel that updated version of Global Guide to Tropical Cyclone Forecasting is available since February, 2015.

https://www.wmo.int/cycloneguide/

2.3 The statistics relating to SYNOP and TEMP of individuals member countries should be mentioned in the Panel report.

2.4 The Panel members also urged to include the statistics of performance of Ocean observations, if available and the same be presented in the annual Panel Session.

3. REPORT OF THE CHAIRPERSON OF THE PANEL

Brief report at the session on the activities carried out since the forty-second session of the Panel in February 2015 and on other relevant matters was presented by chairperson of PTC. The report drew attention to the concerns to the Panel and suggested particular activities to which special attention could be given in the future.

4 REVIEW OF THE 2015 CYCLONE SEASON

4.1 Report of RSMC – Tropical Cyclones New Delhi

4.1.1 General Review

During the year 2015, 12 cyclonic disturbances developed over north Indian Ocean including two Extremely Severe Cyclonic Storm (ESCS) and one Cyclonic Storm (CS) and two deep deression over Arabian Sea where as one cyclonic storm, one deep deression and one depression over Bay of Bengal.Four land depression (D) also formed during 2015. Considering season-wise distribution, out of 12 disturbances, eight during monsoon and three during post-monsoon season. Salient features of cyclonic disturbances during 2015 are given below.

i. There were one cyclone over the Bay of Bengal and three over the Arabian Sea against the long period average of 5 per year over the entire north Indian Ocean including about four over Bay of Bengal and one over Arabian Sea. Thus the cyclonic activity was subdued in the Bay of Bengal during the year 2015. However, the frequency of very severe cyclonic storms was near normal (two)
ii. Though there were four cyclones, none of those crossed Indian coast. CS Ashobaa dissipated over Sea, CS Komen crossed Bangladesh coast and Chapala & Megh crossed Yemen coast
iii. Velocity Flux, Accumulated cyclone energy and Power Distribution Index of the period 2015 are 56.25, 33.92 and 26.34 against long period average based on the data of 1990-2013 and 21.17, 13.09 and 9.67 respectively.
iv. The total duration of cyclonic disturbances during 2015 was 44.5 days against the long period average of 29.4 days based on data of 1990-2013.

Brief descriptions of the disturbances with intensity cyclonic storm and above are given in the following sections.

4.1.2 Descriptions of the disturbances

(a) Cyclonic Storm, 'ASHOBAA' over the Arabian Sea (07-12 June 2015)

The Cyclonic Storm 'ASHOBAA' (07-12 June 2015) developed over eastcentral Arabian Sea from monsoon onset vortex in the morning of 5th June 2015. It gradually moved northwards and became a low pressure area over southeast and adjoining eastcentral Arabian Sea in the morning of 6th June. It concentrated into a Depression (D) in the morning of the 7th June over eastcentral Arabian Sea. Moving nearly north-northwestwards and it intensified into a Deep Depression (DD) in the early hours of 8th

June over eastcentral Arabian Sea. It further intensified into the Cyclonic Storm (CS) 'ASHOBAA' in the morning of of 8th June. It gradually intensified till the night of 10th June. Thereafter, while moving west-southwestwards from forenoon of 10th June to morning of 11th June, it encountered high vertical wind shear and low ocean thermal energy and started weakening. It slowly moved westwards over a colder oceanic region and weakened into a deep depression in the night of 11th June. Due to adverse environmental conditions, interaction with land surface and dry air intrusion from western side, it further weakened into a depression in the morning of 12th June and into a well marked low pressure area over northwest Arabian Sea and adjoining Oman coast in the evening of 12th June.

The salient features of this system are as follows.

i. CS 'ASHOBAA' developed over eastcentral Arabian Sea during the onset phase of monsoon.
ii. It had a unique track, as it moved initially northwards, then north-northwestwards and finally west-southwestwards towards Oman coast.
iii. It dissipated over northwest Arabian Sea off Oman coast before landfall.
iv. The numerical weather prediction (NWP) and dynamical statistical models provided reasonable guidance with respect to its genesis, track and intensity, though there was large divergence in model guidance with respect to track, intensity and landfall.

(b) Cyclonic Storm (CS) Komen over the Bay of Bengal (26 July-02 August 2015)

The cyclonic storm (CS), KOMEN over the Bay of Bengal (BoB) developed from a low pressure area which lay over northeast BoB and adjoining Bangladesh & Gangetic West Bengal on 25th July evening and concentrated into a depression over the same area in the morning of 26th July. It followed a semi-circular track over northeast Bay of Bengal and then crossed Bangladesh coast between Hatia and Sandwip near lat. 22.5^0N and long. 91.4^0E during 1400 and 1500 UTC of 30th July. After landfall, it moved initially north-northwestwards, then westwards and west-southwestwards across Bangladesh, Gangetic West Bengal and Jharkhand. It weakened gradually into a well marked low pressure area over Jharkhand and adjoining north Odisha and north Chhattisgarh at 1200 UTC of 02nd August.

The salient features of this cyclone are as follows.

i. It was the fourth system during the monsoon month of July which intensified into a CS during the satellite era (1965-2015). Of the three systems before CS Komen, the CS in July 1972 & 1973 and the CS in July 1989 crossed Odisha and Andhra Pradesh coast respectively.
ii. The CS Komen had a unique track, as it developed near Bangladesh coast, followed a semi-circular track over the northeast Bay of Bengal and finally moved northward to cross Bangladesh coast.

(c) Extremely Severe Cyclonic Storm (ESCS) Chapala over the Arabian Sea (28 October - 04 November 2015)

An Extremely Severe Cyclonic Storm (ESCS) 'Chapala' formed from a low pressure area over southeast Arabian Sea (AS) which concentrated into a depression in the morning of 28th October. It moved north-northwestwards and intensified into a deep depression in the same evening. It further intensified into a cyclonic storm in the early hours of 29th over eastcentral Arabian Sea. It then moved west-northwestwards, further intensified into a severe cyclonic storm(SCS) in the evening and a very severe cyclonic(VSCS)storm in the midnight of 29th and into an extremely severe cyclonic storm in the morning of 30th. It then moved mainly westwards, maintained its intensity till 1st November and then started weakening gradually. Moving west-northwestwards, it crossed Yemen coast to the southwest of Riyan (14.1^0N/48.65^0E) during 0100-0200 UTC of 3rd November as very severe cyclonic storm. It further westwards and weakened into a severe cyclonic storm in the morning, into a cyclonic storm by noon and into deep depression around midnight of

3rd November, it then weakened into a depression in the early morning of 4th and lay as well marked low pressure area over Yemen at 0300 UTC of 4th November. The salient features of this cyclone are as follows.

i. ESCS Chapala is the first severe cyclone to cross Yemen coast after the severe cyclonic storm of May 1960.
ii. The ESCS Chapala had a life period of 7 days , which is above normal (average life period of VSCS/ESCS is 6 days in NIO and 4.7 days in Post monsoon season for VSCS/ESCS)
iii. It had the maximum intensity of 115 kts (215 kmph) and crossed Yemen coast with a speed of 65 knots (120 kmph).
iv. The system had the longest track length after VSCS Phet in 2010. It travelled a distance of about 2248 km during its life period.
v. The Accumulated Cyclone Energy (ACE) was about 18.29 X 10^4 $knot^2$ (the mean for the period (1990-2013) in the post monsoon season over Arabian Sea is 0.8 X 10^4 $knot^2$), which is same as VSCS, Phet over Arabian Sea in 2010.
vi. The Power Dissipation Index was 17.92 X 10^6 $knot^3$ which is also same as that of VSCS Phet in 2010 (the mean for the period (1990-2013) in the post monsoon season is 0.4 X 10^6 $knot^3$.
vii. The system rapidly intensified from 29th morning to 30th afternoon, when the speed increased from 35 kts at 0000 UTC of 29th Oct to 90 kts at 0900 UTC of 30th Oct.
viii. Though the system moved over to colder Gulf of Aden, experienced dry air intrusion and interacted with the land surface, it did not weaken rapidly due to low vertical wind shear around the centre and in the forward sector of the system.
ix. There was large divergence and hence higher than normal errors in NWP models for prediction of its track and intensity especially, the landfall over Yemen.
x. RSMC New Delhi predicted genesis on 25th October, 3 days in advance and its intensification to ESCS one day in advance on 29th October 2015. The forecast of landfall over Yemen and adjoining Oman coast was issued on the day of genesis i.e., 28th Oct., 6 days advance and landfall over Yemen was issued on 31 Oct. with a lead period of 5 days. Every 3 hourly Tropical Cyclone Advisory were issued to WMO/ESCAP panel countries including Oman and Yemen & Somalia.

(d) Extremely Severe Cyclonic Storm, 'Megh' over the Arabian Sea (05-10 November 2015)

A depression formed over the eastcentral Arabian Sea (AS) at 0000 UTC of 5th November from a low level circulation over Lakshadweep and neighborhood. It moved westwards/west-southwestwards and intensified into a cyclonic storm (CS) at 1200 UTC of 5th November. It continued its west-southwestward movement and intensified into a severe cyclonic storm (SCS) at 0600 UTC of 7th, into a very severe cyclonic storm (VSCS) at 1500 UTC of 7th and rapidly intensified into an extremely severe cyclonic storm (ESCS) at 0300 UTC of 8th. Maintaining its peak intensity for a short period of about 6 hrs, it weakened gradually into a VSCS at 0000 UTC of 9th. From 0600 UTC of 9th, it exhibited west-northwestward movement, weakened rapidly into an SCS at 2100 UTC of 9th, into a CS at 0300 UTC of 10th and deep depression (DD) at 0600 UTC of 10th. It recurved northeastwards from 0300 UTC of 10th and crossed Yemen coast near latitude 13.4°N and longitude 46.1°E around 0900 UTC 10th as a DD. Continuing its northeastwards movement, it weakened into a depression at 1500 UTC of 10th and into a well marked low pressure area over Yemen and neighborhood at 1800 UTC of 10th.

The salient features of the system are as follows.

i. ESCS Megh occurred just after a week of formation of ESCS, Chapala over Arabian Sea. Also, ESCS Megh has been the first back to back cyclone after Chapala that reached Gulf of Aden and crossed Yemen within a week.
ii. ESCS Megh was the second ESCS after Chapala crossing Yemen coast in the satellite era. Chapala crossed Yemen coast close to the southwest of Riyan near 14.1^0N/48.65^0E during 0100-0200 UTC as a VSCS (with maximum sustained wind

speed (MSW) of 65 knots) and Megh crossed Yemen coast near 13.4°N/46.1°E around 0900 UTC as a DD (with MSW of 30 knots).

iii. Unlike Chapala, ESCS Megh was a small core system with a pin hole eye.

iv. Megh maintained the intensity of ESCS for 18 hours (08/03-08/21) unlike Chapala which maintained the intensity of ESCS for 78 hours (30/03-02/09). The peak intensity in Megh was 95 knots for a period of 3 hours (08/06-08/09) against 115 knots for a period of 15 hours (30/09-31/00) in case of Chapala.

v. Lowest estimated central pressure (ECP) was 964 hPa with a pressure drop of 44 hPa unlike Chapala where it was 940 hPa with a pressure drop of 66 hPa.

vi. Like Chapala, ESCS Megh also experienced rapid intensification on 0000 UTC of 7^{th} when its MSW increased from 45 knots to 85 knots at 0000 UTC of 8^{th} (rise in wind speed 40 knots in 24 hours). During same period the ECP fell from 994 hPa to 974 hPa (20 hPa fall in 24 hours).

vii. ESCS Megh experienced rapid weakening over Gulf of Aden from 1800 UTC of 9^{th} (MSW 65 knots) to 0600 UTC of 10^{th} (MSW 35 knots), i.e. Megh experienced a fall in MSW by 30 knots in 12 hours.

viii. The ESCS Megh moved west to west-southwestwards throughout its life period till landfall over Yemen. While, ESCS Chapala moved initially north-northwestwards and then west-southwestwards to Yemen.

ix. Both ESCS Chapala and Megh could intensify upto the stage of ESCS under favourable environmental conditions, mainly low vertical wind shear (5-10 knots) around the system centre and the forward sector of the storm.

x. The system had the longest track length after VSCS Phet in 2010, as it travelled a distance of about 2307 km during its life period.

xi. The Accumulated Cyclone Energy (ACE) was about 8.2 X 10^4 $knot^2$ which is also the maximum after VSCS Phet in 2010 and ESCS Chapala in 2015 over the Arabian Sea.

xii. The Power Dissipation Index was 6.07 X 10^6 $knot^3$ which is the maximum after VSCS Phet in 2010 and ESCS Chapala in 2015 over the Arabian Sea.

xiii. The ESCS Megh had a life period of 5.7 days against long period average of 4.7 days in post-monsoon season for VSCS/ESCS over Arabian Sea)

xiv. The westward movement of the cyclone away from the Indian coasts was predicted from the first bulletin itself i.e. on 5^{th} November 2015 (0300 UTC). Every three hourly Tropical Cyclone Advisories were issued to WMO/ESCAP member countries, Yemen and Somalia.

xv. The NWP and dynamical statistical models provided reasonable guidance with respect to its genesis and track. However, most of the NWP and dynamical statistical models except HWRF could not predict the landfall and rapid intensification/ weakening of ESCS Megh.

4.1.2 The summary report on the 2015 cyclone season provided by the RSMC including the tracks of the cyclonic disturbances formed over the north Indian Ocean during the period is given in **ANNEX 4.1.I**

4.1.3 The Panel expressed its gratitude to the RSMC New Delhi for its continued valuable support to the PTC Member countries and hoped that existing cooperation and collaboration between the Members and the RSMC New Delhi will be further strengthened through these activities.

4.2 Reports of Members on the impact of tropical cyclones

4.2.1 The representative of India informed the panel that during the year 2015, 12 cyclonic disturbances developed over north Indian Ocean and over land including two Extremely Severe Cyclonic Storm (ESCS) and one Cyclonic Storm (CS) and two deep depression over Arabian Sea where as one cyclonic storm, one deep depression and one depression over Bay of Bengal. No cyclone crossed Indian coast.

CS Komen caused isolated heavy to very heavy rainfall over Odisha, Gangetic West Bengal, Jharkhand, Nagaland, Manipur, Mizoram, Tripura, Assam, Meghalaya, Arunachal Pradesh, East Madhya Pradesh and Chhattisgarh.

The deep depression (8-10 November) over Bay of Bengal caused heavy to extremely heavy rainfall over North Tamil Nadu and adjoining Rayalaseema. As the system caused extremely heavy rainfall, it caused extensive inland flooding over coastal districts of north coastal Tamil Nadu.

4.2.2 The representative of Maldives informed the panel that due to prevailing strong winds sustaining in central atolls, seas became rough and two passenger boats ran aground on reef during late January 2015. Tidal surges which are uncommon in February but happened in 'Maduvvari' on 3 February and some house were inundated. Another significant event occurred was the tornado that hit 'Vaadhoo' on 25 February. Following tornado strike, few trees were uprooted and caused some damages to the fishing vessels anchored in the lagoon. On 16 July online newspaper reported damages worth at MVR 2 million to a school in 'Naifaru' due to strong winds and bad weather caused by a trough of low pressure. Heavy downpour measuring 120mm in Kadhdhoo followed by heavy thundershowers to the capital island on 11 August caused widespread damage due to thunder. There were tidal floods incidents in Male' and some other islands. Gushed water caused damaged to many vehicles in a parking lot. Apart from tidal waves gusty winds of 35 – 45 mph sustained 2 hours in southern-most atolls reaching a maximum of 63 mph over Gan/ Addu which brought a catastrophe. A very intense cloud cluster moved over south of Maldives causing very heavy showers to southern most atolls on 24 November. A heavy downpour that resulted out from this cloud burst measured highest ever on the daily records of Maldives. Gan Met Office recorded 228 mm within a 24hour period. Three hours of torrential rain and more than 12 hours of incessant rainfall mad whole city flooded with extensive damage to public property estimated at over three million Maldivian Rufiyaa.

4.2.3 The representative of Oman informed the panel that in the pre monsoon season, Tropical Storm 'ASHOBAA' developed over Arabian Sea on the 5th June 2015, its center was about 1400 km away from the Oman coast. On 9th June the tropical storm moved closer to Oman — approximately 500 km off the coast. Oman's forecasting Center issued a series of reports and advisories to alert the public about the system. On 12th of June, the storm 'ASHOBAA' weakened into a well-marked low pressure area near southeastern coasts of Oman. Moderate to heavy rains were reported from the tropical storm 'ASHOBAA'.

In the post monsoon season they were two tropical cyclones formed over Arabian Sea Chapala and Megh. Tropical Cyclone Chapala formed from a low pressure area over southeast Arabian Sea which intensified into a tropical cyclone on 29th October. On the 3rd of November Chapala crossed Yemen coasts. Heavy thundershowers with strong winds were reported with floods at many Yemeni weather stations. Oman's Met issued a series of bulletins and alerts about 'Chapala' some of them sent to Yemen Met Office. After a week of formation of tropical cyclone 'Chapala' another tropical system 'depression' formed over the east central of Arabian Sea on 5th November. On the 7th of November it intensified into tropical cyclone 'Megh'. By 9th November Megh started weakening rapidly into deep depression and recurved northeastwards on the 10th November and crossed the Yemeni coast as a Deep depression.

4.2.4 The representative of Pakistan informed that the country was not directly affected by any tropical cyclones during 2015. However, one cyclonic disturbance originated in the Arabian Sea; tropical cyclone 'Ashobaa' that formed in the Arabian Sea season during 2nd week of June. Under the peripheral effect of this cyclone some isolated rain/thundershowers occurred along Sindh-Mekran coast and adjoing areas as well as in some areas of southern Punjab and triggered weak westerly for moderate to heavy falls in Upper Punjab and Upper Khyber Pakhtunkhwa. Pakistan Meteorological Department (PMD) issued 14 weather advisories to the local authorities and relevant disaster management organizations for taking necessary precautionary measures.

4.2.5 The representative of Sri Lanka informed the Panel that there was no Tropical cyclone near Sri Lanka during 2015.Normally Cyclones cross Sri Lanka rarely but every year cyclone in both Indian and Pacific ocean alter the wind field over the country. The systems in the both ocean during South west monsoon season strengthen the winds and country experience rain and windy conditions. The swell generated by the cyclones in the south Indian ocean affects the coasts of Sri Lanka.

- During 2015 there were three tropical cyclones in the Arabian Sea and one TC named "MEGH" formed near Sri lanka and affected the weather. A low level circulation formed over Sri Lanka and neighborhood around 26th October. It stagnated over Sri Lankan region causing widespread showers until end of the month and moved Arabian sea on 30th October and moved westwards/west-southwestwards and gradually intensified into a cyclonic storm named "MEGH" on 5th November.it intensified into VSCS and finally it crossed Yemen coast weakening to a depression on the 10th
- Further one depressions and one deep depression formed in the Bay of Bengal to south east of Sri Lanka also resulted wide spread rain during 5-8th and 12-15th November 2015.

4.2.6 The representative of Thailand informed the panel that in 2015, Thailand was much warmer and drier, annual rainfall averaged over the country of 1,419.6 mm, was 168.1 mm (11%) below the 1981-2010 normal. During early rainy season due to a combination of the absence of the monsoon trough influences and El Nino episode, unusual dry and warm conditions occurred in Thailand. The annual mean temperature of 27.9 °C, 0.8 °C above normal, was the second warmest year in Thailand on 65 years record same as 2010 (the warmest year is 1998). The mean temperature was above normal for all months especially December and November which was 2.1 and 1.9 °C above normal, respectively. The maximum temperature reached the new highest record in several areas. Besides, there was only one tropical cyclone namely "VAMCO (1519)" that moved into northeastern Thailand at Ubon Ratchathani province on September 15.
Rainfall was increased when the tropical cyclone "KUJIRA (1508)" located in the upper Vietnam during late June with the low pressure cell in the Gulf of Tokin and Vietnam in July. Moreover, abundant rainfall and flash floods in some areas of central, eastern and southern Thailand affected by tropical storm "VAMCO (1519)" which moved to Thailand as tropical depression at Khong Chiam, Ubon Ratchathani province in the morning of September 15 before moving further to Myanmar and the Gulf of Bengal on September 18. Monthly rainfall in July and September was 5% and 4% above normal respectively. The highest daily rainfall of 2015 was 300.3 mm at Rattanawapi in Nong Khai province on July 28.

4.3 Meteorological Component

ACTIVITIES OF WMO

(a) WMO Information System (WIS)

The global component of the WMO Information System (WIS) is now operational. The focus of WIS implementation has now moved to the national level and is being guided by Regional Associations. Information on WIS implementation in RA II is available online at http://wis.wmo.int/page=RA2-WIS. This page has a link to the RA II WIS implementation plan (http://wis.wmo.int/file=653) adopted by the Fifteenth Session of Region Association II in December 2012, as well as a list of National WIS focal points. The team has good expert participation under the leadership of Ms Li Xiang from China and Mr Kenji Tsunodo from Japan.
Implementation of WIS should lead to significant benefits to Tropical Cyclone warning services in the Bay of Bengal and the Arabian Sea. Global Information System Centres (GISCs) supporting countries in the area include Beijing, Jeddah, New Delhi, Tehran and

Tokyo. It is expected that these GISCs will work together coordinated by GISC New Delhi as the principal GISC for New Delhi Tropical Cyclone RSMC.

The WMO Global Telecommunications System (GTS) is a core component of WIS and comprises a dedicated network of surface-based and satellite-based telecommunication links and centres operated by countries, interconnecting all NMHSs for the round-the-clock rapid and reliable collection and distribution of all meteorological and related data and forecasts between NMHS. It is noted that some countries such as Myanmar do not have a registered GTS link.

Support to NMHS on how to implement and benefit from WIS is available through the Manual on WIS (WMO No. 1060) (http://wis.wmo.int/WIS-manual) and the Guide to WIS (WMO No. 1061) (http://wis.wmo.int/WIS-guide) which now include the information on WIS competencies to better assist all Members to begin to implement the new WIS functionality.

Members are reminded that the Common Alerting Protocol (CAP, ITU Recommendation X.1303) is a content standard designed for all-hazards and all-media public alerting. CAP is used in the disaster response community for delivering information about a large variety of events, and it is suitable for the dissemination of weather, climate and water related alerts and warnings. New applications and systems based on CAP are now available that could be of benefit to TC warning services. For an example, see the Home Alarm at http://wis.wmo.int/doc=3613. CAP is supported in the virtual all hazards network within the WIS-GTS and Members are encouraged to work with their users to be able to benefit from implementation of CAP. Furthermore, Members are encouraged to note the role of the Alerting Authorities Register and its associated benefits in ensuring online search engines and other systems place priority on information from authoritative sources.
See http://alerting.worldweather.org.

(b) Indian Ocean Data Coverage (IODC) - CGMS Roadmap

Proposed CGMS IODC scenario and timeline

EUMETSAT is proposing to CGMS a scenario and a timeline for IODC services after 2016 with associated actions.

Proposed scenario

Satellite	Location	Image	Products	DCS
Meteosat-8	40°E	Yes	Yes	Yes (International)
INSAT 3D	74°E	Yes	Yes	Yes (regional)
Elektro-L N2	77.8°E	Yes	Yes	Yes (regional)
FY2-E	86.5°E	Yes	Yes	Yes (regional)

Dissemination of CGMS Satellite data and products via EUMETCast and the GTS.

Proposed timeline

2015

- EUMETSAT to disseminate INSAT-3D images and products via EUMETCast
- CMA to relocate FY2-E to 86.5°E and commence an operational service
- EUMETSAT to disseminate FY2-E images and products from 86.5°E via EUMETCast

These steps are completed.

2016

- EUMETSAT relocate Meteosat-8 to 40°E
- EUMETSAT commence a Meteosat-8 operational service including images and products via EUMETCast
- Roshydromet commence an Elektro-L N2 operational service
- EUMETSAT to disseminate Elektro-L N2 images and products via EUMETCast

The comprehensive document is available in **ANNEX 4.3.I** or at the following weblink https://www.wmo.int/pages/prog/www/tcp/PTC-43_DocPlan.html

(c) Observing Systems

Regional Basic Synoptic Network (RSNB)

As per the results of the AGM exercise carried out in October 2015, the availability of expected SYNOP and TEMP reports on the Main Telecommunication Network (MTN) from a total of 298 surface and 54 upper-air stations in the RBSN operated by Members of the WMO/ESCAP Panel on Tropical Cyclones are provided in the table below.
Investigations into dissemination of especially upper-air data indicate that some countries continue to perform observations at non standard times of observations1 resulting in the possible non inclusion of availability in the Annual Global Monitoring (AGM) results. The four main standard times of observations for surface synoptic stations are 00, 06, 12 and 18 UTC and for upper-air synoptic stations carrying out radiosonde and radiowind observations it is 00 and 12 UTC.

Availability of SYNOP and TEMP reports from RBSN stations (source: AGM-IWM-SMM)
Annual Global Monitoring: 1-15 October 2014/2015

Country	Number of stations / Reports received (%)							
	Surface (SYNOP)				Upper-Air (TEMP)			
	(10/2014)		(10/2015)		(10/2014)		(10/2015)	
Bangladesh	12	85%	12	92%	3	36%	3	40%
India	81	94%	81	100%	34	23%	34	47%
Maldives	5	100%	5	100%	1	0%	1	43%
Myanmar	27	45%	27	50%	5	6%	5	0%
Oman	23	82%	23	97%	2	42%	2	72%
Pakistan	54	100%	54	100%	3	33%	3	57%

Sri Lanka	9	97%	9	94%	1	0%	1	0%
Thailand	87	100%	87	100%	5	26%	5	20%
Total	**298**	91%	**298**	95%	**54**	23%	**54**	40%

Marine and Ocean Meteorological Observations
Aircraft-based Observations
Surface-based remotely-sensed Observations

The comprehensive document is available in **ANNEX 4.3.II** or at the following weblink https://www.wmo.int/pages/prog/www/tcp/PTC-43_DocPlan.html

RECOMMENDATIONS

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

4.3.1 Panel requested WMO to intervene to reduce the cost of radisonde for least developed countries and also for developed countries to improve upper air observations.

4.3.2 Panel urged that a table containing number of ship observations taken by the member countries may also be included.

4.3.3 Panel requests WMO to intervene in institutionalization the sharing of TCP and TC data.

4.3.4 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.

4.3.5 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.

4.3.6 Aircraft based observations of WMO observation system should be transmitted to WMO GTS to provide high quality vertical profile.

4.3.7 RADAR data as metadata should go into the WMO observational system as more than 80 countries have already participated.

ACTIVITIES OF THE MEMBERS

4.3.8 Detailed activities of the Members are given in **ANNEX 4.3.III**

4.3.9 The representative of Bangladesh informed that the Government of Bangladesh is considering "The Bangladesh Weather and Climate Services Regional project" to support modernization of the Bangladesh Meteorological Department's weather, water and climate information infrastructure, strengthening both the supply of meteorological data, information and services and delivery to sectors and communities.
Modernization of surface, ocean and upper air monitoring networks and ICT systems includes (1) upgrade 35 existing synoptic stations and 200 AgMet automatic weather stations;
(2) strengthen urban resilience through the addition of 65 new automatic rain gauges (ARGs) in urban cities;

(3) install Coastal-Marine Automated Network (C-MAN) comprised of 40 new coastal marine stations to detect meteorological state parameters, wave height, wave period, and storm surge;
(4) installation of 3 buoy stations for measuring ocean temperature, current, wave dynamics, and other parameters;
(5) Strengthen BMD ICT and Data Center with computer servers and software to help store and process data, GTS upgrade to WIS and expansion of GTS/WIS bandwidth, installation of dedicated and reliable high speed internet communications.

4.3.10 Bangladesh to explore the possibility of RADAR data exchange on real time mode through RTH by possibly creating a VPN Link. India will make a proposal for the same.

4.3.11 The meteorological component of the country report of India was presented by Ms. Sunitha Devi, of India Meteorological Department. She summarised the present status and future plans of the observational network including surface (conventional & automatic weather stations, meteorological Buoys, Tide gauges), upper air, RADAR and satellite observations, the telecommunication network for data reception & dissemination, Numerical models which are currently being run, cyclone warning services, training / capacity building related activities and research publications. Various new initiatives of the Ministry of Earth Sciences, Government of India, in the field of meteorological service provision were also discussed. It was informed that 675 Automatic Weather Stations (AWSs) and around 1350 Automatic Rain Gauges (ARGs) have been installed. This is in addition 709 manned observatories. There are 20 High Wind Speed Recorders (HWSRs) out of which 9 are planned to upgrade by integrating pressure sensor. In the upper air network, there are 62 pilot balloon observatories, 39 GPS based RS/RW stations.

- Apart from the Meteorological Buoys and observations from the VOF, the observations from the Indian seas have been augmented by the real time reception of data via GTS, from 39 ships, which are equipped with Automatic Weather Stations as informed by the INCOIS representative during the discussions.
- The INSAT-3D data, apart from being assimilated in various NWP models, are also made available to the weather forecasters, via a web based application christened Real time Analysis of Products & Information Dissemination (RAPID) which has been made operational from January, 2015. A demonstration of this tool was made by Dr. Virendra Singh, of IMD and was appreciated by all the Members. It is also planned to automate Dvorak technique (ADT) and objective tracking of thunderstorms.
- All RS/RW stations are upgraded to GPS based systems. 6 Nos. of GPS based systems (make M/s GRAW Germany) installed/ commissioned (one at each RMC) to upgrade them as per WMO GCOS Network (GUAN) standard. Action being taken for induction of these stations into GUAN network.
- Under the weather RADAR network, IMD has got 21 Doppler weather RADARs at various places. The existing DWR have been networked to assimilate data in NWP models. Composite images are generated centrally.
- IMD utilizes various global & regional models including GFS & WRF to provide forecast upto 7 & 3 days respectively with resolution of 23 & 27X9X3 km. It has also models for specific purposes namely HWRF, MME, EPS, ARP & statistical model like GPP, SCIP for cyclone purpose. APRS, WDSS-II for nowcast. Now it is planned to upgrade GFS to GFS T1534/L64. Efforts are on the anvil to operationalise the extended & seasonal prediction at sub-divisional scale based on CFS-V2 model under Monsoon Mission Programme.

- For information dissemination, WMO information system (WIS) has been implemented with installation of global information system centre (GISC) and mirror RTH at Pune. Mirror GISC is under process. Development of centralised GIS based content managed website of IMD is under process.

- New in-house developed/ re-designed website (user friendly/ easy to navigate): Launched by Hon'ble Minister on 141st IMD foundation day (2016). New links: Established GTS link with Bhutan over internet and 2 links (with Exeter and Offenbach) through RMDCN cloud for data exchange over GTS. Integration of several new data sets like Satellite radiance data, Himawari satellite(JMA), Argo BUFR (INCOIS), METOP etc. for GTS exchange.

4.3.12 Extended range forecast of tropical cyclones for Oct-Dec to be shared among member countries

4.3.13 Maldives can access the WRF products from Thiruvananthapuram site which has a link in IMD website. Member countries can use RAPID system as an alternative to DMDD which is an interactive system. A RAPID user guide to be uploaded on website.

4.3.14 The representative of Maldives informed the panel that 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.
Total of 23 Automatic Weather Stations (AWS) has been installed and only 7 are in operation. Maintenance of these have become costly.
Maldives own only one DWR while 2 or 3 are required to cover entire area.

4.3.15 Myanmar urges the member countries to share their expertise with financial support and give training on telecommunication, satellite and RADAR.

4.3.16 The representative of Oman informed the panel that there are:

- **Synoptic Land Stations:** There are a total of 64 meteorological stations.
- **Doppler Weather Radars**: Four Dual Polarization S-Band Doppler Weather Radar.
- **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 .
- **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). DGMAN run an operational version of COSMO model (Consortium for Small-scale Modeling). COSMO is a non-Hydrostatic limited-area numerical weather prediction. WAM based wave model was established with the kind cooperation of GKSS of Germany, which covers the Arabian Sea, gulf of Oman and Arabian Gulf. WAM model run of 14km resolution and nested into 3.5km resolution and it runs on 8 processors on the PC cluster.
    - Hurricane Weather Research Forecast (HWRF) 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.
    - 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.

4.3.16 The representative of Pakistan through his country report informed the Panel that;

- 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.
- PMD in collaboration with RIMES organized 3rd Monsoon Forum Workshop in Islamabad on 9th June, 2015 in which stakeholders from differnet domains like DRM, climate change, academia, NGOs, electronic and print media participated. The main objective of the workshop was to get feedback from user institutions on the relevance/usability of PMD forecast products and recommendations for further improvement in generation, communication and application of these products as well as to present seasonal forecast for Pakistan for summer monsoon season 2015.
- PMD has recently upgraded its meteorological facilitates in the Gilgit-Baltistan (GB) region and has established a full fledge Regional Meteorological Centre (RMC) in the GB region for the provision of weather and climate information at the door-step of the community living in these areas as well as to service Army Aviation. For strengthening meteorological observation network two (02) Met. Observing stations were also established in District Layyah and Kot Addu (District Muzaffargarh) in the Punjab province.
- A Memorandum of Understanding signed between National Center for Maritime Policy Research (NCMPR), Bahria University, Karachi, and Pakistan Meteorological Department (PMD) on 3rd August, 2015 for research on Meteorological and Climatic Factors in Relation to Maritime Domain and Coastal Areas of the Country. Under this MoUNCMPR and PMD will work together to conduct research in maritime and coastal domains to enhance scholarly cooperation.
- PMD in collaboration with the Centre for Language Engineering (CLE) of University of Engineering & Technology (UET), Lahore launched Pakistan-wide telephone based Weather Information Service on 13th August, 2015. Weather information of 139 districts of Pakistan is being provided by dialling the UAN number 051-111-638-638 and 10 telephone lines have been dedicated to the system at present.
- Memorandum of Understanding was signed between PMD and Qatar Meteorology Department (QMD) on 28th October, 2015 in Doha, Qatar for enhancing cooperation and coordination in the field of marine meteorological service and to support Global Maritime Distress and Safety System (GMDSS) in the Gulf Sea. The cooperation includes multiple aspects; capacity building in the field of marine meteorology, numerical weather prediction and modelling as well as to support activites related to cliamte variability and climate change research and hazardous marine related weather events with mutual exchange of scientific and technical expertise in the field. Representatives from PMD, QMD and WMO attended the MoU signing ceremony.
- PMD in connection to the implementation of Quality Management System (QMS) (ISO 9001: 2008 certification) at its Meteorological Offices located in the country, got renewed ISO certification for 17 Met. Offices in November, 2015 for another 3-years period.
- An MoU was signed between PMD and K-Electric Limited on 22nd March, 2016 for mutual collaboration on disaster prevention due to extreme climate events. This MoU is signed in context of last year's killer heatwave in Karachi that took more than 1000 precious lives. This agreement will bring PMD and K- Electric into closer collaboration to mitigate the impacts of any anomalous weather conditions in the country, particularly in Karachi city.
- In commemoration of establishment of World Meteorological Organization on 23rd March, 1950, PMD made special arrangements to celebrate the World Meteorological (WM) Day on 23rd March, 2016 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 besides sensitizing them about the looming threat of climate change, its implications, weather and climate related disasters. A brochure containing the key messages from the Secretary-General WMO, Secretary (Aviation), Government of Pakistan, and PR of Pakistan with WMO; highlighting climate projections for the 21st century developed by PMD as well as mitigation and adaptation strategies in context of climate change was also distributed among all stakeholders of PMD. At the eve of WM Day, an exhibition was also arranged at IMG, Karachi in which various meteorological and seismological instruments, meteorological charts and met. products were displayed.

- PMD has been running has been running ICOsahedralNonhydrostatic model (ICON) model since March 2015. ICON is a targeting a unified modeling system for global numerical weather prediction (NWP) and climate modeling. The model is installed on a high performance computing cluster system of 184 cores. ICON is driven by initial conditions from the 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. Weather Research and Forecasting (WRF) modeling system also has been deployed on High Performance Cluster Computing System for operational weather forecast up to 72 Hours at a finer resolution (7km). The model is currently being used for diagnostic studies by researchers. A GTS link via ftp has also been established between China Meteorological Administration (CMA), and PMD Islamabad. NWP products of CMA's Global Spectral Model (GSM) in Grib1 format are being uploaded to our ftp server daily at 00:00, 06:00, 12:00, and 18:00 GMT. GSM has a horizontal resolution of TL639 (0.28125 deg) and is used for Short- and Medium-range forecast.

4.3.17 The representative of Sri Lanka informed the Panel that strong El-Niño conditions affected the weather over the island and below normal rainfalls were received in the mid of the year and above normal rainfalls were received at the end of the year 2015.

- **Synoptic Observations:** Data reception from 22 operational stations with the two stations commenced in 2009 namely, Polonnaruwa and Moneragala (No WMO number assigned yet) was very good.

- **Automatic Weather System Network:** The automatic weather system network in Sri Lanka consisting of a total of 38 stations has two types of stations. 22 stations are equipped with sensors to measure Wind speed and direction, Temperature, Humidity, Rainfall, Pressure and Radiation while the balance 16 stations are equipped to measure Wind speed and direction, Temperature, Rainfall and Radiation. All these stations are connected to the headquarters through a satellite based communication system (VSAT manufactured by Gilat, Israel) and observations are transmitted at 10 minute intervals. The automatic weather stations are manufactured by Meisei, Japan.

- **Agro-meteorological Network:** Agro-Meteorological Network consist of stations and are based mostly at agricultural agencies. At these stations in addition to standard meteorological parameters, agriculturally important parameters such as soil temperature and evaporation are observed twice a day by observers trained by the department. Technical assistance for maintaining this network is provided by the department.

- **Raingauge Network:** The total number of stations measuring 24-hour accumulated rainfall in Sri Lanka using manual rain gauges is approximately 512. These stations are manned by voluntary observers (trained by the department. Information from most of these stations are collected on daily basis through

landline telephones while the balance stations submit the information by post at the end of each month.

- **Automated Raingauge Network:** A network of 20 automated rain gauges have been installed in areas prone to exceptionally heavy rain events, particularly in the central highlands of Sri Lanka. Observations performed automatically at these stations are received every 30 minutes at the NMEWC.

- **Upper Air Network:** Upper atmospheric wind observations are made at 04 synoptic meteorological stations (Colombo, Trincomalee, Hambantota and Mannar) at 00, 06 and 12 hrs. UTC through Balloon Theodolites. The only GPS-based Radiosonde (Make: Meisei, Japan) station in Sri Lanka is at Colombo headquarters.

- **Meteorological Satellites:** The satellite imageries through satellite receiving system of CMACast was utilized the imageries and products from Insat and Eumetsat down loaded through internet were utilized throughout the year. Using of Himawari8 satellite imageries and products were commenced in November.

- **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. Under this program, to improve the forecasting capability of department activities on training and utilizing WRF model was done 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. The forums were very successful discussing with the stake holders on rainfall analysis of last monsoon and the forecast for up coming monsoon.RIMES with the collaboration of INCOIS established a " Integrated Ocean Information System for Sri Lanka and wave rider buoy will be deploued in Sri Lankan sea in 2016. Preparing of three day forecast using WRF with 5Km resolution was also continued.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. Capacity building is done in Sri Lanka and it is scheduled to be done in Japan also during up coming years.

4.3.18 The representative of Thailand informed the Panel about the activities carried out by Thailand in relation to the Meteorological Component during 2015. The detail is enumerate below:

- Thai Meteorological Department (TMD) uses its own NWP products. The model is composed of 3 domains: Domain-1 is resolution grid 18 kilometer square, Domain-2 is resolution grid 6 kilometer square and Domain-3 is resolution grid 1 kilometer square.High resolution WRF Bangkok model (resolution1x1 km. vertical 35 levels) was run at TMD for urban weather forecasting and improvement for Bangkok and vicinity short range weather forecast.
- **Operational Room**- Operational Room at Weather Forecast Bureau of TMD is under development for meteorologist who can use observations, seismic, numerical weather prediction and climate models data, to support them. The very short range, short range, medium range and long range forecast will also be given to the relevant authorities, also to public and private agencies for management purpose.
- **Meteorological Satellite** – Japan government, through Japan trust fund with WMO has provided Himawari Cast, received station and related software for TMD. Himawari Satellite tool is established at the top TMD's building and can measure every 10 minutes and operates on routine.
- **Weather Radar**-TMD's radar network totally 26 sites, compose of S-band Doppler radar 5 stations, C-band Doppler radar 16 stations, X-band Doppler radar

5 stations. TMD will establishment a new C-band Doppler radar at Nan station of Nan province and also a new one to replace the old C-band Doppler radar of Ubon Ratchathani station in 2016. JMA transfer the weather radar composite technique to TMD, through operated radar composite on routine.

- **Telecommunication**-In 2016, TMD will develop the global telecommunication (GTS) to integrate data support ICAO.

4.3.19 Member countries may do the cyclone hazard mapping as is done in India.

4.4 Hydrological Component

ACTIVITIES OF THE WMO

Presentations provided by Videoconference from Geneva (WMO/HQ) by Chief of the WMO/Hydrological Forecasting and Water Resources Division, Paul Pilon.

The **Associated Programme on Flood Management (APFM)** is a joint initiative of WMO and the Global Water Partnership (GWP). Its objective is to promoting the concept of Integrated Flood Management (IFM), minimizing loss of life due to flooding and optimizing the net benefits derived from floodplains. As such, it 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".
APFM has implemented various pilot project and training workshops in the region, in particular in Thailand with a pilot project on "Empowering Communities - Community-based Approaches to Flood Management in Thailand and Lao PDR", and in Bangladesh about Coastal Flood Management
The APFM also provides technical backstopping to the development of a national strategy, liaising also with the joint CHy/JCOMM initiative Coastal Inundation Forecasting Demonstration Project (CIFDP).

Full document available in **ANNEX 4.4.I**, or at the following weblink https://www.wmo.int/pages/prog/www/tcp/PTC-43_DocPlan.html

Presentation by Dr Paul Pilon, Chief of the Hydrological Forecasting and Water Resources Division in WMO available at https://www.wmo.int/pages/prog/www/tcp/PTC-43_DocPlan.html

Flash Flood Guidance System (FFGS) Information Note

Resolution 21 (Cg XV) was adopted 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.
Within the framework of the MoU, Mekong River Commission Flash Flood Guidance, (MRCFFG) has been implemented, while, a series of projects are under implementation, including South Asia FFG (SAsiaFFG).

The MRCFFG includes Cambodia, Lao PDR, Thailand and Cambodia. The MRC is the Regional Centre for the project. Efforts have been underway to seek MRC concurrence to have Myanmar participate in the MRCFFG project.

The SAsiaFFG includes Afghanistan, Bangladesh, Bhutan, India, Nepal, Pakistan, and Sri Lanka. The planning workshop had proposed two regional centres for the project, one in Pakistan and one in India

There is a proposal to hold a "Global Flash Flood Guidance Workshop: Advancing Operational Use". The event is to be held in Turkey in March 2017 and is to be funded through contributions from USAID/OFDA. The intent is to being together practitioners to share experiences, identify strengths and weaknesses of the system, and discuss sustainability issues.

Full document available in **ANNEX 4.4.I**, or at the following weblink https://www.wmo.int/pages/prog/www/tcp/PTC-43_DocPlan.html

Presentation by Dr Paul Pilon, Chief of the Hydrological Forecasting and Water Resources Division in WMO available at at https://www.wmo.int/pages/prog/www/tcp/PTC-43_DocPlan.html

ACTIVITIES OF THE MEMBERS

4.4.1 The summary of the report can be found in the **ANNEX 4.3.III**.

4.4.2 The representative of Bangladesh informed the panel that Modernization of hydrological networks include (1) upgrading 308 manual water level stations to be equipped with automatic data collection and reporting in real-time; upgrade 257 rain gauges to automatic and real time; upgrade 10 existing climate stations operated by BWDB; and upgrade or establish 1100 groundwater stations and nests of various configurations to automatically report measurements; (2) purchase of 4 catamarans and 4 survey boats for coastal hydrographic survey and stream gauging; (3) purchase 10 vertical profiling ADCPs; (4) purchase of 20 water quality sondes for measuring salinity and total dissolved solids (TDS); (6) purchase 8 echosounders to support river gauging and river morphology measurements.

4.4.3 The representative of India, IMD informed that there are 10 flood meteorological offices in different flood prone areas to issue hydrological bulletins to Central Water Commission which is nodal agency for flood forecast. Bulletin includes synoptic situation, spatial & temporal distribution of rainfall forecast for the next 3 days. Sub-basin-wise QPF, and heavy rainfall warning is issued for 3 days and outlook for further 4 days based on satellite products, Radar products, various global & regional models including GFS, WRF & MME and sub catchment wise rainfall forecast of NWP models-GFS, WRF and MME.

A project entitled "Modelling of Changing Water Cycle and Climate" is being taken up jointly with IMD and National Centre for Medium Range Weather Forecast (NCMRWF), India. A GIS based customised rainfall information system (CRIS) is operational since 15 January, 2015 which will be further improved for processing real time data in different spatial & temporal scale.

4.4.4 The representative of Oman informed that during the year 2015, a measurements of all hydrological parameters were measured through (4692 monitoring stations). Stations includes (rain gauges, wadi gauges, flow peaks, channels , springs and water level) in addition to 49 dams distributed all over the Sultanate.

- **Rainfall**: During the year 2015, the highest amount of rainfall in:
  - Dhofar governorate (south of Oman) reached (393 mm) in Salalah.
  - In Cyclone Chapala recoreded (85 mm) in Hasik on Arabian sea coast.
  - In South Batinah (208 mm) in Nakhal
  - In the North East (205 mm) in Ibra
  - In the South East (202 mm) in Maseirah after storm Ashabaa hit easten coast.
- **Wadi flow and floods**: The year 2015 is considered one of the years where low discharge rates were recorded. The total flood volumes during 2015 was estimated (133 Mm3) which is below the annual average (330 Mm3) . The highest amount of flooding the governorate of South East (45 million m3) in storm Ashabaa

- **Groundwater level measurements**: 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 and South Sharqiyah governorates.
- **Dams**: A total of 144 Mm3 was retained by recharge dams during 2015 was the highest during the floods in September (81 million m3).

During the year 2015 the Ministry arranged for both local and overseas training and workshops

The training Program	**No. of Trainers**
Monitoring , processing and analysis of water Resource Data	15
GIS & Arcmap	15
Direct & indirect survey measurements Method for Floods	18
Geology of Oman	15

4.4.5 The representative of Pakistan through his report 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. These information's are based on the different types of data obtained from the network of 46 river gauge stations maintained by wapda and irrigation departments, a telemetric rain gauge network of 45 stations and a network of 35 telemetric discharge stations installed in the the catchments of river Indus , Jhelum, Chenab, ravi, Sutlej and on major nullahs. Another set of data is received from the meteorological observatories owned by PMD. The information from five C-band radars at Sialkot, Dera Ismail Khan, Islamabad, Rahim Yar Khan and Karachi and two S-band QPM Doppler weather radars at Mangla and Lahore is incorporated to this for having real time weather situation over the ungauged area. All this information is blended with the Synoptic situation on the weather charts and a future scenario is developed. The hydrological forecasting models FEWS, IFAS, CLS, and statistical are also consulted along with global Meteorological Forecasting Models. On the basis of these information's, two Bulletins are daily issued during the flood season from 15 June to 15 Oct each year. The 'Bulletin A' contains the qualitative information regarding the Synoptic Situation, prevailing Flood Situation, rainfall amount observed during last 24 hours and the Flood Forecast for the next 24 hours in the country. It also contains a further outlook for next 24 to 72 hours based on the future weather conditions. The 'Bulletin B' is the quantitative hydrological version of the 'Bulletin A' containing the values of prevailing river Flows and the Forecasted values for the next 24 hours at all structures of all the rivers starting from the Rim stations down to Kotri in the Indus River Basin. This Bulletin also contains the Dams level, expected Flood level in the rivers and the weather forecast particularly in the upper catchments of all the Major Rivers. If any significant Flood situation is expected, then significant flood information is also issued. Advisories are issued regularly to the Flood mitigation agencies for taking precautionary measures for the safeguard of the general public. The most recent addition to the Flood information has also been started in the form of inundation maps created by the combination of different Flood routing Models. The flood information is disseminated by FFD to more than 300 addresses including the federal government and provincial government functionaries, mitigation agencies, print & electronic media as well as Pak Army.

He further informed that in wake of Super Floods 2010 in Pakistan, the International Centre for Integrated Mountain Development (ICIMOD) based in Nepal", implemented the project "Establishment of Regional Flood Information System in the Hindu Khush Himalayan Region (HKH-HYCOS)" in order to promote regional cooperation in flood risk reduction and to cope with future flood disaster in Pakistan with Federal Flood Commission (FFC) being the coordinating agency while WAPDA and PMD are main beneficiaries of the project. Under this project, three (03) AWS have been installed in flood affected areas in Gupis, Kalam and Lower Dir. The data from these AWS has regularly been shared among ICIMOD Member countries via a website http://hkhhycos.pmd.gov.pk. Further in the aftermath of Floods 2010 in Pakistan,

UNESCO in collaboration with JICA/Government of Japan initiated a project "Strategic Strengthening of Flood Warning and Management Capacity of Pakistan" phase-I 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 including Pakistan Meteorological Department, Federal Flood Commission (FFC), Pakistan Space and Upper Atmosphere Research Commission (SUPARCO), and National Disaster Management Authority (NDMA).Under the first phase of the project, International Centre for Water Hazard and Risk Management (ICHARM) under the auspices of UNESCO and Japan Aerospace Exploration Agency (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. However, after September 2014 floods in the Eastern Rivers and in order to improve Indus-IFAS, there was considered a dire need to extend the Indus IFAS system to cover the whole Indus River catchment 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 IFAS 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 launched in March, 2015.

An International Workshop on "Standardizing Flood Forecasting and Warning Approaches in Transboundary Catchments" was jointly organized by PMD and UNESCO at Lahore, Pakistan on 19-20 April, 2016. This workshop is part of phase-II of UNESCO's "Strategic Strengthening of Flood Early Warning and Management Capacity of Pakistan" Project. The workshop was attended by representatives from national and international partner organizations such as ICHARM, Japan Aerospace Exploration Agency (JAXA), PMD, NDMA, Provincial Disaster Management Authorities (PDMAs), FFC, universities, provincial irrigation departments and international experts from Australia, France, Indonesia, Korea and Japan. The participants shared their knowledge to further enhance the river modelling and flood forecasting models for Indus and the Eastern Rivers.

The representative informed that owing to high vulnerability of glaciated northern part of the Pakistan to Glacial Lake Outburst Floods (GLOFs), PMD under the auspices of UNDP recently carried out a project "Reducing Risks and Vulnerabilities from Glacial Lake Outburst Floods in Northern Pakistan". Under this project, science and community based GLOF Early Warning System has been established at three (03) pilot sites in northern area (Bagrot valley in Gilgit, Bindogol and Golain valleys in Chitral). In wake of establishment of GLOF EWS in the pilot valleys local communities were got involved. Community sensitization campaigns were launched which include the consultative meetings with community elders, discussions with locals, awareness about the water and environmental hazards and also apprised them the importance of the GLOF Early Warning. Pamphlets were also distributed to the communities regarding the awareness of GLOF events besides lectures and training sessions. This community based EWS played important role in saving the live and property of local people during previous year monsoon/flood season. He added that PMD with the financial assistance of UNDP and in cooperation with National Agricultural Research Council (NARC) has introduced a new updated Glacial Lake Inventory. As per this inventory there are 3044 glacial lakes in Hindu-Kush-Karakorum-Himalaya region of Pakistan. Among these lakes 36 are classified as potentially dangerous.

4.4.6 The representative of Sri Lanka Irrigation Department (ID) is the mandated Institution working with hydrological issues in Sri Lanka. As the pioneer organization responsible for developing water resources, ID formed the Hydrology Division (HD), by 1947, in order to collect hydrological data and information required for Planning Reservoirs and Flood Control Works. The Hydrology Division gradually expanded the

hydrological data collection network covering around 30 major rivers of the country. At present it is providing the hydrological data and information to all government and nongovernmental organizations responsible for water related infrastructure development and disaster management.
The prediction for Second Inter Monsoon (from October to) for 2015 and North East Monsoon (December-January) by the South Asian climate outlook forum was for normal to above normal rainfall. The consensus forecast outlook for monsoonal rain and temperature over South Asia have being developed through an expert assessment of the prevailing global climate conditions. Irrigation Department of Sri Lanka received this message in October 2015 at the South Asian Climate Outlook Forum. These forecasts were reviewed during the Monsoon Forum After careful assessment of current water levels in the reservoirs, Irrigation Department issued special instructions to the Irrigation engineers in-charge of reservoir operations, to maintain reservoir water levels 1m below the full capacity level, allowing flood detention and also for smooth operation of radial gates in the spillways.Monthly seasons outlook prepared by the Department of Meteorology was also received through emails and they were used for water management.
It was a relief to the Irrigation Department and to the government, the ability of minimizing the flood damage and also keeping the farming community alert over the possible inundation due to excess drainage based on the weather forecast.

4.4.7 The representative of Thailand informed that for hydrology and water management in the country come mainly under the care of two government agencies - Royal Irrigation Department (RID) and Department of Water Resource (DWR). There are 25 main river basins in Thailand and;

- The area affected by Tropical cyclones are the western region of Thailand. During 1St of April 2015 until end of March 2016, the trend of the precipitation is a bit less than average compare with the past record. It's the main reason to make the capital water in the reservoir is rather less than normal and this cause the strong drought area all of Thailand. So farmer stop to do rice crop in summer season. RID water management by water supply and protect ecology only.
- 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 of population at risk. Management plans are set in terms of monitoring, predicting and warning by establishment of Water Watch and Monitoring System for Warning Center (WMSC) to examine flood situations 24 hours. In addition, the collaborations with national related agencies for implementation plan cope with local flood protections in economic zones where severe flood may occur.
- The state-of-art technologies were established, such as telemetry and flood forecasting systems. Similar to 544 manual river gauges (27 stations decrease from 2013) and 2,294 manual rain gauges, 23 of 25 main river basins have 710 telemetric stations and 430 telemetric micro stations installed for water resources management and flood prevention and mitigation.
- RID collaborates and discusses with other agencies to take decisions during flood situation under the government to reduce the loss from Typhoon and tropical cyclone-related disasters for monitoring and analysis of flood situation.
- Coordinate and exchange information of climate, rainfall, run off and water operation to analyze and forecast the future situation for water management before announcement to public.
- To improve the telemetering system to the rural area which is the high risk area for flood warning and develop the communication system to disseminate flood information like on website or text messages.

4.5 Disaster Risk Reduction (DRR) Component

ACTIVITIES OF THE WMO

The documents provided by the WMO Disaster Risk Reduction Division is available in the **ANNEX 4.5.I** or at the following weblink
https://www.wmo.int/pages/prog/www/tcp/PTC-43_DocPlan.html

ACTIVITIES OF ESCAP

ESCAP provided technical assistance and policy guidance to the Panel members. In the 71st session of ESCAP Commission in 2015, ESCAP liaised with member States and was requested to work on deepening and extending regional cooperation mechanisms.

In following up this request, ESCAP implemented the Drought Monitoring and Early Warning project benefiting 8 countries including PTC member States, Bangladesh, Myanma and Sir Lanka. China and India has provided data, information and technical assistance for the project. ESCAP has also implemented a United Nations Development Account project on mainstreaming disaster risk reduction into national development strategies and plans, and the target countries include PTC members, Maldives and Sri Lanka.

ACTIVITIES OF THE MEMBERS

4.5.1 The summary of the report can be found in the **ANNEX 4.3.III**

4.5.2 The representative of Bangladesh informed the panel that BMD is preparing to produce standardized alerts and warnings. Bangladesh Meteorological Department (BMD) is also planning installation of a Common Alerting Protocol (CAP) which is an international standard that is used to send public alerts and warnings. It is a digital format for changing emergency alerts that allows a consistent alert message to be disseminated simultaneously over many different communication systems. As more systems are built or upgraded to CAP, a single alert can trigger a wide variety of public warning system, increasing the likelihood that intended recipients receive the alert by one or more communities. A contract language will be developed that will result in the set up for CAP for BMD, while coordinating these activities with first responders, such as local community leaders and DDM.

4.5.3 The representative of India informed 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 and Hudhud during 2014 has been reduced to a minimum (22 and 46 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.

4.5.4 The representative of Maldives informed the panel that Maldives Meteorological Service followed the Standard Operating Procedure (SOP) and issued 216 WHITE Alerts, 15 YELLOW Alerts 2015 Cyclone Season.

4.5.5 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 30 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.

PMD installed a Siren System for satellite based tsunami early warning for the communities residing at the coastal cities of Pasni and Gwadar in Balochistan province. Both cities were suffered by a tsunami in November, 1945 and approximately 4,000 precious lives were lost in. The Siren System for tsunami early warning is the donation from Oxfam Great Britain and UNDP. He further informed that in the past Pakistan nation has 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 101 million 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 given as under:

(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 five (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 three (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 Pakistan in the wake of geophysical disasters. He further informed that after the strong Hindu Kush earthquake of M8.1 on October 28, 2015 the National Seismic Monitoring Centre of PMD, started investigating the reasons of increasing frequency of earthquake around the country. A comprehensive report was formulated as an outcome of the research contributed by the scientists of Seismic Monitoring Centre. In addition, after this strong earthquake, PMD and Geological Survey of Pakistan (GSP) responded to National Disaster Management Authority (NDMA)'s request and carried out Micro Zonation of Pakistan.

4.5.6 The representative of Sri Lanka informed the Panel that the 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. District disaster preparedness plans have been completed for all 25 districts plans, 175 divisional plans and 2000 plans for Grama Niladhari (lowest level in the administration) divisional level plans were completed up to now. More than 200 mock drills were also completed in 2015 (Including the National Drills). Cyclone hazard mapping has been completed with technical support from Department of Meteorology and financial support from UNDP. National safety day commemorations was well performed on 26th December 2015 around the country concentrating preparedness activities and public awareness.

4.5.7 The representative of Thailand informed 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 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 of 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 Headquater/ 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. (included typhoon and storm forecasting data sharing with Thai Met)
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 land slide 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.

DDPM has recognized the importance of socio-economic impact in Macro sector which 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.

4.6 Training Component

ACTIVITIES OF THE WMO

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, 22-31 July 2015
- WMO Training Workshop on TC Forecasting and Warnings for PTC Region
  New Delhi, India , 3 – 14 August 2015
- WMO International Training Workshop on Tropical Cyclone Forecasting and Warning
  Nanjing, China, 7 - 11 December 2015

The Panel noted the forthcoming training events planned for 2016, 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 (15-26 August 2016)*
  - *RSMC New Delhi (19-30 September 2016)*

The Panel has constituted an expert group to prepare a draft training plan for the next Panel session.

PTC training plan to support the Coordinated Technical Plan:

4-a.	a) Expert Group to produce a prioritized list of training needs and opportunities of PTC Members through a survey and advise WMO for reporting, planning and implementation purposes. b) The plan to be submitted in the next session of WMO/ESCAP PTC. c) WMO to provide the relevant documents to the expert group and PR of each member country.

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 to produce a prioritized list of training needs and opportunities of PTC Members through a survey and advise WMO for reporting,

planning and implementation purposes. The plan to be submitted in the next session of WMO/ESCAP PTC. WMO to provide the relevant documents to the expert group and PR of each member country.

b) Whilst there are many opportunities available for Panel members to access education and training opportunities, the offers are not always well coordinated and not all members may be aware of the opportunities. Developing and then maintaining and communicating a training plan to complement the agreed Coordinated Technical plan is one way to ensure that the capacity of all Panel members increases. The training plan would also provide a means to identify the training gaps and look for options to address them.

c) The training plan could include seeking information on:

- the types and ranges of TC services provided by the Panel members
- the number of personnel involved in developing, delivering and communicating these services. It may be best to break these personnel numbers down into topic groupings as not all staff may be doing the same types of activities.
- types of systems used by the forecasters for their work
- whether the TC services are based upon the RSMC forecasts or are developed nationally (interpretative vs full forecasting capacity)
- coordination mechanisms and roles with the national emergency authorities (to see what common roles may exist)
- what education and training opportunities may exist and what is being used (secondments to RSMC or other advanced centre, twinning or option for staff from one country to travel to another to assist in training, face-to-face courses, fellowships, online training (as a course or stand-alone self-directed training), participation in regular online meetings or weather briefings such as those offered by the WMO Virtual Laboratory for Satellite Meteorology)
- what financial or other resources may be available to support training (for example use of the COMET MetEd website https://www.meted.ucar.edu/training_detail.php)
- the potential for the proposed TC forecaster competency framework to assist in improving the effectiveness of training courses provided to Panel members.

Full documents available at the following weblink
https://www.wmo.int/pages/prog/www/tcp/PTC-43_DocPlan.html

ACTIVITIES OF ESCAP

In 2015, ESCAP supported 4 experts from PTC and TC to participate in the training organized by RSMC, New Delhi for forecasters in August, 2015. ESCAP also supported 4 experts from PTC to participate in the TC Roving Seminar in November 2015. It further encouraged RSMC, Tokyo to provide training to PTC members, and coordinated with RSMC, Tokyo to invite 6 PTC members to be trained in Japan.

ACTIVITIES OF THE MEMBERS

4.6.1 The summary of the report can be found in the **ANNEX 4.3.III**.

4.6.2 The representative of Bangladesh inform that 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.

4.6.3 The representative of India informed that 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 2015. The course curricula of various training courses have been modified keeping in view the latest developments. 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, Nowcast 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. 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.

4.6.4 The representative of Maldives informed the panel that to build the capacity of MMS further and in accordance with the mandate and action plan, we urgently need to train its personnel in DWR, Aeronautical forecasting, Satellite Met, WRF/ WAM, data assimilation, climate, tsunami propagation and storm-surge modeling.

4.6.5 The representative of Oman informed the panel that the 7th WMO Center of Excellence in Oman has conducted the 11th session of satellite application course (SAC) for Middle East countries in cooperation with Eumetsat.

Workshop/Seminar/Training/Research Course (2015)	Country	No. of Persons
PhD. In Dust Modelling	Australia	1
EUMETSAT Satellite Application Course	Oman	15
Climatological database CLDB	Slovakia	1
Aeronautical Meteorological Forecasting	China	2
Tropical cyclone Forecasting Course	India	2
Marine Forecasting	South Africa	2
Tsunami	Germany	6
Observer Training	India	18
Training in McIDAS-V	Oman	7
Weather Radar	Oman	8
Basics in linux	Oman	5

4.6.6 The representative of Pakistan informed the Panel that 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, thirty-two (32) officers have joined back to PMD after completion of their higher studies (MS/PhD) from some reputeable institutions in UK, Canada, Norway, China and Thailand. During 2015, one scinetist proceeded to Canada for Post-Doc in Meteorology from Environemnt Canada. While two (02) scinetists proceeded abroad one for China and other for Saudi Arabia for doing Ph.D in Meteorology at the Institute of Tibetan Plateau Research, Chinese Academy of Sciences, China under fellowship grant and at the King Abdulaziz University (KAU), Jeddah, Saudi Arabia under award of fellowship by KAU. In addition, one scientist proceeded to Japan for doing M.S in Hydrology & Flood related Disaster Management at the International Centre for Water Hazard and Risk Management (ICHARM) Japan and one scientist proceeded to Nanjing University of Information Science and Technology (NUIST) for doing MS (Meteorology) under scholarship offered by the NUIST-China. Beisdes this one more scientist proceeded abroad for doing 3-years M.Sc (Hydrology) at Russian State Hydrometeorlogical University, St. Petersburg, Russian Federation under award of WMO Fellowship.

While four (04) PMD officers have been doing their Ph.D (Meteorology) at the Chinese Academy of Sciences (CAS), China since 2013. These scientists have been awarded scholarship by the CAS for their PhD program and are expected to return by the end of

year 2016. 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 sience 2013 under scholarship program. In addition, three (03) officers have been doing their 3-years Ph.D Meteorology program at KAU, Saudi Arabia since 2014.

During 2015, four (04) PMD scientists joined back after completion of their Ph.D (Meteorology) from China. One (01) more scientist joined back to PMD after completion of M.S. in Hydrology and Flood related Disaster Management from International Centre for Water Hazard and Risk Management (ICHARM), Japan under generous support by JICA/Government of Japan while one scientist is still doing such program in Japan.

During 2015, around 50 fellowships were availed by PMD scientists for attending short-term trainings/ workshops/ seminars abroad. These fellowships were offered mainly by WMO, ICIMOD, ICTP, IOC-UNESCO, CMA, JMA, JICA, JAXA, NARBO, UNESCO, UN-ESCAP, APCC Korea etc.

Training of Met. Personnel at PMD's Institute of Meteorology and Geophysics (IMG), Karachi: During 2015-2016, various regular and special courses on meteorology were also conducted at IMG, Karachi for in-service Met personnel of PMD as well as for Met officials from other relevant organizations including Met branch of Pakistan Air Force and Navy. These courses include Initial and Preliminary Meteorology Courses (WMO BIP–MT), Basic Forecasting Course (WMO BIP–M) and others.

Training to the Met Officials from neighbouring Countries: PMD started to extend its training facilities to the NMHSs of the neighbouring countries for their capacity building through WMO Voluntary Cooperation Programme in 2008. For this purpose, special Preliminary Meteorology Courses (BIP-MT) were conducted in 2008, 2009 and 2010 at PMD's Institute of Meteorology & Geophysics (IMG), Karachi in which 31 Met Officials from Bangladesh, Bhutan, Maldives, Myanmar, Nepal and Sri Lanka got benefitted from these courses.

In 2015, upon request of Department of Meteorology, Sri Lanka, three (03) Met personnel were imparted training at IMG, Karachi. Air travel and stipend of participants was borne by Govt. of Sri Lanka and PMD provided waiver of tuition fee and free accommodation in hostel facilities of IMG Karachi. Similarly in February 2016, three (03) more Met officials from Department of Meteorology, Sri Lanka have been enrolled in Preliminary Meteorology Course at IMG Karachi.

4.6.7 The representative of Sri Lanka informed the panel that two meteorologists are currently receiving post graduate training at University of Phillipines and Ewha Women University, South Korea under the fellowship of WMO .The following short term training workshop/seminars organized/cosponsored by WMO were attended by the scientific staff of the department.

- 41st Session of the IPCC, Kenya, 24-27 Feb 2015
- South-Asia drought monitoring system, Climate Outlook and Water User Forum, Bangladesh, 20-23 Apr 2015
- Forty –second Session of ESCAP/WMO PTC & 47th session on Tropical Cyclone, Thailand,
  9-13 Feb 2015
- ESCAP/WMO Typhoon Rowing Seminar, Lao PDR, 4-6 Nov 2015
- Severe Weather forecasting Demonstration Project (SWEDP) – Training WS on Severe Wx Forecasting & Warning Services, Thailand, 14-25 Sep 2-15
- Sixth Session of the SASCOF & Forum for Water sector in South-Asia, Bangaladesh, 19-23 Apr 2015
- Capacity Building work shop on Data Rescue, Tanzania, 9-14Nov 2015
- Win SASCOF-1 meeting, India, 14-15 Oct 2015

- Severe Weather forecasting Demonstration Project (SWEDP) – Training WS on Severe Wx Forecasting & Warning Services one week PWS training, Thailand, 14-25 Sep 2-15
- Third WMO/WWRP Monsoon Heavy Rainfall Workshop, India, 22-24 Sep 2015
- Course on Instrument maintenance and Calibration, RA II countries, Nanjing, China, 2-27 Nov 2015
- 5th International Workshop of Port Meteorological Officers, Chile, 2-24 July 2015

4.6.8 The representative of Thailand informed the Panel of training, 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.

4.6.9To understand, interpret and convey the warnings correctly, a training should be held in capacity building of the users and media.

4.7 Research Component

ACTIVITIES OF THE WMO

The Three World Weather Research Programme (WWRP) projects on tropical cyclones below had been extended to 2018:

a) North Western Pacific Tropical Cyclone Ensemble Forecast Project (NWP-TCEFP) for Typhoon Committee members covering the period 2010 to 2018 (Lead: Japan Meteorological Agency);

b) Typhoon Landfall Forecast Demonstration Project (TLFDP) covering the period 2010 to 2018 (Lead: Eastern China Regional Meteorological Center/CMA).

c) Understanding and PreDiction of Rainfall Associated with landFalling Tropical cyclones covering the period 2014-2018 (UPDRAFT) (Lead: Nanjing University)

The NWP-TCEFP is a collaborative effort between WMO and the Typhoon Committee and aims to explore the utility of ensemble forecast products through THORPEX interactive Grand Global Ensemble (TIGGE) and thus promote application of the products to the operational forecasting of tropical cyclones. It is closely linked with the TLFDP. The TLFDP is a collaborative effort with the NWP-TCEFP which had been extended to 2018 to continue its work on tropical cyclone genesis and verification of tropical cyclone forecasts and also include collaborative activities with the work of the Typhoon Committee's The Experiment on Typhoon Intensity Change in Coastal Area (EXOTICA). It is envisioned that all the above-mentioned projects will be instrumental in transferring the recent research advances to operational forecast centers in NMHSs, especially those which have been affected by the recent increase in the severity of tropical cyclone events in highly populated coastal areas. UPDRAFT in 2015 successfully held its' first project-related workshop at the Nanjing University from 30-31 November with the participation of several world-renowned tropical cyclone experts.

Plans are underway to organize the 4th International Workshop on Tropical Cyclone Landfall Processes (IWTCLP-III) and the 9th International Workshop on Tropical Cyclones (IWTC-IX) and in 2017 and 2018 respectively. The two workshops are being organized by WWRP in close collaboration with TCP. The Panel on Tropical Cyclones will be represented by the Director of RSMC New Delhi in the International Organizing Committee for IWTC-IX. Members of the Panel are urged to actively participate in the said Workshop. Operational and research meteorologists from Panel Members who will not need WMO support to participate at the IWTCLP-III and IWTC-IX should, in a timely manner, inform TCP of their intent to attend the said workshops.

The High Impact Weather (HIWeather) project kick-off meeting was held in the UK Met Office (Exeter, UK) from 25-29 April 2016. HIWeather is a ten year activity within the WWRP to promote cooperative international research to achieve a dramatic increase in resilience to high impact weather, worldwide, through improving forecasts for timescales of minutes to two weeks and enhancing their communication and utility in social, economic and environmental applications. The scope of the project is defined by the needs of users for better forecast and warning information to enhance the resilience of communities and countries in responding to a carefully selected set of hazards such as urban floods, rain-induced landslides, localized extreme winds including localized wind maxima within tropical cyclones.

ACTIVITIES OF ESCAP

ESCAP published the following reports, papers and technical materials related to the work of the PTC.

a) ESCAP (2015) Asia-Pacific Disaster Report 2015: Disasters without Borders – Building Resilience for Sustainable Development;
b) ESCAP (2015) Advisory note: El Nino 2015/2016 – Impact outlook and policy implications;
c) ESCAP (2016) Disasters in Asia and the Pacific: 2015 Year in Review;
d) ESCAP and SDMC (2016) Manual of Rapid Assessment for Resilient Recovery, and
e) ESCAP and RIMES (2016) Flood Forecasting and Early Warning in Transboundary River Basins: a Toolkit.

The panel noted of the following training opportunities supported by ESCAP.

a) Regional training on slow-onset disasters impact assessment methdology, June 2016, Thailand, organized by ESCAP together with UNDP and RIMES;
b) Regional training on multi-hazard early warning systems, September 2016, Hyderabad, India, organized by ESCAP, jointly with INCOIS and RSMC, New Delhi; and
c) Regional training workshop on flood forecasting and early warning in transboundary river basins, October 2016, Thailand, organized by ESCAP, jointly with RIMES.

ACTIVITIES OF THE MEMBERS

4.6.1 The summary of the report can be found in the **ANNEX 4.3.III**

4.6.2 The representative of Bangladesh informed that BMD is contributing in the PTC News letter in a regular manner. DEW DROP, a scientific journal of geophysics and meteorology is being published by Bangladesh Meteorological Department once in a year.

4.6.3 The Panel noted that the India Meteorological Department remained involved in extensive research activities. The major achievements during 2015 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) Publication of a book "Tropical Cyclone Activity over the north Indian Ocean" based on the proceedings of the national workshop on 'Unique and enhanced activity of the Tropical Cyclone during 2013' published by the Capital publishing co., New Delhi and Springer.
e) Conduct of national and international seminars, conferences and workshops.
f) WMO's SWFDP over Bay of Bengal implemented w.e.f 2 May 2016.
g) 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

Following are the major on-going projects:

a) Extended range forecast on the number of cyclones in a season and the total number days will be issued w.e.f. post-monsoon season 2016.
b) Tropical Cyclone Data Portal where all data related to cyclones will be made available for access by the countries which can be accessed through Userid and password.
c) Monsoon Mission Programme
d) Integrated Himalayan Meteorology Programme
e) Severe Weather Forecasting Project
f) Development of TCWIND tool for climatological guidance on wind distribution in TC.

4.6.4 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 2015, PMD published two issues (No. 22 and 23) of "Pakistan Journal of Meteorology". These issues contain 13 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 (10) research papers which have been published in various national and international journals like Climate Dynamics, Journal of Glaciology, Journal of Earth Science & Climatic Change and /or presented at international scientific conferences and have been published in the proceedings of these conferences/ seminar.

Development of Future climate scenarios: The Research & Development Division of PMD has developed high resolution climate change scenarios for Pakistan by downscaling General Circulation Models (GCMs) use in IPCC AR5. The climate scenarios are at 25km and 50km grid resolution on the basis of Representative Concentration Pathways (RCP); RCP 4.5 and RCP 8.5 emission scenarios. The future projections data (climate) is discriminated to different research institutes, government and non-governmental agencies in the form of DVD for further research in the field of climate disaster mitigation and adaptation. The same data is also available on PMD website with open access.

National Agrometeorological Centre (NMAC) of PMD regularly publishes monthly agrometerological bulletins for the facilitation of farming community. NAMC aslo publish crops reports and other technical reports and keeps close liaison with Agriculture Universities and research centers. National Drought Monitoring Centre is another unit of PMD which regulary issues fortnightly drought bulletin regarding drought situation in the country.

4.6.4 The representative of Sri Lanka informed the Panel that the following research studies were conducted by the Department during the year 2015

1. Modulation of Seasonal Rainfall in Sri Lanka by ENSO Extremes
2. Identification of Suitable predictors to Develop a Seasonal Forecasting Model for District Rainfall for the onset of Maha Agricultural Season using Climate Predictability Tool (CPT)
3. Analysis of Standard Precipitation Indices to Identify for Drought Condition in 2015
4. Simulate Heavy Rainfall During 19th to 28th December 2014 Using WRF for Different Atmospheric Physics
5. The Influence of La Nina on Sri Lanka Rainfall
6. Synoptic Analysis of Catastrophe Heavy Rain and Strong winds over Sri Lanka on 01st June 2014
7. Influence of Large-scale circulation features and El Nino conditions on Southwest Monsoon Rainfall 2015 in Sri Lanka
8. A comparative study on cloud radiative forcing over Sri Lanka and Indian monsoon region

5. COORDINATION WITH OTHER ACTIVITIES IN THE PANEL REGION

5.1 Within WMO Tropical Cyclone Programme

5.1.1 INTRODUCTION

The WMO Tropical Cyclone Programme carries out its activities in accordance with decisions/resolutions by Congress and Executive Council. The resolutions and decisions at the recent Congress (Cg-XVII) with particular relevance to the Programme may be found in the **ANNEX 5.1.I**: Tropical Cyclone Coordination and Services (Paragraphs from 3.1.63 - 3.1.99 of the Abridged final report with resolutions of the Seventeenth World Meteorological Congress, Geneva, 25 May-12 June 2015 (WMO-No. 1157)).

5.1.2 PROGRAMME IMPLEMENTATION

The TCP Programme was implemented in two components: a general component concerned with collective issues such as methodology and transfer of technology, and a regional component devoted to the activities of the five regional tropical cyclone bodies.

5.1.2.1 Guidance by Cg-XVII and EC

a) to expand and consolidate further the regionally coordinated systems to cover all Members prone to tropical cyclones;
b) to enhance the capacities of Members to provide more accurate forecasting and warning services which are impact-based and in multi-hazard approach (also EC-66 decision);
c) to improve forecasting and warning capabilities of Members through advances in sciences and technologies, and capacity development; and
d) 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.

5.1.2.2 Priorities

Capacity Building

a) Warning capabilities of the Members improved through TCP/PWS joint training workshops in RAs I, IV and V, and the attachment trainings.
b) Cooperative linkage established with the Severe Weather Forecast Demonstration Project (SWFDDP).
c) Requirement for human resources still pressing in developing countries, especially SIDS and LDCs. Competency Standards

Support to Operational Forecasting

Increasing need to support forecasters to meet user's demand through efficient utilization of advanced technologies, data and products.

Global Coordination

Demands are growing for enhanced sharing of technologies and standardization of procedures/products across the regions.

Regional Tropical Cyclone Bodies

Regional TC bodies taking increasing roles as platforms for various regional projects of WMO Programmes including DRR, DPFS, MMOP, WWRP and HWR as well as for Tsunami EWS projects of ICG.

CIFDP Sub-Project in Bangladesh

The CIFDP Sub-Project in Bangladesh has been underway since 2011, with the support of USAID. The first Phase was complete in 2013, and currently Phase 2 of the technical development aspect is nearing completion in 2016, with a forecast simulation exercise. The overall CIFDP Project Steering Group continues to provide guidance. It is expected that all four Phases will be complete by 2018.

SWFDP-Bay of Bengal

The development planning for SWFDP-Bay of Bengal started with a Technical Planning Workshop in New Delhi, India in January 2012 with participation of six countries namely: 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 regional subproject implementation plan (RSIP) for the SWFDP-Bay of Bengal has been developed by India Meteorological Department (IMD) and further updated with input from other contributing global centres of JMA, UKMO, NOAA/NCEP and ECMWF.
As a contributing global centre, IMD is 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. INCOIS will provide location specific products for participating countries including tide and swell wave, high swell and wave alerts and coastal inundation in line with those provided currently to Sri Lanka and Maldives. Archival and retrieval of operational data and products will be made up to 7 days at the originating level by IMD. The Indian Institute of Tropical Meteorology (IITM) upon request of IMD has also agreed to provide extended range forecast on dry and wet spells as a global partner to this subproject. India has a unique role in the subproject for being one of the contributing global NWP centres, the lead Regional Centre for SWFDP-Bay of Bengal, the RSMC for tropical cyclone forecast support and a beneficiary country of the subproject.
The password-protected subproject website has been developed by RSMC New Delhi in 2015, as an in-kind contribution by IMD to the project. This website was demonstrated to the participants of SWFDP training workshop in Bangkok, Thailand in September 2015. Presently, only products from Indian centres (i.e. IMD, NCMRWF and INCOIS) are available through subproject website. The products from other global NWP centres will also become available during 2016. RSMC New Delhi will start issuing the Daily Guidance product (in graphics format) towards the participating NMHSs on experimental basis from 16 May 2016.
Based on Members' interest in SWFDP-Bay of Bengal 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.

a) Need to ensure active involvement of hydrologists and DRR experts to strengthen the link between the three key areas of the regional activities – meteorology, hydrology and disaster risk reduction (SSOP).

Application of Research and Development

a) Cooperative interaction promoted between forecasters and researchers through TCP/WWRP joint workshops.
b) As its outcome, projects launched aiming to operationalize R&D achievements and to improve satellite analyses and database.
c) Need to further strengthen the cooperation on both global and regional bases.

Storm Surge Watch Scheme (SSWS)

a) Through collaboration with JCOMM, regional SSWSs should be implemented in all the cyclone basins with the initiative of TC RSMCs.
   - RSMC New Delhi in 2009
   - RSMC Tokyo in 2012
   - RSMC Miami: workshop on SSWF, Miami, US, 20 – 23 January 2015. Plans to implement the SSWS.
   - RSMC La Réunion: within the 24 to 36h before an expected landfall, potential tide surge data are provided (since 2012 and TC landfall on Madagascar's eastern coast).

b) Need to develop the warning capability also on a national level through capacity building to establish the SSWS globally.

5.1.2.3 A list of the events organized or co-sponsored under the Programme during the period from February 2015 to April 2016 are given in **ANNEX 5.1.II** and the updated list of Members of the regional bodies is shown in **ANNEX 5.1.III**.or at the following weblink https://www.wmo.int/pages/prog/www/tcp/PTC-43_DocPlan.html

5.1.3. COOPERATION WITH OTHER ORGANIZATIONS

5.1.3.1 There has been close cooperation and collaboration with the Economic and Social Commission for Asia and the Pacific (ESCAP), the International Strategy for Disaster Reduction (ISDR) Secretariat, International Civil Aviation Organization (ICAO), and Secretariat of the Pacific Regional Environment Programme (SPREP) on a variety of matters of common concern. The main items include ESCAP's co-sponsorship of the Typhoon Committee and the Panel on Tropical Cyclones, as well as the ISDR Secretariat in the context of the DRR of TCP.

5.1.3.2 As part of the cooperation between WMO and the International Civil Aviation Organization (ICAO), TC RSMCs and one Tropical Cyclone Warning Centre (TCWC) are designated as ICAO Tropical Cyclone Advisory Centres (TCAC) by ICAO Regional Air Navigation Agreements. Those TCACs listed below provide specialized tropical cyclone warning services for the aviation community:

RSMC/TCWC	Area(s) of responsibility
Darwin (Australia)	South-eastern Indian Ocean, South-western Pacific Ocean
Honolulu (USA)	Central North Pacific
La Réunion (France)	South-western Indian Ocean
Miami (USA)	North Atlantic, Caribbean, Eastern North Pacific
Nadi (Fiji)	Southern Pacific
New Delhi (India)	Bay of Bengal and the Arabian Sea
Tokyo (Japan)	Western North Pacific, including the South China Sea

5.1.4. ACTIONS FOR 2016 AND BEYOND

5.1.4.1 Major activities of TCP planned for 2016 in the global and regional components are set out below:

General component:

a) Training and Capacity Development

- Enhancement of the collaboration with other WMO Programmes in implementing TC training courses and workshops.
- Set up of an expert group for each TC regional bodies to prepare a draft training plan. This training plan could identify the training needs, opportunities and available opportunities as well as the gaps that will need to be addressed.
- PTC constituted an expert group involving Bangladesh, India, Maldives and Sri Lanka to prepare a draft training plan (2017-2019). The report will be finalized through email by the expert members and then by the member countries of the PTC. Thereafter the PTC secretariat will send the report to WMO by September 2016. WMO will provide the guidance material to the Expert Group by 15th May 2016.

b) Support to Operational Forecasting

- Maintaining the Tropical Cyclone Forecaster Web Site with the support of Hong Kong, China [http://severe.worldweather.wmo.int/TCFW/]
  Lately the website has been enriched with the training material from RSMC Miami Workshop on Hurricane Forecasting (2016) and RSMC La Réunion Workshop on TC Forecasting (2015)
- Maintaining the Global Guide to Tropical Cyclone Forecasts. The web version of the Guide has been announced in Cg-XVII document on TCP.
  http://www.wmo.int/cycloneguide

c) Application of Research and Development (R&D)

- Implementation of the TCP/WWRP joint projects;
  - North Western Pacific Tropical Cyclone Ensemble Forecast Project (NWP-TCEFP) including its extension to North Indian Ocean Typhoon Landfall Forecast Demonstration Project (TLFDP)
  - Summary of the 2nd phase and extension to the 3nd phase of TLFDP in Typhoon Committee region.
- Organization of the 2nd International Workshop on the Satellite Analysis of Tropical Cyclones (IWSATC-2), held back to back with the second International Best Track Archive for Climate Stewardship (IBTrACS-2) workshop (Honolulu, Hawaii, USA, 16 – 19 February 2016).
  Preliminary recommendations on those workshops can be found in **ANNEX 5.1.IV** or at the following weblink https://www.wmo.int/pages/prog/www/tcp/PTC-43_DocPlan.html

d) Global Coordination

- Development of TC forecaster competency.

e) Further development and establishment of Storm Surge Watch Scheme.

Regional component:

a) 16th session of the RA V Tropical Cyclone Committee for the South Pacific and Southeast Indian Ocean (Solomon Islands, 29 August-2 September 2016)
b) Forecaster Attachment Trainings in RSMC New Delhi, and Indian Institute of Technology Delhi (dates to be determined) and forecaster Attachment Trainings in RSMC Tokyo (RSMC Tokyo, 15–26 August 2016)
c) WMO International Workshop on Storm Surge and Wave Forecasting (Jointly with MMOP, date and venue to be determined)

5.1.4.2 In more general terms:

a) Activities for the implementation of the Tropical Cyclone Programme section of the WMO Strategic Plan;
b) Continued activities for the implementation of the Regional Cooperation Programmes, Technical Plans and other work programmes of the regional tropical cyclone bodies;
c) Actions following decisions made by the Seventeenth WMO Congress (Cg-XVII), the Executive Council, the Regional Associations concerned and the regional tropical cyclone bodies.

5.3 Outcomes and Recommendations from TCM-8

Below are presented the recommendations about Tropical Cyclone Coordination and Services. The TCM-8 full report can be found at the following weblink: https://www.wmo.int/pages/prog/www/tcp/reports.html

TROPICAL CYCLONE COORDINATION AND SERVICES
Outcomes of 17th WMO Congress (Cg-17) and Executive Councils for TCP

1. Further expansion and consolidation of the regionally coordinated systems to cover all Members prone to tropical cyclones;

2. Enhancement on the capacities of Members to provide more accurate forecasting and warning services which are impact-based and in multi-hazard approach (which is also a decision of EC-66);

3. Strengthening TCM in global coordination on tropical cyclones;

Recommendation: The TCM recommended that the TCP facilitate a task team that includes the RSMCs/TCWCs to draft an appropriate Terms of Reference for the TCM to address both current and future roles (by consulting other relevant Members as appropriate) for potential submission to EC which will include the aspects presented in the Cg-XVII documentation (ref. 3.197, 3.1.98, 3.1.99). The TCM proposed that it needs to better understand how the current evaluation of the WMO structure and constituent bodies will provide opportunity to move forward.

4. WMO Global Initiative for Tropical Cyclone Forecasting (WMO-GIFT).

Recommendation: The TCM acknowledged the request Congress made to TCM to develop a proposal to enhance its roles and activities (Cg-XVII 3.1.99) and in response agreed among the membership that the first step in this enhancement was in defining the TCM roles through confirming Terms of Reference. At that point the TCM will look at areas for further improvement and strengthening of programme activities. As part of that activity, some of the actions and decisions made during this meeting will be folded in to this effort and expressed in the Terms of Reference.

5.3.1 TCM should find an appropriate place in WMO governance. WMO should decide which technical commission, out of 8 is more suitable for it.

6. REVIEW OF THE COORDINATED TECHNICAL PLAN AND CONSIDERATION OF THE WORK PROGRAMME FOR THE NEXT FOUR YEARS

6.0.1 The Panel considered the coordinated technical plan 2016-2019 of the five components. It adopted the CTP 2016-2019 as shown in the **ANNEX 6.I**

6.0.2 The Panel considered the 2016 Annual Operating Plan (AOP) of the five components. It adopted the 2016 AOPs as shown in the **ANNEX 6.II.**

6.1 Working Group on Meteorology (WGM)

6.1.1 ACTIVITIES OF THE WGM

The report of WGM has been included in the AOP.

6.2 Working Group on Hydrology (WGH)

6.2.1 ACTIVITIES OF THE WGH

URBAN FLOOD RISK MANAGEMENT

Report by the Chair of PTC WGH.

The PTC member countries are facing multiple flood hazards such as Heavy rains due to cyclones which cause urban floods and inundate the whole city. Summer monsoon inherently provides torrential rains due to the moist current, monsoon low or depression each year .It generates urban floods causing inundation. Some cities in south east Asia are locating in the vicinity of major subduction fault line in the Sea ,which can trigger Tsunomogenic earthquake and inundation of the city.Some of the highly populated cities of the member countries are have such topography in which these are located near a flood plains and are affected by river floods as well as by urban floods due to heavy rains over the city and on the watersheds of the rivers passing through or near the city .While some cities are near to the coasts which fight against not only the storm surge but also the inundation due to the River floods ,where as in some cases it is at three pronged attack when the city falls in the grip of inundation due to tsunami ,storm surge and overhead heavy rains.
Consequently high financial losses occur to public exchequer in terms of destruction of infrastructure, loss of Human lives and Environmental degradation .Therefore it is the urgent need to develop an urban flood and risk management project to minimize the loses and damages.

Basically the Urban floods occur due to the following factors

- Torrential rain
- Less capacity of drainage system with respect to rain intensity
- Irregular topography
- Environmental pollution

To effectively mitigating urban floods and efficient Early warning is required which should be capable enough to make short, medium and long rang quantitative rain forecast.The prerequisite for such system the following studies are essential to be conducted for finding the root causes to propose suitable solution for managing the urban flood. This information's will also provide the scale of the flood for designing appropriate contingency plan and baseline for the remedial actions.

1: Probable Maximum precipitation,

2: Probable Maximum Flood

4: Inundation mapping for flood through rain and Tsunami (if required)

5: Disaster risk analysis and risk factor,

6: Storm rating, mass and frequency curve

7: Standing operating procedure.

Rainfall / Cyclone monitoring & flood forecasting for mega cities

Dr. M. Mohapatra in his presentation on Rainfall / Cyclone monitoring & flood forecasting for mega cities (www.rsmcnewdelhi.imd.gov.in) discussed that for an effective flood forecast and flood management, the information on the city's Hydro-Meteorological Parameters such as water bodies and their water level, drainage system, soil moisture, run off, and the city specific critical thresholds of rainfall for warning purpose is required. Also the hydrological model outputs are required for the decision support system. With this information Impact based warning products generation in text and graphics in GIS platform and suggested actions can be generated. For better generation and understanding of the forecast, there is need for capacity building of forecasters and stakeholders through regular training.

6.2.3 ACTIVITIES BY ESCAP

The Panel recognizes the urgent need to address urban flood risk. In this regard, the Panel ***recommends*** ESCAP and WMO to organize a joint expert meeting of the WMO/ESCAP Panel on Tropical Cyclones and the ESCAP/WMO Typhoon Committee to share experiences and expertise in managing urban flood risk in 2017. A project proposal on urban flood risk management of the Panel on Tropical Cyclones may be developed based on the discussions and information from the meeting.

6.3 Working Group on Disaster Risk Reduction (WGDRR)

6.3.1 ACTIVITIES OF THE WGDRR

6.3.2 ACTIVITIES OF THE ESCAP

Implementation of SFDRR in Asia-Pacific: International Network for Multi-Hazard Early Warning Systems (NM-HEWS)

The *Sendai Framework for Disaster Risk Reduction 2015-2030* (the Sendai Framework) calls for enhancing and strengthening multi-hazard early warning systems (MHEWS). In response to this call, the International Network for MHEWS (IN-MHEWS) was established as a multi-stakeholder partnership that will facilitate the sharing of expertise and good practices for MHEWS. 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 by deepening and extending regional coordination mechanisms for multi-hazard early warning systems including the WMO/ESCAP Panel on Tropical Cyclones and the ESCAP/WMO Typhoon Committee. In this regard, ESCAP will work with the Panel in strengthening the work of the Panel on multi-hazard early warning systems.

Impact-based Forecasting

Decision-makers and the public often found difficult to understand forecasting products and early warning in technical terms. Impact-based forecasting involves translation of hazard information into the potential impact as well as associated sectoral damage and loss under different scenarios. It enables engagement of all the key stakeholders for better disaster preparedness. ESCAP and UNDP, in collaboration with RIMES, is currently developing methodological options for impact-based forecasting. ESCAP will also work with the Panel on Tropical Cyclones to promote and build the capacity for the impact-based forecasting in the region.

6.4 Publications

Panel News

6.4.1 It is to inform that Panel News letter of PTC is a bi-annual document which is issued after every six months. During 2015-2016 two (02) publications of PTC newsletter "Panel News" Issue No. 39, 40 were published and the same were distributed among PTC Members, WMO, ESCAP 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.

6.4.2 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 May 2016 for 41st Edition.

6.4.3 Panel agreed to stop providing hard copy of PTC Newsletters in order to minimize expenses and instead sending of e-version of the Newsletters by email and to upload same on the PTC website.

7. REVIEW OF THE TROPICAL CYCLONE OPERATIONAL PLAN

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 2015) which was re-established by Dr. Mohapatra, rapporteur of Tropical Cyclone Operational Plan (TCOP) in 2015, with the support of the PTC Secretariat and in response to the recommendation of the Panel made at the 41st Session in Bangladesh and 42nd session in Thailand.

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 and PTC Secretariat about the updates/additions/amendments, if any, before mid of June 2016. Panel requested Dr M Mohapatra to act as Rapporteur for the year 2016 to update the Operational Plan of PTC.

8. PTC SECRETARIAT

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

8.2 On behalf of PTC secretariat, Mr. Alf Shareef, Vice-Chair of the PTC briefed the Panel on the activities of PTC Secretariat 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 **ANNEX 8.I**.

8.3 The PTC Secretariat provided the Panel with a detailed breakdown of its expenses incurred during the Inter-sessional period (see **ANNEX 8.II**). Upon request of the PTC Secretariat, the Panel agreed to provide US$ 4,000 to support the activities of the PTC Secretariat 2016.

9. SUPPORT FOR THE PANEL'S PROGRAMME

9.1 The Panel's Trust Fund

9.1.1 The Panel agreed to the participation of Secretary of PTC in the 49th Session of ESCAP/WMO Typhoon Committee as well as in the Annual Session of UN-ESCAP through PTC Trust Fund.

9.1.2 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.

9.1.3 The Panel endorsed the use of the Trust fund for 2016 for the following specific purpose:

1. Support to the attachment training at RSMC, New Delhi for per diem of the participants (US$ 6,000)

2. Support to the attachment training on storm surge in India for per diem of the participants (US$4,000)

3. Support to the PTC Secretariat for its operating expenses and running of the PTC-website (US$ 4,000)

4. Support to the participation of Secretary of PTC in the 11th Session of ICG/IOTWS

9.1.4 A detailed financial report of the Trust Fund as of 31 December 2015 was submitted by WMO to the Panel (see **ANNEX 9.I**).

9.2 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 **ANNEX 9.II** or is available at
https://www.wmo.int/pages/prog/www/tcp/PTC-43_DocPlan.html

9.3 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 **ANNEX 9.III** and **ANNEX 9.IV**.

9.4 Implementation of SFDRR in Asia-Pacific: International Network for Multi-Hazard Early Warning Systems (IN-MHEWS)

The Sendai Framework for Disaster Risk Reduction 2015-2030 (the Sendai Framework) calls for enhancing and strengthening multi-hazard early warning systems (MHEWS). In response to this call, the International Network for MHEWS (IN-MHEWS) was established as a multi-stakeholder partnership that will facilitate the sharing of expertise and good practices for MHEWS. 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 by deepening and extending regional coordination mechanisms for multi-hazard early warning systems including the WMO/ESCAP Panel on Tropical Cyclones and the ESCAP/WMO Typhoon Committee. In this regard, ESCAP will work with the Panel in strengthening the work of the Panel on multi-hazard early warning systems **ANNEX 9.V**.

10. SCIENTIFIC LECTURES

10.1 Presentations of scientific lectures

Following scientific lectures were delivered during this session.

1. *Flood monitoring and forecasting in India:* by Director, Central Water Commission, Govt. of India
2. *Disaster Risk Reduction Initiatives in India*: by Prof Santosh Kumar
3. *Storm Surge and Coastal Inundation Modeling*: by Prof. A.D. Rao
4. *Wave Monitoring and Forecasting In India*: By Dr T. BalaKrishnan
5. *Tropical cyclone advisory information for international civil aviation*, by Mr. Peter Dunda of ICAO
6. *On impact based forecasting - the experience of 2015/2016 El Nino,* by Dr. Sanjay Srivastava, Chief of Disaster Risk Reduction Section of ESCAP
7. *RIMES services to PTC*: by Dr. A.R. Subbiah, Director of RIMES

These lectures can be downloaded from the link http://rsmcnewdelhi.imd.gov.in

The Members thanked all the Resource Persons for delivering the scientific lectures, which helped in sharing of knowledge and experience.

Summary of the Tropical cyclone advisory information for international civil aviation, by Mr. Peter Dunda of ICAO (Lecture Nr 5 of the Item 10)

Considering the significant impact of tropical cyclones on the safety, regularity and efficiency of the air traffic system, and in view of air transportation's major role in global economic and social development – and the continuing, significant growth of air traffic – actions that lead to improved availability and quality of information on the occurrence or expected occurrence of tropical cyclones in support of international civil aviation operations can be viewed as positively contributing to the overall objectives of the PTC.

ICAO, in close coordination with WMO, develops the policies and Standards for meteorological service for international air navigation (contained in Annex 3 to the Convention on Civil Aviation) deemed necessary or desirable for safe and regular international air navigation. Annex 3 requires the provision of tropical cyclone advisory information by designated tropical cyclone advisory centres (TCACs).

Tropical cyclone advisory information provided by the TCACs should be provided in graphical format in addition to the required alphanumeric format. Information on tropical cyclones is also contained in the significant weather (SIGWX) forecasts issued by the two world area forecast centres (WAFCs). As a means of harmonizing the information on tropical cyclones, the TCACs are invited to participate in routine coordination sessions hosted by WAFC Washington.

The 2013 fourth edition of ICAO's Global Air Navigation Plan (GANP) (Doc 9750) introduces a rolling fifteen-year strategy for air transport improvements to 2028 and beyond — that will eventually realize a fully-harmonized global air navigation system. Meteorological information will be a key enabler to the realization of the global air traffic management operational concept envisioned by the GANP; future developments in aeronautical meteorological service will support improvements in global interoperability of systems and data.

Interoperability within the future air traffic system relies on the concept of system-wide information management (SWIM). The success of SWIM will be, in part, contingent upon the exchange of digital information that uses non-proprietary, open-source code forms such as the extensible markup language (XML) and the geography markup language (GML), since these will allow for the required streamlined sharing of information.

The transition to digital meteorological information exchange that will support the meteorological-component of SWIM commenced with Amendment 76 to Annex 3, applicable in November 2013, which enabled the exchange of aeronautical meteorological messages (specifically METAR, SPECI, TAF and SIGMET) in digital form using XML/GML by States in a position to do so. Amendment 77 to Annex 3, applicable in November 2016, upgrades the initial enabling provisions to the status of *Recommendation* and extends the requirement for digital exchange using XML/GML to other meteorological information including tropical cyclone advisory information.

Guidance on the information exchange model, XML/GML and the metadata profile is provided in the Manual on the Digital Exchange of Aeronautical Meteorological Information (ICAO Doc 10003).

To support implementation of Amendment 77 to Annex 3, States should consider the essential steps, including the development of software modifications, training of operational staff, testing of software and communications infrastructure, and operational acceptance of software changes, which are required in addition to addressing the modified ICAO provisions in national regulations and national implementation plans. Additionally, States may explore opportunities for twinning/mentoring arrangements to assist States in the implementation of digital information exchange.

In view of the above, the meeting recognized the importance of:

- Full implementation of the ICAO provisions related to the content, format and dissemination of tropical cyclone advisory information;
- Coordination of the information on tropical cyclones issued by the TCACs and WAFCs; and
- Migration to the digital exchange of meteorological information to support international air navigation, including tropical cyclone advisory information, and the essential steps to be followed by States in order to implement the proposed Amendment 77 to Annex 3.

10.2 Other issues

10.2.1 On the suggestion by Sri Lanka, the Panel agreed that RIMES may be requested to support the PTC in capacity building, strengthening observational and forecasting network in the PTC member countries.

10.2.2 Sri Lanka suggested the need for more capacity building activities for tropical cyclone forecasters in the PTC region. The Panel ***requested*** WMO to consider supporting training of tropical cyclone forecasters of PTC in various training activities conducted under the WMO-TCP and WWRP within and outside of the PTC region.

10.2.3 The Panel recognized the urgent need to address urban flood risk. In this regard, the Panel ***recommended*** ESCAP and WMO to organize a joint expert meeting of the WMO/ESCAP Panel on Tropical Cyclones and the ESCAP/WMO Typhoon Committee to share experiences and expertise in managing urban flood risk in 2017. A project proposal on urban flood risk management of the Panel on Tropical Cyclones may be developed based on the discussions and information from the meeting.

11. DATE AND PLACE OF THE FORTY-FOURTH SESSION

The Panel noted and appreciated that Maldives offered to host the 44th Session of the PTC in Maldives in 2017 subject to the approval of its Government. Dates will be determined in consultation with WMO, ESCAP and PTC Secretariat.

12. ADOPTION OF THE REPORT

The report of the forty-third session was adopted at 13:30 hours on Friday 6th May, 2016.

13. CLOSURE OF THE SESSION

The session closed at 13:40 hours on Friday 6th May, 2016.
