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Report on Activities of Working Group on Hydrology (WGH) of TC in 2019

(Item 9 of Tentative Program for TC 52nd Session)

(Submitted by WGH)

ACTION REQUIRED:

This Committee is invited to:

- a) Review the activities of TC WGH conducted in 2019
- b) Approve the recommendations and AOPs of WGH for 2020 and beyond

APPENDIXES:

- I. DRAFT TEXT FOR INCLUSION AT SESSION REPORT
- II. Report on activities of Working Group on Hydrology (WGH) of TC in 2019

APPENDIX I

DRAFT TEXT FOR INCLUSION AT SESSION REPORT

9.2 Hydrological Component

1. The Committee reviewed the activities of the Members related to the implementation of the TC Strategic Plan and its annual operating plan (AOP) for the hydrological component during the past year. Details can be found in the **Appendix ??**.
2. The Session noted that, the water-related disaster events, including river flood, urban flood, flash flood and debris flow, and drought caused serious damage in most Members of the Committee in the past year, such as Cambodia; China; Lao PDR; Japan; Republic of Korea; Malaysia; Philippines; Thailand; Guam, USA; and Vietnam, etc. The hydrological departments in the Members provided valuable service of flood forecasting and early warning to the decision-making departments of the Governments. The Members achieved remarkable progresses on capacity building of hydrological monitoring, data collection and flood forecasting and early warning in 2019, particularly data sharing of hydrological information of dam operation in China; flood forecasting and warning system development in Philippines; flood risk mapping and flood inundation mapping in Malaysia and the Republic of Korea; hydrological monitoring network construction in Laos; and flash flood warning system application in Vietnam.
3. The Session noted with pleasure that, WGH 8th Working Meeting with theme of “Knowledge Sharing on Hydrological Data Quality Control and Flash Flood Forecasting Using Radar Rainfall Data” was successfully held in Seoul, Republic of Korea (ROK) from 15 to 18 October 2019. Totally 26 participants from 9 Members, namely China, Japan, Lao PDR, Malaysia, Philippines, the Republic of Korea, Thailand, USA and Vietnam, and the hydrologist of TCS, took part in the meeting. The Session expressed its appreciation to the Government of the ROK through the Han River Flood Control Office (HRFCO) of the Ministry of Environment (ME) and the Korea Institute of Civil Engineering and Building Technology (KICT) for generously hosting the meeting.
4. The Session was informed with appreciation that the Japan is willingness to host WGH 9th Working Meeting from 21 to 22 October 2020 in combination with the 4th Asia Pacific Water Summit to be held in Kumamoto, Japan from 19 to 20 October 2020.
5. The Committee was informed on the implementation status in 2019 and future activities of on-going projects (AOPs):
 - a) Flash Flood Risk Information for Local Resilience
 - b) Application of Hydrological Data Quality Control System in TC Members
 - c) Enhancement of Flood Forecasting Reliability with Radar Rainfall Data and Stochastic Technique
 - d) OSUFFIM Phase-II: Extension of OSUFFIM Application in TC Members

- e) Impact Assessment of Climate Change on Water Resource Variability in TC Members
 - f) Flood Risk Watch Project for Life-saving
 - g) Platform on Water Resilience and Disaster under IFI (International Flood Initiative)
6. The Session noted that, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) and International Centre for Water Hazard and Risk Management (ICHARM) of Japan conducted a series of activities in 2019 for implementation of the project on Flash Flood Risk Information for Local Resilience, including further research, sharing good practices and hosting held a session at the World BOSAI Forum. The Session was informed that the project which was launched in 2017 has been closed at 52nd Session, and an electric version of Final Report for summarizing the implementation and achievement of the project was uploaded on the TC webpage under TC Publications.
7. The Session noted that, two expert-missions were sent to Lao P.D.R, Malaysia, Philippines and Thailand in 2019 for field survey of the project led by ROK on Application of Hydrological Data Quality Control System. ROK has drafted the design report and technical report for developing hydrological data quality control system. The operation platform is already in development. The Session was also noted that, in 2020, a field survey wrap-up meeting for this project will be held in Seoul in May 2020; the technical report will be finalized and published at TC 15th Integrated Workshop to be held in Vietnam; and the operation platform will be further improved with establishment of database and criteria.
8. The Session noted that, in conjunction with AOP2, two expert-missions were sent to Lao P.D.R, Malaysia, Philippines and Thailand in 2019 for field survey of the project led by ROK on Enhancement of Flood Forecasting Reliability with Radar Rainfall Data and Stochastic Technique. ROK has drafted the design report for upgrading LEVEL 3 of Extreme Flood Forecasting System (EFFS) & establishment of stochastic forecasting system. The Session also was noted that, in 2020, the field survey wrap-up meeting will be held in combination with AOP2 in Seoul, and the LEVEL 3 of EFFS will be upgraded focusing on the analysis of the past radar rainfall data couple with flood stage.
9. The Session noted that, the phase-II of the project on Development and Application of Operational System for Urban Flood Forecasting and Inundation Mapping (OSUFFIM-II) for TC Members, which is led by China, made remarkable progresses and achievement in 2019, including: a) published the Guidelines for Developing Operational System for Urban Flood Forecasting and Inundation Mapping as TC publication (TC/TD-No. 0017) in March 2019; b) totally 5 workshops/seminars (joint working) were held in Sun Yat-Sen University with funding support in 2019, including one for Thailand in July; one for Vietnam in August; one for Malaysia in October; two short-seminars with participants from piloting Members and TCS in February and August, respectively. c) totally 7 expert missions with 11 person-times from Sun Yat-Sen University were sent to Malaysia, Philippines, Thailand, and Vietnam for DEM data collection, river measuring, system configuration, and software installation.

10. The Session also was informed that, OSUFFIM-II will conduct following activities in 2020: a) for Malaysia, the flood forecasting system will be installed and put into trial operation in Pinang catchment. Based on this goal, two field works and a training workshop have been scheduled in 2020. b) for Philippines, the necessary funding will be raised for promoting the hydrological observation network and finalize the flood forecasting model for Martina catchment. At least two field works in the river basin and a working meeting in Sun Yat-Sen University have been schedule. c) for Viet Nam, the flood forecasting system will be installed and put into trial operation in Hue. Two field works and a training workshop in Viet Nam are also. d) two more pilot studies will be selected in Thailand, Cambodia and Laos if requested. e) a high level Panel meeting has been planned to be held in Sun Yat-Sen University in the middle of 2020 before WGH 8th working meeting with at least one expert from each involved Member and 3 experts from other TC Members for evaluation of OSUFFIM. f) an OSUFFIM workshop has been planned to be held in Sun Yat-Sen University in 2020 after the TC 15th IWS.
11. The Session noted that, the piloting Members requested China-side to consider the possibility to extend the AOP of OSUFFIM-II, which was proposed to be closed in 2020, two more years to 2022 for providing continual technical support, considering there are many work not yet completed in participating Members on DEM data collection and analysis, system configuration may not be totally completed in 2020.
12. The Session was informed that, the implementation activities were conducted in 2019 for the project on the project on Impact Assessment of Climate Change on Water Resource Variability in TC Members, including: 1) two short training workshops on the Research Center for Climate Change Water Balance Model (RCCC-WBM) were held in Nanjing Hydraulic Research Institute (NHRI) of China for Lao PDR and Malaysia in January and December, respectively. 2) the team leader, Dr. Zhenxin BAO visited Laos and Malaysia in September for field survey and discussion on the application of RCCC-WBM model in in typical catchments. 3) One and three pilot rivers have been selected in Laos and Malaysia, respectively. The input data have been prepared well for the RCCC-WBM model, and the model parameters of the RCCC-WBM model have been calibrated, and will be used for water resources simulation. The Session was also noted that, the activities will be conducted in 2020 including: 1) to generate hypothetical climatic scenarios in the typical catchments in Laos and Malaysia; 2) to run the RCCC-WBM model to simulate streamflow using the hypothetical climatic scenarios as inputs; 3) to assess the impact of CC on water resources in the typical catchments in Laos and Malaysia; and 4) to hold a workshop on the outputs of this project.
13. The Session was informed that, the progresses of the Japan-led project on Flood Risk Watch Project for Life-saving in 2019 includes 1) conducted the field survey from 22 to 24 January 2019 in Malaysia at Klang Valley and Langat, Pinang river basin; 2) held a meeting on 25 January 2019 in Malaysia; and 3) conducted the meeting for further discussion on 24 October 2019 in Malaysia. The Session was also noted that, the activities to be conducted in 2020 will include 1) to conduct the expert mission with Malaysia to share Japanese experiences in January 2020 in Japan (??); and 2) to seek the possibility to introduce 3L (low-cost, long-life and localized) water level gauge and system in Malaysia and TC Members.

14. The Session was informed that, the Project of Platform on Water Resilience and Disasters under IFI (International Flood Initiative), which was proposed by ICHARM of Japan at 51st Session as one of TC cross-cutting projects, has achieved progresses as: 1) conducting IFI Platform session on 7 February 2019 in Manila, the Philippines with participants from WGH members and TCS hydrologist. 2) conducting the capacity development training program on Flood Forecasting for Thailand, and on Climate Change Adaptation for Philippine. 3) conducting the preliminary study on how to establish the platforms in the TC Members. and 4) participating in the 46th Session of Panel on Tropical Cyclones (PTC) on 9-13 September 2019 and making bridges between TC WGH and PTC. The Session was also informed that, the main activities to be conducted in 2020 includes: 1) to conduct IFI Platform session in Philippines with the participation from JMA; 2) to conduct the capacity development training program in the TC member countries upon requests; 3) to disseminate the IFI Platform activities at regional/international conferences including the 4th Asia Pacific Water Summit in October 2020; 4) to organize a thematic session at 9th WGH meeting which will be in conjunction with 4th Asia Pacific Water Summit. and 5) to make bridges between TC WGH and PTC through implementing the IFI Platform activities in the Philippines, Myanmar, Sri Lanka and Indonesia.
15. The Session was informed that, Weather Forecast Office (WFO) Guam, USA proposed a cooperation project on Knowledge Sharing on Storm Surge Inundation Modeling as one of AOPs of WGH with objectives of providing a storm surge inundation mapping open source program to interested Members to assist in providing this data to their respective offices of emergency management. The goal is to provide the program and assist the interested Members in adjusting this program for their respective countries. The proposed AOP will be implemented for a period of 3 years from 2020 to 2022 with the road map as: 1) in 2020, to introduce Pacific Ocean Storm Surge Inundation Modelling (POSSIM) to all working groups; to identify interested TC members and coastal regions to be covered; to determine of availability of LiDAR and other bathymetry data; and to determine necessary expert missions to provide local enhancements to program; 2) in 2021, to determine which Members will need expert missions or assistance in producing bathymetry data, preferably LiDAR; and to possibly provide expert mission to interested Members to assist in localizing POSSIM; and 3) in 2022, this program could be extended to interested PTC countries as well. The Session also informed that, the implementation activities to be conducted in 2020 will include: 1) summary of interested TC Members and coastal regions to be covered during first 2 quarters of 2020; 2) determination of availability of LiDAR or other bathymetry data for the interested Members during last 2 quarters of 2020; and 3) determine necessary expert missions to provide local enhancements to program during final quarter of 2020.
16. The Session noted that, TC WGH webpage has been continue operating for sharing information among WGH members, and has been linked with TC Webpage (<http://www.typhooncommittee.org/wgh-web-page/>). The webpage will be updated and operated by HRFCO continuously in cooperation with KICT and TCS.
17. The Committee noted that, Mr. YU Jun, Regional Officer of WMO Regional Office for Asia and the South-West Pacific in Singapore, made a presentation on “Regionalizing WMO” at TC

14th IWS, which provided valuable information for WGH to enhance the cooperation with other regional bodies of WMO in future.

CONCLUSIONS OF WGH

18. On the basis of the outcomes 8th WGH working meeting and the discussion of the WGH Parallel Session at 14th IWS, the following conclusions were reached:
- It is a consensus on that, the working meeting of WGH is very important to review and push forward hydrological activities with deep technical discussion of implementation status of WGH AOPs, and also is very necessity to prepare both IWS and annual session. The funding support and in-kind contribution from Members have played a vital role in organizing the annual working meeting. WGH appreciated the generous contribution from Republic of Korea and Japan in the past years, and encourages the more and wider resources to support the activities to keep its sustainability. WGH also encourage more Members to host its working meeting.
 - It is recognized that, to effectively promote the capacity of forecasting, early warning and risk management for urban flood risk is an urgent need among TC Members, especially the real-time operational system on urban flood forecasting and inundation mapping. As the subsequent activity of TC first Cross-cutting project of Urban Flood Risk Management (UFRM), the on-going project of WGH on Development and Application of Operational System for Urban Flood Forecasting and Inundation Mapping (OSUFFIM) is a tangible measure on this aspect and it will play very meaningful and important role for TC Members to promote the capacity on the technique of urban flood forecasting and warning. To extend the achievement of pilot study in the region is necessity and meaningful to promote the capacity on urban flood risk forecasting and warning. Urban flood inundation mapping definitely is very complex, particularly development of a real time operational system. China-side was requested to consider the possibility to extend the AOP of OSUFFIM two more years to 2022 to provide continual technical support for Members on DEM data collection and analysis, system configuration, etc..
 - It is a consensus on that, to draw up a plan on considering and proposing a bank of new cooperation projects under the umbrella of TC Strategic Plan in a linkage with the initiatives and activities of ESCAP and WMO would be an urgent matter at present for WGH since all on-going AOPs of WGH will be closed in 2020-2022. In order to conduct the cooperation projects sustainably in TC Members, WGH discussed and determined the list of topics as the priority cooperation activities for long-term direction to develop the Member's Capacity on water-related disaster risk forecasting and warning.
 - Hydrological monitoring network (station) is the cornerstone of all hydrological activities and an important basic work to serve economic and social development and ecological civilization construction. In recent years, the construction of hydrologic monitoring network in TC Members has been developed rapidly. The increasing amount of hydro-meteorological data collected in real time has brought new challenges to the management mode of the monitoring operation of the existing hydrological stations and the integration of hydrological data. The collection of raw-

data is basic, and the data quality control is great significance to ensure the accuracy of flood forecasting and warning as well as project design and construction. Nowadays, the lack of standard data-processing procedure and comprehensive operation platform for hydro-meteorological data quality control is a common problem existed in the most TC Members. WGH recognized that, it is necessary and very meaningful, based on existing works and experiences in Members, to enhance the study of the standard data-processing procedure, and to design and develop an integrated working platform with comprehensive functions, high efficient and easy operation.

- Enhancement of the close collaboration with the WMO CHy, WMO RA II Working Group on Hydrological Services in several themes of common interest provides significant benefits to the Committee. WGH should take substantial measures to step forward. WGH is willing to enhance the cooperation with PTC and other regions, under the Cooperation Mechanism between TC and PTC, through involving more participants from outside of Typhoon Committee region in WGH AOPs and working meeting.

RECOMMENDATIONS OF WGH

19. On the basis of the outcomes of 8th WGH working meeting and the discussion at the Parallel Session of 14th IWS and subsequent discussion, the WGH made the following recommendations:
 - to request US\$13,000 from TCTF in total for supporting WGH members participating TC 15th IWS to be held in Vietnam.
 - to request US\$25,000 from TCTF in total for supporting overall WGH activities for 2020 calendar year.
 - to approve the proposal of the project on Knowledge Sharing on Storm Surge Inundation Modeling by WFO Guam as one of AOPs of WGH.
 - To request China to extend the project on OSUFFIM to the year of 2022 for providing continual technical support to Members.
 - to thank Republic of Korea for hosting WGH 8th Working Meeting in Seoul from 15 to 18 October, 2019.
 - To request Japan to host WGH 9th working meeting with funding support in a junction with 4th Asia Pacific Water Summit to be held in Kumamoto, Japan in October 2020.
 - to request HRFCO to continue maintaining and operating the WGH webpage for effective sharing information among WGH members with support from KICT and TCS.
 - to appoint the focal point of WGH in RO Korea, Dr. Hyeongyo JEONG, as the liaison to PTC and WMO RA II for WGH of the Committee for enhancing hydrological cooperation between TC and other regional bodies.
 - to continue focusing on improving the ability to forecast hydrological phenomena and provide measures for the effectiveness of the improvements.

APPENDIX II

Report on Activities of Working Group on Hydrology (WGH) of TC in 2019

In 2019, Working Group on Hydrology (WGH) of Typhoon Committee (TC) conducted a series of activities very positively referring to the decision of 51st Session which was held at in Guangzhou, China from 26 February to 01 March 2019. This report was drafted mainly on the base of the outcomes of 8th WGH working meeting which was held in Seoul, Republic of Korea from 15 to 18 October 2019, and the discussion of the parallel session of TC 14th Integrated Workshop (IWS) which was held in Tumon, Guam, from 4 to 7 November 2019.

The report highlighted the main progresses and achievements on hydrological component in Members in past year; briefed the activities of WGH conducted in 2019, and summarized the status of implementation of WGH AOPs 2019. Based on the communication among Members and the discussion at TC 14th IWS, WGH proposed the implementation plan of AOPs for 2020 and beyond; and consequently requested the TCTF allocation for supporting WGH activities in the year of 2020.

I. The Major Progresses on Hydrological Component in Members in 2019

- 1) The WGH reviewed the hydrological activities conducted in Members in 2019 and noted the major progresses which may benefit other Members.
- 2) In Cambodia, the rainfall intensity from January to May is below normal according to El Nino effected and near normal from May to September. Dry spell occurred in the third week of July for 7 days. In the first period of the year (January to April); almost provinces received less rainfall and severely dry occurred in low lying area and Coastal Area and near normal in Plateau area. From May to September the rainfall situation was becoming normal over the county; and extremely wet found in coastal area and Plateau area from August to September.

In the early August the monsoon trough lied across the upper part of Thailand, Laos and Vietnam toward to the low pressure cell in upper South China Sea associated with the active southwest monsoon prevailed over the Gulf of Thailand lead to continuously rainfall over coastal area associated the torrential rain at midnight 08 August for 272 mm per 6 hours caused severe flash flood in Sihanouk ville (Kampongsm province).

- 3) In China, there are totally five typhoons landed in the mainland in 2019, among which the super strong typhoon Lekima caused 139 rivers of 8 provinces exceeding the warning level, 54 rivers exceeding the guarantee level, and 10 rivers claimed the historical record of flood. In the coastal area, there are 7 tide stations reported high tide levels exceeding the warning level, and one tide stations reported high tide levels that exceeded historical records.

Based on 130 climatic factors, long series hydrological observation data and earlier stage of weather conditions, China carried out the medium and long term prediction of precipitation, typhoon, flood and drought situation of flood season using pattern recognition and data mining technologies, which effectively supported the deployment of flood and drought disaster prevention and the rainstorm and flood caused by typhoon. Besides, China strengthened the data sharing of hydrological information of

reservoirs, and developed an integrated flood forecasting and reservoir regulation system, which improves the flood forecasting accuracy and effectively supports the decision making of flood regulation.

- 4) Hong Kong, China was affected by five tropical cyclones in 2019, up to 28 October, namely Tropical Depression Mun (1904) in July, Tropical Storm Wipha (1907), Severe Tropical Storm Bailu (1911) and Tropical Storm Podul (1912) in August, Tropical Depression Kajiki (1914) in September. Among them, only Wipha necessitated the issuance of the No. 8 Gale or Storm Signal. Wipha was also the wettest tropical cyclone affecting Hong Kong by far in 2019, bringing more than 350mm of rainfall to some parts of the territory. For Bailu, bands of intense thundery showers associated with it brought frequent thunderstorms and squalls to Hong Kong on the small hours of 25 August. Nearly 4000 cloud-to-ground lightning strokes were also recorded in Hong Kong for that period.

A dedicated website for the Regional Specialized Meteorological Centre (RSMC) for Nowcasting has been operating to provide real-time rainfall nowcast and significant convection products to NMHSs (<https://rsmc.hko.gov.hk/>). As a core component of RSMC Nowcasting in support of capacity building in nowcasting of high-impact weather, the community version of the SWIRLS nowcasting system, a.k.a. “Com-SWIRLS”, has been completely revamped using Python programming language and open-source libraries. The Hong Kong Observatory (HKO) enhanced the WMO website of SWIC using technology of Geographical Information System (GIS) adopting the latest WMO map from ArcGIS. As at Sep 2019, the SWIC 2.0 website incorporates 64 official data feeds of warnings and alerts, including tropical cyclone related ones, in the format of Common Alerting Protocol (CAP) from Members. An “Earth Weather” webpage featuring NWP forecast products over the Asia-Pacific region was launched in March 2019. With interactive display of NWP products, the webpage displays wind forecasts from the ECMWF model for the next nine days using animated streamlines and allows users to select a colour overlay showing the distribution of temperature, rainfall or wind speed. Furthermore, users can overlay the tropical cyclone forecast tracks issued by the HKO to better appreciate the spatial extent of winds and rainfall forecasts associated with the tropical cyclone.

For stakeholder engagement and public education, the HKO and Fire Services Department co-organised two identical half-day Government-wide Seminar on Tropical Cyclone Disaster Preparedness and Response before the tropical cyclone season in 2019. A special 6-episode series of educational videos on the impact and damages brought by Mangkhut was also produced for broadcasting on local TV stations as well as HKO’s social media platforms. Moreover, HKO is collaborating with the COPE Book, a series of beautifully illustrated children’s books intended for global distribution, to increase the disaster resilience of children.

- 5) Torrential rain fell in Saga, Nagasaki, Fukuoka, Japan due to a rain front from 27 to 28 August, 2019. Some river overflowed and it caused flooding at residential areas and a lot of oil spillage in residential areas due to inundation of iron works. MLIT constructed an oil fence around the ironworks and the sluice pipe was gated to prevent an oil spillage in the river and the sea.

Typhoon Hagibis hit eastern Japan on October 12 and 13, 2019 and caused record-breaking rain in Japan from 12 to 13 October, especially in Tokyo and surrounding areas. The total amount of rainfall reached 1000mm in Kanagawa, and it exceed 500mm in 17 areas. The torrential rains caused flooding and levee breaches in 139 sites totally. In this event, 70 people died and 11 people were missing, 52,989 houses were inundated. MLIT dispatched TEC-FORCE (Technical Emergency Control Force) with pumping vehicle. Emergency works were conducted around the clock. MLIT completed all of the works(MLIT levee) within about a week.

MLIT attended the Fourth UN Special Thematic Session on Water and Disasters which was held on June 24, 2019 in New York (UN-ECOSOC Chamber) with participants from Indonesia, Japan, Korea, Mexico,

the Netherlands, Tajikistan, and the High Level Panel on Water and Disaster. The primary objective of the event is to overarch the issue of Water-related Extreme Events, which are to be placed at the core of Adaptation to Climate Change and are crucial for achievement of sustainable development. Japan made contributions to this meeting including the keynote speech by Kudo Shozo, Vice minister of MLIT. “The Principles on Investment and Financing for Water-related Disaster Risk Reduction” was published for this meeting. It would promote the capacity on investment for disaster prevention and preparedness.

Japan will host the 4th Asia-Pacific Water Summit from 19 (Mon) to 20 (Tue) October 2020 in Kumamoto City, Kumamoto Prefecture with the theme of Water for Sustainable Development ----Best Practices and Connecting to the Next Generation.

- 6) Lao PDR was effected by 3 storm From August 28 to September 1, 2019, that as Wipha, Podul and Kajiki moved into the Central and southern part of Laos and then there was a moderate to heavy rainfall from September 1 to 6 in the south. Over the six days, there were some areas with a total rainfall of 140 to 700 mm. The southeast monsoon dominated in the south with moderate to heavy rainfall and heavy rainfall in some areas..

Due to the continuous rainfall in the period, the levels of the Mekong River and the tributaries of Central and the South continued to increase, especially in Khammouane, Savannakhet, Champasack, Saravan, Sekong and Attapeu provinces extensive inundation caused great damage to people's property and transportation.

At the tributaries level, there was also an increase in water levels, especially in Xebangfai, Xedone, Xebanghieng and Xekong Rivers. Until September 17, 2019, the level of the Mekong River and its tributaries have been decreasing.

Despite the downward trend, water levels and tributaries remain in danger.

Therefore, it is important to remind all the authorities and tribal people living along the Mekong River in the south and along the Rivers such as XeBang, Xeon, Sekong and Sekong to keep their livestock and livestock in high ground.

- 7) In Malaysia, National Flood Forecasting and Warning Centre (PRABN) was managed flood forecast model for three river basins during northeast monsoon season from November 2018 to January 2019. It was successfully issued 3 flood forecast warning for the Terengganu river basin areas. First forecast warning issued in 5th November 2018 predicted 50 villages will affected by flood. In 6 November 2018, second forecast warning issued for reducing the possible flooded area to 12 villages. In late evening 6 November 2018, the storm was turn to north-ward direction and landed in southern part of Thailand. Further, third flood forecast warning issued in 14 December 2019 for Terengganu river basin provide early warning to 22 villages affected. Between January to September 2019, 185 flash flood events occurred in the whole country where the state of Sarawak recorded highest numbers of flash flood.

The establishment flood forecasting systems in three river basin using advance technology and the capabilities to simulate real-time flood inundation area using 2D analysis with supported 7 days in advance Numerical Weather Prediction rainfall data strongly help to support readiness disaster prevention agencies and increase the preparation time for early evacuation. Under National Flood Forecasting and Warning Programme (PRAB), the system will expand to 38 major river basins for the whole country.

Department of Irrigation and Drainage has updated 7 Hydrological Procedures (HPs) and also produced 3 new Hydrological Procedures. The new HPs were focusing on the installation of instruments for rainfall, water level and water quality.

- 8) The Republic of Korea was affected by seven (7) typhoons directly or indirectly from July to early October 2019, which is the record for the past 60 years. Especially after September, three (3) typhoons affected with heavy rain.

In 2019, the Flood Control Office issued seventeen (17) flood alerts nationwide: Two (2) alerts by the Yeongsan River Flood Control Office due to the heavy rain caused by the monsoonal front, and Two (2) alerts by the Nakdong River Flood Control Office and the Yeongsan River Flood Control Office, respectively, affected by the typhoon TAPHA. And the rest Thirteen (13) alerts by the Nakdong River Flood Control Office affected by the typhoon MITAG. In addition, the level of crisis warning was subdivided into four levels to spread the risk of flooding through cell phone text messages. A text message service was also provided for the management of facilities located along the stream and the river.

In Korea, the scope and works of flood forecasts (special flood bulletin and information) by reflecting the trend of unexpected heavy rainfall due to climate change are expanded to enable to diagnose the situation and respond rapidly. In this regard, as of 2019, 60 spots for special bulletins nationwide will be expanded gradually to 70. When heavy rainfall due to typhoons or barometers are expected, increase in water level at 60 stations nationwide are estimated based on precipitation forecast data and results of numerical forecasting model. This information called “Flood Projection against Heavy Rainfall” data is provided for related organizations and agencies to help preparation for typhoons and heavy rain in a practical field.

The national-wide basic survey for flood risk mapping was conducted in 2001, and was completed for national rivers in 2016. Since then, the Han River Flood Control Office (HRFCO) of the Ministry of Environment, has been making a flood risk map to prepare for flooding of local rivers and urban flood inundation. The flood risk maps will be completed for all rivers in all over the country by 2021. Flood risk mapping for the Nakdong River area was launched in 2018, and is underway for the Geum River area in 2019. In addition, the HRFCO is operating the production standards for the flood risk mapping to ensure the accuracy and quality of flood risk maps, and updating them to reflect the latest technological advances.

- 9) In Thailand, there are 3 tropical storms impacted the country from January to September 2019. The first tropical storm ‘PABUK’ reached the southern east coast peninsula on 3rd January. The precipitation in Nakhon Si Thammarat Province was almost 300 mm within 2 days. It caused overbank flow and urban flood in many areas in the south of Thailand. The latest tropical storm ‘PODUL’ greatly affected Thailand in late August. It caused heavy rainfall in the Northeastern Region of Thailand. Ubon Ratchathani Province was the most impacted area that faced the big floods (about 20-year return periods) for almost a month. The water depth in some areas were more than 4 meters. The situation was recovered to normal condition on 4th October.

Meanwhile, Thailand particularly in lower northeastern (e.g. Nakorn Ratchasima Province), and central regions (e.g. Suphanburi, Uthaitхани Provinces) also faced the drought situation for few months in the mid-year, despite during rainy season. From February to mid of July, there were many areas occurred the drought in the North Northeastern, and Central Regions. The amount of precipitation was 10-20% less than the average. Several large-scale dams in Thailand only had water stored around 30% of their capacities. Thailand’s water related agencies such as Royal Irrigation Department had to adjust the water management plan to solve the problems.

- 10) In Guam of USA, by the end of September, 2019, below normal rainfall occurred across the Marianas and Micronesia as only 1 major tropical system affected Kosrae, Pohnpei, and Chuuk States in Micronesia with more systems affecting the Marianas, mainly over the northern CNMI. A few moved through the region north of the Micronesia islands as Tropical Disturbances before developing into Tropical Storms or

Typhoons north and west of the islands. The end of 2018 through mid-2019 saw a borderline/weak El Niño pattern. El Niño reverted to ENSO-neutral by September and is expected to continue through spring of 2020. Dry conditions developed over the northern Marshall Islands and the Marianas from the middle of February and continued for most of Micronesia through late June. Dry conditions continued through late July for the Marianas and the northern Marshall Islands, when beneficial rains eased the water shortage. Drought Information Statements (DGT) were provided by the WFO Guam on a bi-weekly basis from February 2019 until the final statement was issued, ending the drought on August 22. A total of 15 Drought Information Statements were issued during this period.

Several tropical systems affected the western Pacific from October 2018 through the end of September 2019. Super Typhoon Yutu brought massive devastation to the islands of Tinian and Saipan, along with heavy rainfall. Rainfall amounts are estimated due to the loss of rain gauges to the storm. Rainfall estimates were in excess of 10 inches (~255 mm) for both Tinian and Saipan, while less than 2 inches occurred on Rota and Guam. Super Typhoon Wutip began as a tropical disturbance south of Kosrae around February 16, bringing heavy rains to most of the islands along with tropical storm to typhoon force winds to a few of the islands of western Pohnpei and Chuuk states. The storm slowed and lingered to the southwest of Guam, keeping tropical storm conditions over the island for an extended period of time along with heavy rainfall in excess of 6 inches (~150 mm) over 36 hours. TD 17W formed east of the Mariana Islands in mid-September. This system moved toward the north-northwest, eventually becoming TS Peipah. This system brought heavy rain to the islands, with a new record daily rainfall of 8.20 inches (~209 mm) of rain in less than 24 hours for Guam, and amounts in excess of 6 inches (~150 mm) for the remainder of the Marianas. This resulted in a Flash Flood Warning for Guam and Urban and Small Stream Flood Advisories for the CNMI.

Otherwise, a few weak disturbances brought short periods of beneficial rains to many of the smaller islands experiencing drought conditions.

- 11) Vietnam was directly affected by 5 storms and 8 heavy rain-events as of the end of October 2019. Especially, the rain event from September 1-5, 2019 in the central provinces, the common rainfall is from 400-700mm; Some stations reach over 1000mm. Extreme flood exceeding the level 3 has appeared in the rivers of Ha Tinh, Quang Binh, Quang Tri and Quang Ngai provinces; extensive inundation caused great damage to people's property.

With the promotion of the socialization of hydrometeorology, the number of automatic rain gauge stations in Vietnam has exceeded 1500 up to September 2019. A system of hydro-meteorological data management is in the process of being completed (Center Data Hub), which will manage all types of hydro-meteorological data, radars, digital model products, forecast messages. All these data are shared online with the Disaster Prevention Steering Committee to support the decision-making process to minimize damage.

In addition, the Southeast Asia flash flood warning system (SeAFFG) is being implemented by support from WMO, and HRC. Vietnam with a role of regional center has established a system to receive data from countries of Lao DR, Cambodia and Thailand and is expected to operate the SeAFFG system in 2020.

II. Review of the eighth WGH Working Meeting

- 12) Following the decision at the 51st Session of ESCAP/WMO Typhoon Committee (TC) which was held in Guangzhou, China from 26 February to 01 March 2019, the 8th Meeting of TC Working Group on

Hydrology was held in Seoul, Republic of Korea, from 15 to 18 October 2019 at the kind invitation of the Han River Flood Control Office (HRFCO) of the Ministry of Environment, Republic of Korea.

- 13) The proposed theme of the meeting is “Knowledge Sharing on Hydrological Data Quality Control and Flash Flood Forecasting Using Radar Rainfall Data” with the following purposes:
 - to review the implementation progresses of WGH Annual Operating Plan (AOP) in 2019;
 - to introduce Korean national hydrological data quality control system and flash flood forecasting using radar rainfall data in Korea;
 - to share the information on hydrological data quality control techniques in Members;
 - to proposal the implementation plan and success indicators for WGH AOPs in 2020;
 - to discuss the preparation and hydrological contribution to prepare the 14th Integrated Workshop to be held in Guam and 52th Annual Session in 2020.
- 14) The meeting was held in the Han River Flood Control Office (HRFCO) of Ministry of Environment and the Korea Institute of Civil Engineering and Building Technology (KICT) consecutively.
- 15) The Meeting was co-chaired by WGH chairperson Dr. Tetsuya Ikeda, Chief Researcher of International Centre for Water Hazard and Risk Management (ICARM), Japan, and vice chairperson Dr. Hyo-Seob CHO, Director of Water Resources Information Center of HRFCO, Republic of Korea. The Director General of HRFCO Mr. Jeong-Seop HONG delivered his opening address.
- 16) The meeting was attended by 26 participants in total from 9 Members, namely China, Japan, Lao PDR, Malaysia, Philippines, the Republic of Korea, Thailand, USA and Vietnam. Dr. Jinping LIU, the hydrologist of TCS took part in the meeting.
- 17) The meeting reviewed the implementation progresses of WGH Annual Operating Plan (AOPs) in 2019; discussed the success indicators for AOPs in 2020 and preliminary budget request for support the activities of WGH in 2020.
- 18) The meeting shared the technology and experiences on Flash Flood Forecasting Using Radar Rainfall Data in Republic of Korea and National Hydrological Data Quality Control System in Republic of Korea and Quality Control Techniques.
- 19) The meeting discussed the potential proposals of new AOP for WGH in next years.
- 20) The meeting also discussed how to enhance the cooperation among Members through the implementation of AOPs with the target of promoting the capacity building of flood forecasting and warning.
- 21) The participants expressed their heartfelt appreciation to Republic of Korea Government through HRFCO with cooperation of KICT for kindly hosting the meeting and for all the excellent hospitality and logistic arrangement.
- 22) Dr. Masahiko MURASE, Head of International Affair Office, Water and Disaster Management Bureau of MLIT, Japan, expressed Japan-side is willingness to host WGH 9th Working Meeting in combination with the 4th Asia Pacific Water Summit to be held in Kumamoto, Japan in October 2020. The participants expressed their sincere appreciation to Japan Government for the generous offer. Also it is regarded that it should be a good opportunity for hydrologists from Members to share the information and the knowledge at 4th Asia Pacific Water Summit.
- 23) The representations from Malaysia expressed their willingness to host the WGH working meeting subject to the funding support for participants from Members. Japan and the Republic of Korea

expressed their willingness to seek the funding to support hosting WGH working meeting in selected Member. Thailand also expressed to consider the possibility of hosting the meeting.

- 24) It was suggested that, WGH may consider the possibility to involve the Members from Panel of Tropical Cyclone (PTC) in to its activities under the Cooperation Mechanism between TC and PTC.

III. Progresses of WGH AOPs in 2019 and Implementation Plan for 2020

- 25) The implementation status and the success indicators of WGH AOPs in 2019 were reviewed and discussed. The project leaders and/or their representatives from China, Japan, RO Korea, Malaysia, Philippines and Thailand presented the progresses on AOPs achieved in 2019 and implementation plan for 2020.
- 26) The WGH AOPs in 2019 and beyond was summarized in the table 1. The implementation status of WGH AOP 2019 is summarized in the Annex 1 and the success indicators of AOPs for 2020 are shown in Annex 2.

Table 1: The list of WGH AOPs in 2019 and beyond

Item	Projects	Driver	Duration
AOP1	Flash Flood Risk Information for Local Resilience	Japan	2017~2019
AOP2	Application of Hydrological Data Quality Control System in TC Members	Korea	2018-2022
AOP3	Enhancement of Flood Forecasting Reliability with Radar Rainfall Data and Stochastic Technique	Korea	2018-2022
AOP4	OSUFFIM Phase-II: Extension of OSUFFIM Application in TC Members	China	2018~2020
AOP5	Impact Assessment of Climate Change on Water Resource Variability in TC Members	China	2018~2020
AOP6	Flood Risk Watch Project for Life-saving	Japan	2019~2022
AOP7	Platform on Water Resilience and Disaster under IFI	Japan	2019~2022

AOP1: Flash Flood Risk Information for Local Resilience

- 27) This project was officially launched in 2017 and will be closed in end of 2019. Base on the decision of TC 51st Session, the Meeting reviewed the progresses on the Japan-led project of Flash Flood Risk Information for Local Resilience in 2019 briefed as below:
- conducted further researches on flash flood related topics in TC Members.
 - shared good practices on flash flood related topics between the Members.
 - held a session at the World BOSAI Forum on flash flood related topics and invited two experts from Thailand and Republic of Korea.
 - Compiled a guideline for the flash flood risk information for local resilience.

- 28) Japan-side was proposed to provide a summary report for the implementation and achievement of the project before TC 52nd annual session to be held in Hong Kong, China in February 2020.

AOP2: Application of Hydrological Data Quality Control System in TC Members

- 29) Base on the decision of TC 51st Session, the Meeting reviewed the progresses of the RO Korea-led project on Application of Hydrological Data Quality Control System in TC Members in 2019:

- Conducted 1st Expert mission for hydrological data quality control management in Lao P.D.R and Malaysia. KICT expert Dr. Chung-Soo Kim, the leader of the project, with team members from Laos and Thailand accompanied by TC hydrologist has been visited DID Malaysia, and HMD of Laos in 29-30 April, and 30 April and 1 May 2019, respectively. The mission's objective is to learn and understand the current status of hydrological data collection, quality control and data sharing to stakeholders. The experts had seminars with local staff to determine the direction of AOP2 project relating to enhancing data quality control in piloting Members. Also the mission visited some hydrological monitoring stations and data control centers in two countries.
- Drafted the design report for establishment hydrological data quality control system and technical report for hydrological quality control system. Design report of hydrological data quality control system will be finalized in 2020, and technical report will be published at 15th Integrated Workshop.
- Developed the operation platform of data quality management preliminarily.
- Organized the seminar at WGH 8th working meeting with the theme of "Knowledge Sharing on Hydrological Data Quality Control and Flash Flood Forecasting Using Radar Rainfall Data" from 15 to 18 October, which was attended by 26 participants from 9 Members.
- Scheduled the 2nd expert mission to Philippines and Thailand in the last week of November, 2019, to be attended by participants from Lao PDR, Malaysia, Philippines, the Republic of Korea, and TCS.

- 30) In 2020, following activities will be conducted:

- To host the technical mission wrap-up meeting in Seoul in April or May 2020.
- To finalize and publish the technical report for hydrological quality control system at 15th Integrated Workshop to be held in Vietnam.
- To continue developing the hydrological data quality control system (Phase 1), including gather the 10-year historical hydrological data (rainfall, water level) from 4 target countries (Lao P.D.R, Malaysia, Philippines, Thailand) into the database, and to establish the criteria in order to check and screen unusual data. Procedure of establishing the criteria will be systemized and the data modification methodologies will be selected finally.

AOP3: Enhancement of Flood Forecasting Reliability with Radar Rainfall Data and Stochastic Technique in TC Members

- 31) Base on the decision of TC 51st Session, the Meeting reviewed the progresses of the ROKorea-led project on Enhancement of Flood Forecasting Reliability with Radar Rainfall Data and Stochastic Technique in TC Members in 2019 as below:

- Conducted the 1st technical mission combined with the experts mission of AOP2 in Malaysia and Lao P.D.R. For the purpose of enhancement of flood forecasting reliability with radar rainfall data and stochastic technique, expert mission radar stations and exchanged the experiences, knowledge and technology of operating and managing radar station and radar rainfall data in target member countries.

- Drafted the design report for upgrading LEVEL 3 (EFFS) & establishment of stochastic forecasting system.
- Organized the seminar at WGH 8th working meeting with the theme of “Knowledge Sharing on Hydrological Data Quality Control and Flash Flood Forecasting Using Radar Rainfall Data” from 15 to 18 October, which was attended by 26 participants from 9 Members.
- Scheduled the 2nd expert mission to Philippines and Thailand in the last week of November 2019 which will be combined with AOP2.

32) The following activities for the project in 2020 will be conducted:

- To host the technical mission wrap-up meeting in combination with AOP2 in Seoul in April or May 2020.
- To upgrade the LEVEL 3 of EFFS focusing on the analysis of the past radar rainfall data couple with flood stage and establish the relationship between two data, modification of EFFS LEVEL 3.

AOP4: OSUFFIM Phase-II: Extension of OSUFFIM (Development Operational System for Urban Flood Forecasting and Inundation Mapping) Application in TC Members

33) Base on the decision of TC 51st Session, the Meeting reviewed the progresses of the China-led project on OSUFFIM Phase-II: Extension of OSUFFIM (Development Operational System for Urban Flood Forecasting and Inundation Mapping) for selected TC Members in 2019:

- During the 51st TC session held in Guangzhou in later February of 2019, an OSUFFIM workshop was held in Sun Yat-sen University. During this workshop, the 2019 working plan was discussed and finalized, the field survey plan and preliminary date was set.
- The OSUFFIM team, led by Prof Yangbo CHEN, compiled the conclusion report of OSUFFIM I in early 2019. This report, entitled as “Guidelines for Developing Operational System for Urban Flood Forecasting and Inundation Mapping”, also serves as the technical guide for OSUFFIM, was published in May of 2019 as TC publication (TC/TD-No 0017), which marked the formal conclusion of OSUFFIM-I. This publication is financial supported by TCTF and Sun Yat-Sen University jointly.
- **Pilot study in Thailand.** In January of 2019, three OSUFFIM team members from Sun Yat-Sen University joined an expert mission to Hat Yai, Thailand to validate the model for the pilot study in Thailand, and installed the operational system in the computer of the Royal Irrigation Department of Thailand for real-time operation, and made technical training to the local team.
- **Pilot study in Viet Nam.** In February of 2019, Team leader, Prof. Yangbo CHEN visited Viet Nam and made a field survey with OSUFFIM Viet Nam team member to Hue, and decided to select Hue as the pilot study of OSUFFIM II in Viet Nam. After that, the OSUFFIM team has been working very hard on the modeling of Hue. Up to early August of 2019, the team worked out a preliminary model structure, collected some hydrological data, and detected a few challenges. In later August of 2019, three members of OSUFFIM Viet Nam team were invited to visit Sun Yat-sen University with financial support from Sun Yat-Sen University. Team members discussed the latest research outcomes, existing problem and solutions, and proposed the roadmap beyond. In later September, Prof. Yangbo Chen visited Hue again to make site verification with local team, and discussed the work of 2020. Two team members were supported by Sun Yat-Sen University to make another field trip to Hue in November 2019 to make necessary data collection and survey. Finally the progress report of 2019 was prepared and presented in the WGH meeting.

- **Pilot study in Malaysia.** In March of 2019, team leader, Prof. Yangbo Chen visited Malaysia and made a field survey with OSUFFIM Malaysia team member to Pinang, and decided to select Pinang as the pilot study of OSUFFIM II in Malaysia. After that, the OSUFFIM team has been working very hard on the modeling of Pinang catchment. Up to early October of 2019, the team worked out a preliminary model structure, collected some hydrological data, and detected a few challenges. In 8-13 October 2019, three members of OSUFFIM Malaysia team were invited to visit Sun Yat-sen University with financial support from Sun Yat-Sen University. Team members discussed the model structure, corrected some error in the hydrological data, and proposed a model parameter. The team also estimated the land use/cover changes of Pinang in the past decades with satellite remote sensing data, and found the urbanization pattern in Pinang in the past decades. The members also proposed the works beyond, and planned to have a joint expert mission to Pinang 17-22 November 2019 to verify the model structure, to measure the river cross-section size, and to finalize the model parameters, with financial support from Sun Yat-Sen University. Finally the progress report of 2019 was prepared and presented in the WGH meeting.
- **Pilot study in Philippines.** In August of 2019, Team leader, Prof. Yangbo Chen visited Philippines and made a field survey with OSUFFIM Philippines team member to Davao, and decided to select Davao as the pilot study of OSUFFIM II in Philippines. During this events, the team also visited the Davao municipal government, and met the vice Mayor of Davao to discuss the plan. The vice Mayor of Davao city strongly supported this implementation of OSUFFIM II in Davao, and asked the governmental agencies to follow up and provide support. After that, the OSUFFIM team has been working very hard on the modeling of Martina catchment. Up to early October of 2019, the team worked out a preliminary model structure. As Martina catchment has not hydrological observation network, the team proposed a plan for setting up a comprehensive hydrological observation network, and validating the rational, and proposed the funding raising schemes. Three members of OSUFFIM Philippines team have been invited to visit Sun Yat-sen University in middle November of 2019 shortly after the IWS meeting with financial support from Sun Yat-Sen University. A joint field trip to Davao in December 2019 has also been conducted with financial support from Sun Yat-Sen University. The objective of this mission is to verify the model structure, to measure the river cross-section size, and to discuss the work plan with local government. The members also proposed the works in 2020, and proposed the progress report of 2019, which was presented in the WGH meeting.

34) In 2020, following activities will be conducted for the project:

- For Malaysia, the main goal of 2020 is to install and trial operate the flood forecasting system in Pinang catchment. Based on this goal, two field works has been scheduled to Malaysia for field data survey and validation, trial system installation and operation. A training workshop is also scheduled to be held in Malaysia for Malaysian hydrologists over the country, this is not only to train the staff in Pinang to use the system in Pinang, but also to raise national awareness to this project and its benefit. After this training workshop, more application is going to be done in Malaysia in the later time.
- For Philippines, the main goal for 2020 is to raise funding to build the hydrological observation network for Martina catchment, and build and makes it into operation in 2020, and finalize the flood forecasting model for Martina catchment. Based on this scheme, the planned activities includes at least two field works to Philippines to finalize the locations of the rain gauges and river gauges, and to stall and maintenance the equipment. A working meeting has also been schedule to be held in Sun Yat-Sen University and to train the Philippines team members.
- For Viet Nam, the main goal of 2020 is to install and trial operate the flood forecasting system in Hue. Based on this goal, two field works has been scheduled to Viet Nam for field data survey and

validation, trial system installation and operation. A training workshop is also planned to be held in Viet Nam for Vietnamese hydrologists over the country, this is not only to train the staff in Hue for using the system in Hue, but also to raise national awareness to this project and its benefit. After this training workshop, more application is going to be done in Viet Nam in the later time.

- In 2020, OSUFFIM II will select two pilot studies in Thailand, Cambodia and Laos, or all of them depending on the local participation. Planned activities include selecting pilot studies in Members after expert mission in early 2020, set up the model, and put the trial system in operation.
- A high level Panel meeting has been planned to be held in Sun Yat-Sen University in the middle of 2020 before the WGH meeting, at least one expert from the involved Member, and 3 others from other Members will be invited to give an evaluation for OSUFFIM.
- An OSUFFIM workshop has been planned to be held in Sun Yat-Sen University in the end of 2020 after the IWS, at least one participant from each involved Members will be invited to attend this workshop.

- 35) The piloting Members expressed that, urban flood inundation mapping is a very complex, particularly development of a real time operational system. Considering the works on DEM data collection and analysis, system configuration may not be totally completed in 2020, China-side was requested by piloting Members to consider the possibility to extend this AOP of OSUFFIM two more years to 2022 for providing continual technical support.

AOP5: Impact Assessment of Climate Change on Water Resource Variability in TC Members

- 36) Base on the decision of TC 51st Session, the Meeting reviewed the progresses of the China-led project on Impact Assessment of Climate Change on Water Resource Variability in TC Members in 2019 as below:

- In January of 2019, a two-days training workshop on RCCC-WBM was held in Nanjing Hydraulic Research Institute. Two technical experts from Laos and two technical experts from Malaysia have been invited to attend the workshop. The training courses include introduction of the RCCC-WBM model, preparing input data, model calibration, streamflow simulation, visualization, case study, etc. The experts have learned how to use the RCCC-WBM for streamflow simulation.
- In September of 2019, Team leader, Prof. Zhenxin Bao visited Laos and Malaysia and made a field survey for discussing the application of RCCC-WBM model for streamflow simulation in typical catchments, the methodology of the sensitivity of water resources to climate change, the impact of climate change on water resources, and the next step of the project were discussed.
- One and three case rivers in Laos and Malaysia have been selected, respectively. The input Data have been prepared well for the RCCC-WBM model.
- The model parameters of the RCCC-WBM model have been calibrated, and will be used for water resources simulation.
- A short training course for experts of Malaysia and Laos has been conducted in Nanjing Hydraulic Research Institute (NHRI), China in November 2019.

- 37) In 2020, following activities will be conducted.

- To generate hypothetical climatic scenarios in the typical catchments in Laos and Malaysia.
- To run the RCCC-WBM model to simulate streamflow using the hypothetical climatic scenarios as inputs.

- To assess the impact of CC on water resources in the typical catchments in Laos and Malaysia.
- To hold a workshop on the outputs of this project.

AOP6: Flood Risk Watch Project for Life-saving

38) Base on the decision of TC 51st Session, the Meeting reviewed the progresses of the Japan-led project on Flood Risk Watch Project for Life-saving in 2019 as below:

- Conducted the field survey on 22-24 January 2019 in Malaysia at Klang Valley and Langat, Pinang river basin.
- Conducted the meeting related AOP6 on 25 January 2019 in Malaysia.
- Conducting the meeting for further discussion about AOP6 on 24 October 2019 in Malaysia.

39) In 2020, following activities will be conducted.

- **To conduct the expert mission with Malaysia to share Japanese situation about AOP6 on January 2020 in Japan.**
- To seek the possibility to introduce 3L water level gauge and system in Malaysia and TC Members.

AOP7: Platform on Water Resilience and Disasters under IFI (International Flood Initiative)

40) Base on the decision of TC 51st Session, the Meeting reviewed the progresses of the Japan-led project on Platform on Water Resilience and Disasters under IFI (International Flood Initiative) in 2019 as below:

- Conducting IFI Platform session on 7 February 2019 in Manila, the Philippines inviting the WGH members and hydrologist of TC Secretariat;
- Conducting the capacity development training program on Flood Forecasting for Thailand (TMD and RID) and on Climate Change Adaptation for the Philippine (DOST) as one of the key components of the IFI Platform activities;
- Conducting the preliminary study on how to establish the platforms in the TC member countries;
- Disseminating the IFI Platform activities as WGH AOP7 at the several international conferences such as Stockholm World Water Week and the conferences/seminars organized by UNESCO, WMO and World Bank;
- Input of the IFI Platform activities as WGH AOP7 for the technical session at the World Bosai Forum on 11 November 2019 in collaboration with meteorological and DRR sectors, inviting WGH members as session speakers;
- Participating in the 46th Session of Panel on Tropical Cyclones (PTC) on 9-13 September 2019 and making bridges between TC WGH and PTC.

41) In 2020, following activities will be conducted:

- To conduct IFI Platform session in the Philippines with the participation from WGM member (Japan Meteorological Agency);
- To conduct the capacity development training program in the TC member countries upon requests;
- To disseminate the IFI Platform activities as WGH AOP7 at the several international conferences including the 4th Asia Pacific Water Summit in October 2020;
- To organize a thematic session of AOP7 during the 9th WGH meeting in October 2020 in Japan;

- To make bridges between TC WGH and PTC through implementing the IFI Platform activities in the Philippines, Myanmar, Sri Lanka and Indonesia.

IV. Proposal for New AOPs

- 42) The participants discussed how to enhance the cooperation among Members through the implementation of AOPs and potential proposals for WGH AOPs in 2020 and beyond.
- 43) The participants reached their consensus on that, WGH should mainly focus on enhancing the knowledge sharing and capacity building on the management of flood disaster risks forecasting and early warning for a resilient future in Typhoon Committee region. The following topics were recommended at 8th working meeting and discussed at Parallel Session of 14th IWS:
 - Innovative flood forecasting for non-data river basin
 - Flash flood (landslide, mud-flow) prediction and warning using QPE/QPF
 - Extension the application of urban flood forecasting and inundation mapping
 - Rainfall-runoff and rain-storm inundation mapping for river basins and coastal areas
 - Radar and satellite data utilization in flood forecasting and warning
 - Long-term forecasting for water resource management and utilization, drought monitoring and warning under climate change
 - Data-quality control for better flood forecasting and warning
 - Data-sharing in transboundary rivers
 - Dam operation for flood risk management under climate change
- 44) Mr. Kenneth KLEESCHULTE expressed that, USA is willing to share the knowledge on storm-surge inundation mapping with Members, and he proposed a cooperation project named “Knowledge Sharing on Storm-surge Inundation Modelling” as a new AOP for WGH in 2020 and beyond.

New AOP: Knowledge Sharing on Storm Surge Inundation Modeling

- 45) Storm surge inundation mapping is important to assist the hydrologist and meteorologist see which areas would most likely be affected by dangerous or damaging storm surge to assist in issuing warnings and advisories. This information is also important to assist the Emergency Managers in planning for and executing evacuations, and the Disaster Risk Reduction arena to assist in determining which areas are at greatest risk for damage inundation.
- 46) On this connection, an AOP on Knowledge Sharing on Storm Surge Inundation Modeling was proposed with objectives of providing a storm surge inundation mapping open source program to interested Members to assist in providing this data to their respective offices of emergency management. The goal is to provide the program and assist the interested Members in adjusting this program for their respective countries.
- 47) The proposed AOP will be implemented for a period of 3 years from 2020 to 2022. The road map for whole implementation period was summarized as below:
 - In 2020:
 - Introduce **P**acific **O**cean **S**torm **S**urge **I**nundation **M**odelling (**POSSIM**) to all working groups.
 - Identify interested TC members and coastal regions to be covered.
 - Determine of availability of LiDAR and other bathymetry data.

- Determine necessary expert missions to provide local enhancements to program.
 - In 2021:
 - Determine which countries will need expert missions or assistance in producing bathymetry data, preferably LiDAR.
 - Possibly provide expert mission to interested countries to assist in localizing POSSIM.
 - In 2022:
 - This program could be extended to interested PTC countries as well.
- 48) The following activities for implementation of the project will be implemented in 2020 :
- Summary of interested TC Members and coastal regions to be covered during first 2 quarters of 2020.
 - Determination of availability of LiDAR or other bathymetry data for the interested Members during last 2 quarters of 2020
 - Determine necessary expert missions to provide local enhancements to program during final quarter of 2020.
- 49) The WGH AOPs for 2020 and beyond were summarized in Table 2.

Table 2: The list of WGH AOPs in 2020 and beyond

Item	Projects	Driver	Duration
AOP1	Knowledge Sharing on Storm Surge Inundation Modeling	USA	2020~2022
AOP2	Application of Hydrological Data Quality Control System in TC Members	Korea	2018~2022
AOP3	Enhancement of Flood Forecasting Reliability with Radar Rainfall Data and Stochastic Technique	Korea	2018~2022
AOP4	OSUFFIM Phase-II: Extension of OSUFFIM Application in TC Members	China	2018~2022
AOP5	Impact Assessment of Climate Change on Water Resource Variability in TC Members	China	2018~2020
AOP6	Flood Risk Watch Project for Life-saving	Japan	2019~2022
AOP7	Platform on Water Resilience and Disaster under IFI	Japan	2019~2022

V. Enhancement of Cooperation with other WGs and regional/international organizations

- 50) Mr. YU Jun, Regional Officer from WMO Regional Office for Asia and the South-West Pacific in Singapore, made a presentation at TC 14th Integrated Workshop which was held in Guam, USA from from 4 to 7 November 2019 on “Regionalizing WMO” which provided valuable information for WGH to enhance the cooperation with other regional bodies of WMO in future.

- 51) Dr. Tetsuya Ikeda introduced the information about the PTC annual session and APWS 2020. He suggested that to make bridges between TC WGH and PTC through implementing the IFI Platform activities in the Philippines, Myanmar, Sri Lanka and Indonesia.
- 52) WGH participants discussed how to enhance the cooperation with other WGs and regional/international organizations, and agreed to consider the possibility to involve PTC Members in WGH activities in future.

VI. Review TCTF allocation for WGH activities in 2019 and Proposed Request for 2020

- 53) WGH reviewed the usage of the allocated budget of TCTF for WGH activities in 2019 shown in table 3.

Table 3 The summary of TCTF Budget Request for 2019 Activities

Item	Projects	Driver	Budget
1	AOP1: Flash Flood Risk Information for Local Resilience	Japan	5000
2	AOP2: Application of Hydrological Data Quality Control System in TC Members	Korea	6000
3	AOP3: Enhancement of Flood Forecasting Reliability with Radar Rainfall Data and Stochastic Technique	Korea	4000
4	AOP4: OSUFFIM Phase-II: Extension of OSUFFIM Application in TC Members	China	6000
5	AOP5: Impact Assessment of Climate Change on Water Resource Variability in TC Members	China	4000
	Total		25000

- 54) Based on the discussion, WGH proposed the budget request including \$13,000USD for support participation of 15th IWS to be held in Vietnam, and \$25000USD for support its activities in 2020 shown in table 4.

Table 4 The summary of TCTF Budget Request for 2020 Activities

Item	Activities	Driver	Budget
1	Support the activities related to Application of Hydrological Data Quality Control System in TC Members	Korea	4000
2	Support the activities related to Enhancement of Flood Forecasting Reliability with Radar Rainfall Data and Stochastic Technique	Korea	2000
3	Support the activities related to OSUFFIM Phase-II: Extension of OSUFFIM Application in TC Members	China	8000
4	Support the activities related to Impact Assessment of Climate Change on Water Resource Variability in TC Members	China	4000
5	Support the activities related to Platform on Water Resilience and Disaster under IFI and hosting WGH 9 th Working Meeting in Japan	Japan	7000
	Total		25,000

VII. Conclusions

- 55) On the basis of the outcomes at 8th WGH working meeting and further discussion at parallel session of 14th IWS, participants recognized the importance in following aspects for further direction of WGH:
- It is a consensus on that, the working meeting of WGH is very important to review and push forward hydrological activities with deep technical discussion of implementation status of WGH AOPs, and also is very necessity to prepare both IWS and annual session. The funding support and in-kind contribution from Members have played a vital role in organizing the annual working meeting. WGH appreciated the generous contribution from Republic of Korea and Japan in the past years, and encourages the more and wider resources to support the activities to keep its sustainability. WGH also encourage more Members to host its working meeting.
 - It is recognized that, to effectively promote the capacity of forecasting, early warning and risk management for urban flood risk is an urgent need among TC Members, especially the real-time operational system on urban flood forecasting and inundation mapping. As the subsequent activity of TC first Cross-cutting project of Urban Flood Risk Management (UFRM), the on-going project of WGH on Development and Application of Operational System for Urban Flood Forecasting and Inundation Mapping (OSUFFIM) is a tangible measure on this aspect and it will play very meaningful and important role for TC Members to promote the capacity on the technique of urban flood forecasting and warning. To extend the achievement of pilot study in the region is necessity and meaningful to promote the capacity on urban flood risk forecasting and warning. Urban flood inundation mapping definitely is very complex, particularly development of a real time operational system. China-side was requested to consider the possibility to extend the AOP of OSUFFIM two more years to 2022 to provide continual technical support for Members on DEM data collection and analysis, system configuration, etc..
 - It is a consensus on that, to draw up a plan on considering and proposing a bank of new cooperation projects under the umbrella of TC Strategic Plan in a linkage with the initiatives and activities of ESCAP and WMO would be an urgent matter at present for WGH since all on-going AOPs of WGH will be closed in 2020-2022. In order to conduct the cooperation projects sustainably in TC Members, WGH discussed and determined the list of topics as the priority cooperation activities for long-term direction to develop the Member's Capacity on water-related disaster risk forecasting and warning.
 - Hydrological monitoring network (station) is the cornerstone of all hydrological activities and an important basic work to serve economic and social development and ecological civilization construction. In recent years, the construction of hydrologic monitoring network in TC Members has been developed rapidly. The increasing amount of hydro-meteorological data collected in real time has brought new challenges to the management mode of the monitoring operation of the existing hydrological stations and the integration of hydrological data. The collection of raw-data is basic, and the data quality control is great significance to ensure the accuracy of flood forecasting and warning as well as project design and construction. Nowadays, the lack of standard data-processing procedure and comprehensive operation platform for hydro-meteorological data quality control is a common problem existed in the most TC Members. WGH recognized that, it is necessary and very meaningful, based on existing works and experiences in Members, to enhance the study of the standard data-processing procedure, and to design and develop an integrated working platform with comprehensive functions, high efficient and easy operation.
 - Enhancement of the close collaboration with the AWG of WMO CHy, WMO RA II Working Group on Hydrological Services in several themes of common interest provides significant benefits to the Committee. WGH should take substantial measures to step forward. WGH is willing to enhance the cooperation with PTC and other regions, under the Cooperation Mechanism between TC and PTC,

through involving more participants from outside of Typhoon Committee region in WGH AOPs and working meeting.

VIII. Recommendations to the Committee

- 56) On the basis of the deep discussion and communication, participants agreed to submit the following recommendations to the Committee at TC 52nd Annual Session to be held in Hong Kong, China from 25 to 28 February 2020:
- to request US\$13,000 from TCTF in total for supporting WGH members participating TC 15th IWS to be held in Vietnam.
 - to request US\$25,000 from TCTF in total for supporting overall WGH activities for 2020 calendar year.
 - to approve the proposal of the project on Knowledge Sharing on Storm Surge Inundation Modeling by WFO Guam as one of AOPs of WGH.
 - To request China to extend the project on OSUFFIM to the year of 2022 for providing continual technical support to Members.
 - to thank Republic of Korea for hosting WGH 8th Working Meeting in Seoul from 15 to 18 October, 2019.
 - To request Japan to host WGH 9th working meeting with funding support in a junction with 4th Asia Pacific Water Summit to be held in Kumamoto, Japan in October 2020.
 - to request HRFCO to continue maintaining and operating the WGH webpage for effective sharing information among WGH members with support from KICT and TCS.
 - to appoint the focal point of WGH in RO Korea, Dr. Hyeongyo JEONG, as the liaison to PTC and WMO RA II for WGH of the Committee for enhancing hydrological cooperation between TC and other regional bodies.
 - to continue focusing on improving the ability to forecast hydrological phenomena and provide measures for the effectiveness of the improvements.

Annex 1. Implementation Status of WGH AOP 2019

Annex 2. Successor Indicators of WGH AOP 2020

Annex 1. Implementation Status of WGH AOP 2019

KRA	Objective Number	Objective	Action	Other WGs Involved	TCS Responsibility	Expected Quarter Completed	Other Organizations Involved	Success Indicators	Funding Required	Funding Sources	Status Yes/No
KRA 2 KRA 3 KRA 4	1	Flash Flood Risk Information for Local Resilience	To develop a guidance tool for enhancing local resilience to flash flood disaster risks and disseminate it among the WGH member countries.	WGDRR WGM [TBD]	Coordination	(a) First (b) Second (c) Third (d) Fourth	PAGASA of Philippines	(a-c) Conduct a field research of IFI activities with other TC members. (b-d) Compile case study of Flash Flood measures implemented in TC member countries and IFI activities.	5000USD	ICHARM, MLIT	YES On-going
KRA2 KRA3 KRA4	2	Application of Hydrological Data Quality Control System in TC Members	To analyses the status of data quality control in TC Members		See above	(a) First (b) Second (c) Third (d) Fourth	PAGASA; DID; Malaysia; HMD, Laos, RID, Thailand	(a)(b) 1 st Field survey results of status analysis for hydrological data quality control management in 5 countries (ROK, Thailand, Philippines, Laos, Malaysia) (c)(d) Design report for establishment hydrological data quality control system (e) WGH working meeting (d) Technical report (draft version) for hydrological quality control system	6000USD	HRFCO, ME	YES YES YES
KRA2 KRA3 KRA4	3	Enhancement of Flood Forecasting Reliability with Radar Rainfall Data and Stochastic Technique	To analyses the status of radar data application in flood forecasting in TC Members		See above	(a) First (b) Second (c) Third (d) Fourth	PAGASA; DID; Malaysia; HMD, Laos, RID, Thailand	(a)(b) 1 st Field survey results of status analysis for flood forecasting using radar rainfall data in 4 countries (ROK, Thailand, Philippines, Laos) (c)(d) Design report for upgrading LEVEL 3 (EFFS) & establishment stochastic forecasting system	4000USD	HRFCO, ME	YES On-going
KRA2 KRA3 KRA4	4	OSUFFIM phase-II: extension of Application of OSUFFIM	to extend the application of OSUFFIM in selected Members		See above	(a) First (b) Second (c) Third (d) Fourth	RID, Thailand; DID, Malaysia MHA, Vietnam	(a) OSUFFIM workshop during TC session in 2019, publication of report (b)-(c) maintain the operation system in Hat Yai city of Thailand and Dongguang city of China; field survey, data collection and study urbanization pattern in 3 new pilot river basins, training workshop during WGH meeting in 2019 (d) hydrological model set up in 3 new pilot river basins .	6000USD (for data collection, field survey and a workshop)	HFC; SYS Uni. China	YES YES On-going
KRA3	5	Impact Assessment of Climate Change on Water Resource Variability in TC Members	Application of RCCC-WBM model at selected pilot catchments		See above	(a) First (b) Second (c) Third (d) Fourth	DID, Malaysia MHD, Laos	(a) to select Case Rivers in Lao and Malaysia and prepare the input Data of the RCCC-WBM model (b) field survey and meetings at Laos and Malaysia (c)-(d) to calibrate the model parameters of the RCCC-WBM model and to use the model for water resources simulation	4000USD (for data collection, field survey and meetings)	HFC and NHRI of China	Yes Yes On-going

KRA	Objective Number	Objective	Action	Other WGs Involved	TCS Responsibility	Expected Quarter Completed	Other Organizations Involved	Success Indicators	Funding Required	Funding Sources	Status Yes/No
KRA1,2,3,4,5	6	Hydro Risk Watch Project for Life-saving	Promoting to install 3L water level gauge and flood forecasting system in TC Members	WGM	See above	(a) First (b) Second (c) Third (d) Fourth		(a) field survey and meetings in partner country (b) to hold one-day workshop at TC members (c-d) to introduce 3L water level gauge and system in TC Members		MLIT	Yes On-going On going
KRA1,2,3,4,5	7	Platform on Water Resilience and Disasters under the International Flood Initiatives (IFI)	Demonstrating the effectiveness of establishing the platforms on water resilience and disasters by involving the national government organizations for further improved flood management through collecting data, transferring knowledge and enhancing the capacity	WGM WGDRR	See above	(a) First (b) Second (c) Third (d) Fourth	PAGASA DPWH, OCD TMD RID	(a) Organize the session on the platform in the Philippines (a) Hold the capacity development programs (Thailand) (c-d) Conduct the preliminary study on how to establish the platforms in the TC member countries. (d) Organize the workshops for its demonstration and dissemination (WBF2019) (c-d) Seek the possibility to develop the platforms in the TC member countries		ICHARM MLIT	YES YES YES YES YES

- KRA 1: Enhance capacity to monitor mortality and direct economic loss caused by typhoon-related disasters.
- KRA 2: Enhance capacity to generate and provide accurate, timely and understandable information using multi-hazard impact-based forecasts and risk-based warnings.
- KRA 3: Improve typhoon-related flood control and integrated water resource management.
- KRA 4: Strengthen typhoon-related disaster risk reduction activities in various sectors, including increased community-based resiliency with better response, communication, and information sharing capability.
- KRA 5: Enhance Typhoon Committee's Regional and International collaboration mechanism.

Annex 2. Success Indicators of WGH AOP 2020

KRA	Objective Number	Objective	Action	Other WGs Involved	TCS Responsibility	Expected Quarter Completed	Other Organizations Involved	Success Indicators	Funding Required	Funding Sources
KRA 2 KRA 3 KRA 4	1	Knowledge sharing on Storm Surge Inundation Modeling	To share, prepare and localize Pacific Ocean Storm Surge Inundation Modeling (POSSIM) program with TC members (possibly PTC members in future)	WGDRR WGM	Coordination	(a) First (b) Second (c) Third (d) Fourth	To be determined	(a-b) Summary of interested TC members and coastal regions to be covered (c-d) Determination of availability of LiDAR and other bathymetry data (d) Determine necessary expert missions to provide local enhancements to program		WFO Guam
KRA2 KRA3 KRA4	2	Application of Hydrological Data Quality Control System in TC Members	To analyses the status of data quality control in TC Members		See above	(a) First (b) Second (c) Third (d) Fourth	PAGASA; DID; Malaysia; HMD, Laos, RID, Thailand	(a-b) Summary of field survey results in 5 countries (Laos, Malaysia, Philippines, ROK, Thailand) and hosting field survey wrap-up meeting (c-d) Development of hydrological quality control system (1) (d) Finalization of technical report for hydrological data quality control	4000	HRFCO, ME
KRA2 KRA3 KRA4	3	Enhancement of Flood Forecasting Reliability with Radar Rainfall Data and Stochastic Technique	To analyses the status of radar data application in flood forecasting in TC Members		See above	(a) First (b) Second (c) Third (d) Fourth	PAGASA; HMD, Laos, RID, Thailand	(a-b) Summary of field survey results in 4 countries (Laos, Philippines, ROK, Thailand) and hosting field survey wrap-up meeting (c-d) Modification of EFFF LEVEL 3	2000	HRFCO, ME
KRA2 KRA3 KRA4	4	OSUFFIM phase-II: extension of Application of OSUFFIM	to extend the application of OSUFFIM in selected Members		See above	(a) First (b) Second (c) Third (d) Fourth	RID, Thailand; DID, Malaysia; MHA, Vietnam; PAGASA, Philippines	(a) expert mission, new pilot study selection in 2 new pilot river basins . (b-d) OSUFFIM trial systems to be installed and trial operated in Malaysia and Viet Nam (d) hydrological model set up in 2 new pilot river basins .	8,000	HFC; SYS Uni. China
KRA3	5	Impact Assessment of Climate Change on Water Resource Variability in TC Members	Application of RCCC-WBM model at selected pilot catchments		See above	(a) First (b) Second (c) Third (d) Fourth	DID, Malaysia MHD, Laos	(a) Generating hypothetical climatic scenarios in the typical catchments in Laos and Malaysia. (b) run the RCCC-WBM model to simulate streamflow using the hypothetical climatic scenarios as inputs. (c) assess the impact of CC on water resources in the typical catchments in Laos and Malaysia. (d) Workshop on the outputs of this project.	4000	HFC and NHRI of China
KRA1,2, 3,4,5	6	Hydro Risk Watch Project for Life-saving	Promoting to install 3L water level gauge and flood forecasting system in TC Members	WGM	See above	(a) First (b) Second (c) Third (d) Fourth	DID, Malaysia	(a) expert mission and meetings in partner country (b) to hold one-day workshop at TC members (c-d) to introduce 3L water level gauge and system in TC Members		MLIT

KRA	Objective Number	Objective	Action	Other WGs Involved	TCS Responsibility	Expected Quarter Completed	Other Organizations Involved	Success Indicators	Funding Required	Funding Sources
KRA1,2,3,4,5	7	Platform on Water Resilience and Disasters under the International Flood Initiatives (IFI)	Demonstrating the effectiveness of establishing the platforms on water resilience and disasters by involving the national government organizations for further improved flood management through collecting data, transferring knowledge and enhancing the capacity	WGM WGDRR	See above	(a) First (b) Second (c) Third (d) Fourth	PAGASA DPWH, OCD TMD RID	(b) Organize the session on the platform in the Philippines (b) Promote collaboration with the other WGs as a cross-cutting project (b-d) Hold the capacity development programs (c-d) Conduct the preliminary study on how to establish the platforms in the TC member countries. (d) Organize the workshops for demonstration and dissemination at some major international events (c-d) Seek the possibility to develop the platforms in the TC member countries (d) Organize WGH 9th in October 2020 in Japan	7000	ICHARM MLIT

- KRA 1: Enhance capacity to monitor mortality and direct economic loss caused by typhoon-related disasters.
- KRA 2: Enhance capacity to generate and provide accurate, timely and understandable information using multi-hazard impact-based forecasts and risk-based warnings.
- KRA 3: Improve typhoon-related flood control and integrated water resource management.
- KRA 4: Strengthen typhoon-related disaster risk reduction activities in various sectors, including increased community-based resiliency with better response, communication, and information sharing capability.
- KRA 5: Enhance Typhoon Committee's Regional and International collaboration mechanism.