

Report on Activities of Working Group on Hydrology (WGH) of TC in 2021

(Item 9 of Tentative Program for TC 54th Session)

(Submitted by WGH)

ACTION REQUIRED:

This Committee is invited to:

- a) Review the activities of TC WGH conducted in 2021
- b) Approve the recommendations and AOPs of WGH for 2022 and beyond

APPENDIXES:

- I. DRAFT TEXT FOR INCLUSION AT SESSION REPORT
- II. Report on activities of Working Group on Hydrology (WGH) of TC in 2021

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 decision of TC 53rd Session 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 the flood-related disasters happened in 2021 and hydrological activities conducted in Members in the year, and also noted the special measures took in Members for flood disaster risk reduction and the progresses achieved in Members under the situation of COVID-19.
3. The Session noted with pleasure that, the video conference (VC) for 10th working meeting of Working Group on Hydrology (WGH) was organized by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) in cooperation with Infrastructure Development Institute (IDI) and International Centre for Water Hazard and Risk Management (ICHARM) of Japan on 22 October 2021. The VC was attended by more than 50 participants from 11 of 14 Members of the Typhoon Committee, namely: China; Hong Kong, China; Japan; Lao People's Democratic Republic (Lao PDR); Malaysia; the Philippines; Republic of Korea; Singapore; Thailand; USA and Viet Nam. Typhoon Committee Secretariat (TCS) and Thai Meteorological Department (TMD) of Thailand also participated in the VC. The Session expressed its appreciation to the Japan government through MLIT with cooperation of ICHARM and IDI of Japan for generously hosting the meeting.
4. The Session was informed with appreciation that the Japan is willingness to host the potential face to face conference for WGH 11th working meeting in 2022 subject to the situation of COVID-19.
5. The Session was informed that the project of "Knowledge Sharing on Storm Surge Inundation Mapping" led by Guam of USA has been put on hold indefinitely in past two years due to the limitations in travel and other problems during the Covid-19 outbreak. However, the project leader expressed that, this project will be kept on track as soon as face to face meetings are again allowed, and to continue to solicit all countries to send their interest in program as soon as possible so that the implementation plan of this worthwhile project can be began to make progress toward initiating in 2022. The session also was informed that the project will be considered to extend 3 more years to end of 2025 with adjustable subject to the situation of COVIN-19.

6. Following the decisions made at TC 53rd Session, WGH tried its best to conduct the activities for implementing its following 6 AOPs in 2021 including domestic research, paper works and virtual meetings:
 - a) AOP2: Application of Hydrological Data Quality Control System in TC Members
 - b) AOP3: Enhancement of Flood Forecasting Reliability with Radar Rainfall Data and Stochastic Technique
 - c) AOP4: OSUFFIM Phase-II: Extension of OSUFFIM Application in TC Members
 - d) AOP5: Impact Assessment of Climate Change on Water Resource Variability in TC Members
 - e) AOP6: Flood Risk Watch Project for Life-saving
 - f) AOP7: Platform on Water Resilience and Disaster under IFI (International Flood Initiative)

7. The Session noted that, Han River Flood Control Office (HRFCO) of the Republic of Korea in cooperation with Korea Institute of Civil Engineering and Building Technology (KICT) conducted a series of activities for the project on Application of Hydrological Data Quality Control System in TC Members and the project on Enhancement of Flood Forecasting Reliability with Radar Rainfall Data and Stochastic Technique, including: (1) organized a joint virtual seminar on 18 December 2021 for wrap-up the expert mission of field survey which was conducted in 5 participating Members, namely Laos, Malaysia, Philippines, ROK and Thailand in 2019. (2) upgraded the operation platforms for two projects. and (3) published the technical report for hydrological data quality control management (TC/TD No. 0022). The Session also noted the implantation plans for 2022, including: (1) to finalize the establishment of the hydrological data quality control system (PC-version); (2) to develop the stochastic flood forecasting system. and (3) to publish the Manuals for two projects.

8. The Session noted that, the pilot study for 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 was continually conducted in China and achieved the satisfactory results. SYS University of China organized with funding support a special volume on the Typhoon Commission Journal “Tropical Cyclone Research and Review (TCRR) which collected 5 papers presenting the achievements of pilot study in Members in past years. in pilot studies in the selected members. The Session also noted that the pilot study will be continued in 2022, and a potential face to face workshop was scheduled in Guangzhou, China subject to the situation of COVID-19 in 2022.

9. The session was informed with appreciation that, due to the impact of Covid-19, some scheduled activities of OSUFFIM project were postponed. Based on the communication between leading country and participating Members, China-side agreed to extend this project one more year to the end of 2023 to support participating Members to complete scheduled pilot studies.

10. The Session was informed with pleasure that, a virtual training workshop was organized for the project on Impact Assessment of Climate Change on Water Resource Variability in TC

Members by the Information Centre of the Ministry of Water Resources (MWR) of China in cooperation with the Research Centre for Climate Change (RCCC) of MWR and the Nanjing Hydraulic Research Institute (NHRI) on 15 December 2021. Over 60 participants from 7 countries, namely China, Ethiopia, Malaysia, Myanmar, Korea, Thailand, and Vietnam, attended the virtual training course and were issued the Participation Certificates jointly by TCS and RCCC. The session also noted with appreciation that Chinese institutions agreed to open and share the source code of RCCC Water Balance Model (WBM) with TC Members following the request from Members. The scheduled activities for 2022 includes: (1) to organize 1-2 on-line or/and off-line training workshops; (2) to improve RCCC-WBM model by adding flow duration curve module; and (3) to publish the technical report before TC 17th IWS in 2022.

11. The Session noted with gratitude that, following the request from Members, China agreed to extend the project on Impact Assessment of Climate Change on Water Resource Variability in TC Members two more years to the end of 2024 for further training on RCCC-WBM model and its applications in TC Members.
12. The Session was informed that, the schedule of the project on Flood Risk Watch Project for Life-saving in 2021, i.e. test installation of 3L Water Level Gauges (WLGs) in Malaysia was forced the suspension due to the impact of Covid-19. The Session also noted that, Japan and Malaysia will proceed with concrete activities toward the start of 3L WLGs observation in early 2022, and like to share the information about 3L WLGs to TC Member if needed.
13. The session was informed with appreciation that Japan-side will extend this project one more year to the end of 2023 due to the impact of COVID-19.
14. The Session was informed that, in 2021, ICHARM of Japan conducted following activities for the Project of Platform on Water Resilience and Disasters under IFI (International Flood Initiative), including: (1) establishing the platform on water resilience and disasters, and developing the flood forecasting system in Philippines; (2) building the Online Synthesis System (OSS) for Davao city, Philippines; and (3) organizing the E-learning workshops in Philippines and Indonesia. The Session also noted that the Hands-on Training Workshop is scheduled as the second phase of the project in 2022.
15. The Session was informed that, 5 new projects were proposed from Members as WGH new AOPs for further discussion at WGH 11th working meeting and TC 17th IWS in 2022, and to be officially launched at 55th Annual Session in 2023, including:
 - Improvement of Hydrological Data Quality Control System by using AI technology from Republic of Korea.
 - Improvement of Flood Forecasting modelling by using AI technology from Republic of Korea.
 - Knowledge Sharing on the Southeast Asia Flash Flood Guidance System (SeAFFGS) from Viet Nam.
 - Flood Monitoring for Risk Reduction (tentative) from Japan. and
 - Flood Resilience Compatible with Sustainable Development (tentative) from Japan.

16. The Session noted with pleasure the proposed modifications of the Key Result Areas (KRAs) and Priorities related to hydrological component under updating TC Strategic Plan 2022-2026.
17. The Session was informed with pleasure that the vice chairperson of WGH Dr. Hyo-Seob CHO was selected as a Chair of the WMO RAI Coordination Panel on Hydrology and Water Resource, and Dr. CHO expressed that he would make his contribution on enhancing the cooperation between TC WGH and RAI WGH at his position.

CONCLUSIONS OF WGH

18. On the basis of the discussion and outcomes at 10th WGH working meeting and the parallel session of TC 16th IWS, participants recognized the importance in following aspects for further direction of WGH:
19. It is a consensus on that, the impact of COVID-19 may become a normal situation in a certain period. TC Members may need to consider how to coexist with COVID-19. In this connection, it is needed to analyze the new countermeasures under public emergencies on typhoon-related disaster risk reduction in TC Members in this typhoon season, including monitoring, data collection, forecasting and warning, information sharing and emergency response; summarize the experience and coping strategy on typhoon-related disaster risk reduction in the region of TC and other regions in the world; and provide reference and guidance for TC Members on typhoon-related disaster risk reduction under public emergencies in future. Members also may need to consider how to push the Working-Group's annual operation plan (AOP) forward under the situation of COVID-19. It is recognized that it should be an effective measure to establish a regular mechanism for on-line activities instead of face-to-face interaction including training course, workshop, etc.
20. It is a consensus on that, the working meeting of WGH is very important to review and push forward hydrological activities and is very necessary to prepare IWS and annual session. WGH appreciated the generous contribution from Republic of Korea and Japan in the past years for hosting WGH working meetings. WGH also encouraged more Members to host its working meeting.
21. Due to the impact of COVID-19, the virtue conference has become a normal format for WGs' annual meeting and TC integrated workshop (IWS). Due to the limited agenda, it is very hard for AOP leaders to have enough time for deep technical discussion and explanation on WGs' meetings and TC IWS. To resolve this problem, HRFCO in cooperation with KICT organized virtual workshops special for Korea-led AOPs in past two years. Following this good example, all AOP leading Members may need to consider on-line AOP workshop or training course annually for their led AOPs with the purpose of deep discussion of AOP's implementation so as to keep its momentum and sustainability.
22. 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 2022-2026 in a linkage with the initiatives and activities of ESCAP and WMO would be an urgent matter at present for WGH. To conduct the cooperation projects sustainably in TC Members, WGH discussed and determined the list of potential topics and keywords as the priority cooperation activities

for long-term direction to develop the Member's capacity on water-related disaster risk forecasting and warning.

23. WGH members recognized that the application of big data and AI technology in flood forecasting and early warning will become a mainstream and development direction in future. WGH should consider a cooperation project as its AOP on this area to enhance the application study.
24. WGH agreed to continue enhancing 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 working meeting.

RECOMMENDATIONS OF WGH

25. On the basis of the deep discussion and communication, participants agreed to submit the following recommendations to the Committee at TC 54th Annual Session to be held in February 2022:
 - to request US\$25,000 from TCTF for supporting overall WGH activities for 2022 calendar year.
 - to thank MLIT, Japan in cooperation with ICHARM and IDI for hosting the video conference for WGH 10th Working Meeting on 22 October 2021.
 - to request USA to extend the project of AOP1 (AOP1 (Knowledge Sharing on Storm Surge Inundation Mapping) three more year to the end of 2025.
 - to request China to extend the project of AOP4 (OSUFFIM Phase-II: Extension of OSUFFIM Application in TC Members) one more year to the end of 2023.
 - to request China to extend the project of AOP5 (Impact Assessment of Climate Change on Water Resource Variability in TC Members) two more years to the end of 2024.
 - To request Japan to extend the project of AOP6 (Platform on Water Resilience and Disaster under IFI) one more year to the end of 2023.
 - to request MLIT, Japan to host the face-to-face WGH 11th working meeting in Japan subject to the situation COVID-19 in 2022.
 - to request HRFCO, Republic of Korea in cooperation with KICT to further refine the proposals of "Improvement of Hydrological Data Quality Control System by using AI technology" and "Improvement of Flood Forecasting modelling by using AI technology" for approval at TC 55th Session as WGH AOPs for 2023 and beyond.
 - to request VNMHA of Viet Nam to further refine the proposal of "Knowledge Sharing on the Southeast Asia Flash Flood Guidance System (SeAFFGS)" for approval at TC 55th Session as WGH AOP for 2023 and beyond.
 - to request MLIT and ICHARM of Japan to further refine the proposals of "Flood Monitoring for Risk Reduction (tentative)" and "Flood Resilience Compatible with Sustainable Development (tentative)" for approval at TC 55th Session as WGH AOP for 2023 and beyond.
 - 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, **Mr. Yo-Han CHO**, as the liaison to PTC and WMO RA II for WGH of the Committee for enhancing hydrological cooperation between TC and other regional bodies under the supervision of Dr. Hyo-Seob CHO as the Chairperson of the RAII Coordination Panel on Hydrology and Water Resources of WMO.
- 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 2021

In 2021, despite the impact of COVID-19, Working Group on Hydrology (WGH) of Typhoon Committee (TC) conducted a series of activities referring to the decision of 53rd Session. This report was drafted mainly on the base of the outcomes of 10th WGH working meeting which was hosted virtually by Japan on 22 October 2021, and the discussion of the parallel session of TC 16th Integrated Workshop (IWS) which was hosted jointly by TCS and ESCAP on 2-3 November 2021 via virtual conference.

The report highlighted the main progresses and achievements on hydrological component in Members in past year; briefed the activities of WGH conducted in 2021, and summarized the status of implementation of WGH AOPs 2021. Based on the communication among Members and the discussion at TC 16th IWS, WGH proposed the implementation plan of AOPs for 2022 and beyond; and consequently, requested the TCTF allocation for supporting WGH activities in the year of 2022.

I. Organization of the Video Conference for WGH 10th Working Meeting

1. The video conference for 10th working meeting of ESCAP/WMO Typhoon committee (TC) Working Group on Hydrology (WGH) was organized by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) in cooperation with Infrastructure Development Institute (IDI) and International Centre for Water Hazard and Risk Management (ICHARM) of Japan on 22 October 2021.
2. The theme of WGH 10th Working Meeting was proposed as “River Basin Disaster Resilience and Sustainability by All”—— Challenges for Integrated Management in the Post-COVID-19 World.
3. The video conference (VC) has the time-critical agenda items with following objectives:
 - to review Members’ Reports on hydrological activities in 2021
 - to review the implementation status of WGH AOP 2021
 - to discuss the implementation plan of WGH AOP and budget request for 2022
 - to discuss the Strategic Plan 2022-2022 for updating
 - to discuss new proposal of WGH AOPs for 2023 and beyond
4. The VC was convened by Chairperson Dr. Mamoru MIYAMOTO, Chief Researcher of International Centre for Water Hazard and Risk Management (ICHARM) of Japan. Mr. Hidenori FURUICHI, director of International Affairs Office, Water and Disaster Management Bureau of MLIT, Japan delivered welcome address on behalf of Japan government.
5. The VC was attended by more than 50 participants from 11 of 14 Members of the Typhoon Committee, namely: China; Hong Kong, China; Japan; Lao People’s Democratic Republic (Lao PDR); Malaysia; the Philippines; Republic of Korea; Singapore; Thailand; USA and Viet Nam. Typhoon Committee Secretariat (TCS) and Thai Meteorological Department (TMD) of Thailand also participated in the VC.
6. The participant expressed their highest appreciation to Japan government through MLIT in cooperation with IDI and ICHARM of Japan for hosting WGH 10th working meeting.

7. Japan-side expressed its willingness to host a face-to-face conference for WGH 11th working meeting in Japan in 2022. The participant expressed their highest gratitude to Japan government through MLIT in cooperation with ICHARM and IDI of Japan for the generous offer.
8. It was recognized that a wide range of opportunities of WGH working meeting to be hosted by various Member should be rather welcomed. The participants were encouraged to consider the possibility of hosting future WGH working meeting.
9. The meeting was informed that vice chairperson of WGH Dr. Hyo-Seob CHO was selected as a Chair of the RAI Coordination Panel on Hydrology and Water Resources of WMO. The participants expressed their warmest congratulations. Dr. CHO expressed that he would make his contribution on enhancing the cooperation between TC WGH and WMO.

II. The Summary of Member Report on Hydrological Component in 2021

10. The WGH reviewed the flood-related disaster happened in 2021 and hydrological activities conducted in Members in the year, and also noted the special measures took in Members for flood disaster risk reduction under the situation of COVID-19.
11. In 2021, Cambodia was impacted by local thunderstorm and monsoon trough lied over the country from April to October which caused a series of flood events (including flash flood, urban flood and landslide) in Pursat city; Phnom Preuk district, Battambang province; Sihanouk Vile city; and Phnom Penh City.
12. In 2021, five of the twenty typhoons generated in northwest Pacific Ocean landed in China, among which typhoon In-Fa brought the most serious storm and flood to the east area of China. Affected by the heavy rainfall, forty-eight rivers in seven provinces, including Zhejiang, Shanghai, Jiangsu, Anhui, Shandong, Inner Mongolia and Heilongjiang, experienced floods exceeding the warning level with a range of 0.05 ~ 2.54 m, 15 rivers have exceeded the guaranteed water level with a range of 0.01 ~ 2.48 m. There are forty-two tidal stations along the coast of Fujian, Zhejiang, Shanghai, and Jiangsu provinces exceeding the warning level, among which eleven stations claimed the historical records.
13. Democratic People's Republic of Korea (DPRK) was indirectly affected by four typhoons including IN-FA, LUPIT, OMAIS and CHANTHU in 2021. These typhoons caused gales, heavy rain, torrential rainfall and storm surge, but there was no great damage in several sectors in our country.
14. In Hong Kong, China, there were eight tropical cyclones affected Hong Kong in 2021. Among these tropical cyclones, Tropical Storm Lionrock (2117) and Typhoon Kompas (2118) successively affected Hong Kong within a week from 8 to 14 October 2021. Under the combined effect of the tropical cyclones and the northeast monsoon, the No. 8 Gale or Storm Signals were issued for both tropical cyclones. Lionrock was also the wettest tropical cyclone affecting Hong Kong by far in 2021 with more than 200mm of rainfall generally recorded over the territory on 8 October 2021. The rainfall recorded at the Hong Kong Observatory Headquarters on that day even reached 329.7mm, more than two times of October's monthly total normal figure of 120.3mm and the highest daily rainfall on record for October. The storm surge induced by Kompas raised the water level in Hong Kong over 1m higher than the normal tide levels on the morning of 13 October. Coincided with the astronomical high tide, the aggregated effect resulted in the inundation of some low-lying areas in Hong Kong.

For hydrological activities, the Drainage Services Department (DSD) collaborated with the Hong Kong Observatory (HKO) for delivering two sharing sessions in August 2021 to government departments and other important public service providers, showcasing the possible resilience measures in Hong Kong and providing general guidance on emergency preparedness in case of extreme rainstorms. The Member also shared DSD's new model sensors at some drainage channels by utilizing the Government Wide Internet-of-Thing Network. The advantages of the new model sensors included wide coverage, low cost, low power consumption and easy installation and maintenance. This initiative facilitated early deployment

of DSD's emergency teams to the flooding locations for carrying out flood alleviation works and provided supplementary information to assist HKO's daily operation and long-term water level monitoring.

15. In 2021, eight typhoons approached Japan in total, and three of them landed. These typhoons have not caused any major water disasters. However, heavy rain occurred due to the influence of the Baiu front, which stagnated for a long time from early to mid-July, resulting enormous damage including river flooding in 64 rivers in 31 water systems throughout Japan, mainly in the Tokai region and the southern part of the Kanto region. In Shizuoka prefecture in the Tokai region, 72-hour cumulative rainfall reached the top in the history of observation at several points, caused the occurrence of debris flow. A vigorous front that stagnated near Japan in August caused linear precipitation zone, with heavy rains continuing for a long time in the same place. At many points in western Japan, the 72-hour cumulative rainfall was the highest in the history of yearly or monthly observation in August, resulting flooding and inundation due to river overflow occurred by 89 rivers in 29 river systems.

Every year in Japan, torrential rains and typhoons cause enormous damage. In order to respond to the increasing impacts of climate change, Japan revised the hydraulic control measures that have been implemented in the past. After Typhoon Hagibis in 2019, MLIT shifted its focus to mainstream public disaster prevention and mitigation, with work on transition to River Basin Disaster Resilience and Sustainability by All. The approach involves a new concept for flood management in collaboration with relevant parties around river basins based on the major considerations of disaster resilience, inclusiveness and sustainability. Against this background, MLIT is upgrading its flood management plans in consideration of expected impacts of climate change.

The "Law to partially revise Specified Urban River Inundation Control Law" was enacted in the Diet in April 2021 and promulgated in May 2021, in order to enhance the effectiveness of "basin hydraulic control" and promote strongly. This law amendment is an integrated revision of nine laws, including the River Law, Sewerage Law, Flood Control Law, City Planning Law, Urban Green Space Law, and Building Standards Law, in addition to Specified Urban River Inundation Control Law.

Specifically, a legal framework was established to enhance the effectiveness of "basin hydraulic control" for the following four items:

- (1) Strengthening of plans and systems for "basin hydraulic control", including (a) expand rivers that utilize the "basin hydraulic control" plan; and (b) establishment of a council on basin flood control and enhancement of "basin hydraulic control" plan
- (2) Measures to prevent flooding as much as possible, including (a) establishment of a council for pre-discharge of water utilization dams and power generation dams; (b) set target rainfall to prevent flood damage in the sewerage plan and accelerate flood control measures in the sewerage system; (c) mandatory formulation of operating rules for sewer drainage gutters; (d) establishment of a system to secure land with water retention and retarding basins along the river; (e) conservation of urban green spaces with rainwater storage and infiltration functions; and (f) support for the development of local and private rainwater storage and infiltration facilities through certification systems and subsidies; etc.
- (3) Measures to reduce the damage targets, including (a) establishment of a system to confirm the safety of flood damage in advance, such as housing and facilities for people requiring special consideration; (b) expansion of area requirements for disaster prevention group relocation promotion projects; (c) promotion of development of evacuation bases in the event of a disaster; and (d) promotion of flood control measures for each district; etc.
- (4) Measures for damage reduction, early recovery, and reconstruction, including (a) expand the target rivers for creating flood hazard maps to small and medium-sized rivers; (b) establishment of a

municipal advice / recommendation system for evacuation plans for facilities for people requiring special attention; and (c) expansion of target rivers that the Minister of MLIT will act as an authority in the event of a disaster; etc.

16. In 2021, Lao PDR was directly affected by four tropical cyclones: TS2104 KOKUMA (10-14 June), TY2113 CONSON (14-15 September), TS2115 DIANMU (24-27 September), and TS2118 KOMPASU (15-16 October), as well as indirectly by one tropical cyclone, TY2107 CEMPAKA (19-21 July). Despite the fact that the water level in the Mekong River in 2021 was lower than the average historical water level, tropical cyclones this year caused the water level in tributaries to rise above the danger level during June, July, and September, resulting in flood and flash flood in eight provinces of Lao PDR, which mostly in the northern part such as Bokeo, Xaiyabouly, Luangnamtha, Xiangkhouang Province, and the southern part such as Champasak, Sekong, and Saravane Province. There are two province was affected in central part of Lao PDR which are Vientiane and Borikhamxay Province.
17. In 2021, Macao, China was affected by 7 tropical cyclones. Among them, Typhoon Cempaka brought 130mm accumulated rainfall; Tropical Storm Lionrock brought over 200mm daily accumulated rainfall amount was recorded, which had become the maximum daily precipitation in October since 1952; Typhoon Kompasu caused a significant storm surge, resulting flooding and inundation in low-lying areas with about 0.43m water depth. The blue storm surge warning was issued.
18. In 2021, Malaysia has experienced 622 flood events between January to September 2021. More than 80% of flood is flash flood that most affected area located along west coast Peninsular Malaysia, Sabah and Sarawak. On 18 August 2021, Headwaters and Debris Mudflow flood occurred in the surrounding area of mountain of Jerai at Kedah State. The flash flood occurs between 5pm to 8pm with recorded 271mm rainfall in 5 hours equal to 71 years return period. This extreme rainfall has caused the phenomenon of headwaters and mud flood to a depth of 0.1m to 0.3m in the district of Kuala Muda and 0.2m to 1.5m in the district of Yan. The overflow of many rivers along mount of Jerai catchments brought rubbish, wood and tree stumps that cause stuck on the bridges, resulting 6 peoples died and more than and 133 peoples were evacuated. Usually, between November to February of the following year, flash floods will decrease where monsoon floods will hit the east coast of Peninsular Malaysia such as Kelantan, Terengganu, Pahang, Johor, Sarawak and Sabah, however, in recent years, flash floods still occur in many places in west coast areas of Peninsular Malaysia such as Kedah, Penang, Perak, Selangor, Negeri Sembilan, Melaka and Johor. This may be due to the change of climate pattern that also taking place around the world especially in the humid tropics area.
19. From October 2020 to September 2022, the Philippines affected by 18 tropic cyclones in total and caused severe floods in major river basins including Pampanga, Agno, Bicol, Cagayan, Pasig Marikina Tullahan and Cagayan de Oro. PAGASA issued timely advisories and bulletins for major river basins, and General flood Advisories for principal river basins, and situationer/warning for hydrological dam operation.
20. In 2021, there were three (3) typhoons directly and indirectly affected Republic of Korea (ROK) from August to September and among them one (1) typhoon (No.12, OMAIS) landed inland in August. The rainy season in Korea, a litter later than usual, started in early July. In the southern coastal area, the records of daily and hourly precipitation in July were newly updated. Particularly, in Jeollanam-do, three people were killed, more than 500 houses were inundated due to flooding, the submerged rice paddies reached over 21,000 ha, and road loss and flood damage occurred in various places due to landslides. However, the inland damage caused by typhoons in 2021 is much less than normal year.

In terms of strengthening preemptive capacity to respond to flood in ROK, the Ministry of Environment (ME) has promoted the expansion of flood warnings and information points so that more residents nearby rivers can quickly recognize flood information, respond and evacuate ahead of the natural disaster countermeasure period (May 15 to October 15). Accordingly, the number of flood warning points for national and local rivers has been increasing and flood information points, which provide the risk of

flooding of vulnerable points such as parks and parking lots in rivers by real-time observation along with flood warning points, were operated at 534 points, an increase of 125 compared to the previous year (409 locations).

In addition, the ME provides the ‘Flood Alarm’ APP service for flood forecast-related special warnings and information. Also, an online version of the Flood Risk Map was released on the Flood Risk Map Information System (www.floodmap.go.kr) since March 2021 so that the maps have been using in a more effective way for the general public to quickly identify flood risk areas and evacuate timely. These can be seen as one case of Korean policy reflecting the principle that it is important not only to the government but also to the people themselves to quickly recognize the flood-related risk information around them in order to respond to localized torrential heavy rainfall, which are frequently increasing recently due to climate change, etc.

21. For 2021, there were weather events in Singapore which may have been indirectly induced by Tropical Cyclones/Storms (TC/TS) in the Indian Ocean and the western Pacific Ocean, despite the island’s location near the Equator. TC/TS have been observed to influence wind patterns, which may in turn trigger or enhance weather systems affecting Singapore such as the “Sumatra” squalls. The atmospheric circulation patterns during both Typhoon Conson and Super Typhoon Chantu possibly contributed to the development of such a squall on 9th September 2021 which brought widespread intense rain and gusty winds to the island. Singapore also saw the wettest August in 2021 when the highest monthly total rainfall of 426.2 mm surpassed the previous record of 346.6 mm set in 1996. During the month, there were three occurrences of flash floods across the island, one of which had the highest daily total rainfall of 247.2 mm recorded on 24 August 2021. This surpassed the previous record of 181.8mm set in 1983. The wet weather was attributed to the active Madden Julian Oscillation (MJO) phase 2 in addition to the negative phase of the Indian Ocean Dipole in the background.

Singapore updated on the progress of the KRA in the following regional activities which had contributed to Southeast Asia’s capability-building in extreme weather, including:

- Southeast Asia Regional Climate Centre Network (SEA RCC-Network).
- ASEAN Climate Outlook Forum (ASEANCOF).
- Subseasonal-to-Seasonal Predictions for Southeast Asia (S2S-SEA)

For ASEANCOF particularly, Singapore highlighted on the establishment of the ASEANCOF Working Group, with the goal of guiding and supporting the long-term development of ASEANCOF’s activities

22. In January 2021, there was strong monsoon affect to the South of Thailand caused floods occurred in Narathiwat and Pattani Province. Later from February to May, the amount of rainfall was above average about 5-10%. Nevertheless, the rain-shortage before rainy season caused drought in many agriculture areas. The water storages in the large-scale dams in the North and West were less than the average. As of October, Thailand was influenced by several monsoon-troughs, the strong southwest monsoon, the strong low-pressure cell, and tropical depression, resulting 30 provinces were confronted with rainstorm-floods and flash floods. Especially, On 24 September, tropical storm DIANMU downgraded to a tropical depression and an active low-pressure cell moving along the monsoon-trough line, covered the Northeast and the Central of the country, resulting heavy to very heavy rainfall in the areas of North, the Northeast, the Central including Bangkok Metropolis and its vicinity, and the East regions. In total floods occurred in 39 provinces with 69 hydrological stations.

During the rainstorm-flood events, Thai Meteorological Department (TMD), ONWR, and Royal Irrigation Department (RID) took effective measures to enhance weather and flood forecasting and early warning for disaster prevention and mitigation, including (1) readiness preparation for support water pump, truck etc.; (2) improving the forecasting by using flood modeling and AI technology; (3) using

internet and video conference for communication under COVID-19 pandemic; and (4) developing dashboard information for monitoring and publishing on official websites.

23. In 2021, several tropical systems affected the western North Pacific from October 1, 2020 through the end of October 2021. The pattern began as a La Nina pattern, became ENSO-neutral, then returned to a La Nina pattern. This helped to limit TC development over the Marianas and most of Micronesia, Guam, USA. Most of the TCs passed through the region as Tropical Depressions. There were a few that were noteworthy, including super Typhoon Surigae, Tropical Storm Omais (16W) and Super Typhoon Mindulle. Super Typhoon Surigae caused heavy rain of up to 15 inches (381 mm) on Yap Island and from 14 to 19 inches (356 to 483 mm) for some of the islands in the Palau, producing flooding, damage to the roads, and mudslides on the higher islands. Super Typhoon Mindulle caused rainfall ranged from about 5 inches (127 mm) over Saipan and Tinian and over 10 inches (254 mm) in some locations on Guam. This produced some minor flooding with only minor flood damage reported.

In 2021, with rainfall below normal for the first 6 to 8 months of 2021, amounts increased to near or a little above normal across most of Micronesia and the Marianas by the end October . A significant amount of rainfall came from periods of strong monsoon activity, especially for the western islands, rather than the passage of TCs. This was especially true over Palau and Yap. Koror received several days of significant rainfall during the month of October, resulting in mudslides, damaged roads and flooding. Yap saw increased rainfall as well, though not as extreme as Palau. The Marianas, especially Guam, saw nearly 13 inches (330 mm) above normal rainfall for the month, setting a new record of 26.68 inches (677.7 mm) for the month of October.

24. In 2021, as of October, Vietnam had several major-flood events, less than in previous years. The main reasons include: (1) the average rainfall during dry season is lower than the long-term average leading to low flow in large rivers; (2) the flood-detention capacity of reservoirs are much improved, especially those in the North and Central regions.

In the Northern part of Vietnam, the frequency of local heavy rainfall is increasing, resulting more and severe flash floods and landslides. This situation rises big challenge in flood-hazard warning and forecasting. WMO has agreed to deliver Vietnam National Meteorological and Hydrological Administration (VNMHA) as a Regional Center for developing and implementing the SouthEast Asian Flash Flood Guidance System (SeA FFGS) include members: Cambodia, Lao PDR, Thailand, and Viet Nam under Global Flash Flood Guidance System of WMO. The implementation of SeA FFGS will include (1) System development and implementation; (2) Support for online FFG-related courses; (3) Operational training at HFC; (4) Regional operations training; (5) Operations sustainability training, and (6) Operation support. Vietnam-side advocated and recommended to apply advanced technologies in real-time warning and forecasting in operation for flood, flash flood, landslide, and inundation.

III. Progresses of WGH AOPs in 2021 and Implementation Plan for 2022

25. The project leaders and/or their representatives from China, Japan, RO Korea presented the progresses in 2021 and the implementation plan for 2022. The participants reviewed and discussed the implementation status in 2021 and the success indicators for 2022 of WGH AOPs.
26. The WGH AOPs in 2021 and beyond was summarized in the table 1. The implementation status of WGH AOP 2021 is summarized in the Annex 1.

Table 1: The list of WGH AOPs in 2021 and beyond

Item	Projects	Driver	Duration
AOP1	Knowledge Sharing on Storm Surge Inundation Mapping	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	2018~2022
AOP6	Flood Risk Watch Project for Life-saving	Japan	2019~2022
AOP7	Platform on Water Resilience and Disaster under IFI	Japan	2019~2022

AOP1: Knowledge Sharing on Storm Surge Inundation Modeling

27. The leader of this project Mr. Kenneth Kleeschulte from National Weather Service (NWS), Weather Forecasting Office (WFO) Guam informed that, due to the limitations in travel and other problems during the Covid-19 outbreak, the project does not get any progress in past two years. He has received no additional requests, other than from Korea, for any cooperation or interest in the program. However, the project leader expressed that, he would like to get this project back on track as soon as face to face meetings are again allowed. This information is very important, and he would like to continue to solicit all countries to send their interest in the program as soon as possible so that the project team can begin to make progress toward initiating this worthwhile project.
28. The project is considered to be extent 3 more years to 2025 with adjustable subject to the situation of COVIN-19.

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

29. At TC 52nd Session, following activities were scheduled for the project on Application of Hydrological Data Quality Control System in 2021:
- to host the expert mission wrap-up meeting
 - to publish the technical report for hydrological data quality control system
 - to continue developing the hydrological data quality control system
30. Han River Flood Control Office (HRFCO) in cooperation with Korea Institute of Civil Engineering and Building Technology (KICT) pushed this project forward in 2021. The implementation status and progresses were described as below:
- Project team summarized the results of field survey, which was conducted in 5 participating Members, namely Laos, Malaysia, Philippines, ROK, and Thailand.
 - Development of hydrological quality control system is on-going.
 - Finalization of technical report for hydrological data quality control is on-going.

- Due to the impact of Covid-19, the scheduled expert mission wrap-up meeting was replaced by virtual meeting on 18 November 2021 on ZOOM. The system development and technical report were reported and discussed at this virtual meeting.

31. The implementation plan is scheduled for 2022 as:

- To finalize the establishment of the hydrological data quality control system (PC-version);
- To publish the hydrological quality control system manual as final technical report of the project.

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

32. At TC 52nd Session, the following activities for the project on Enhancement of Flood Forecasting Reliability with Radar Rainfall Data and Stochastic Technique were scheduled in 2021 as:

- Hosting the expert mission wrap-up meeting
- Finalizing the upgrading LEVEL 3 of the EFFF

33. The implementation status and progresses in 2021 were described as:

- Summarized the results of field survey which was conducted in 4 countries, namely Laos, Philippines, ROK and Thailand.
- The modification of EFFF LEVEL 3 is on-going.
- Due to the impact of Covid-19, the scheduled expert mission wrap-up meeting was replaced by virtual meeting on 18 November 2021 on ZOOM. The system development and technical report were reported and discussed at this virtual meeting.
- Submitted two papers to Tropical Cyclones Review and Research (TCRR) as below:
 - Comparison of the performance of a hydrologic model and a deep learning technique for rainfall runoff analysis
 - Analysis of AI-based techniques for forecasting water level according to rainfall

34. The implementation plan is scheduled for 2022 as:

- To develop the stochastic flood forecasting system
- To publish the stochastic flood forecasting system manual as final technical report of the project.

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

35. At TC 52nd Session, the following activities for the project on OSUFFIM Phase-II: Extension of OSUFFIM (Development Operational System for Urban Flood Forecasting and Inundation Mapping) Application in TC Members were scheduled in 2021 as:

- OSUFFIM will go on the field survey for data collecting and measuring in selected Members, and selecting new pilot studies in TC Members.
- Hydrological observation and real-time flood forecasting will be conducted in Buji River.
- Hydrological model parameter finalizing, Operational system development and pilot implementation in the selected TC Members.
- Working meeting for 2021 and beyond will be conducted in Shenzhen, China, and high-level delegations from pilot members visiting to SYSU.
- Technical trainings in pilot studies will be organized in the selected Members.

36. The implementation status and progresses of the project achieved in 2021 were described as:

- Due to the impact of Covid-19, the scheduled field survey for data collection and measuring in Field survey in selected Members could not implemented.
- Conducted flood observation in Chebei and Buji Basin in southern China that are pilot studies in China.
- Liuxihe model has been set up for the flood forecasting for Nanshui Reservoir, one of the pilot studies in China, and the results are satisfactory.
- Project team reviewed the works and achievements of the pilot study in past years. All participating Members submitted the summary reports. Based on these reports, the team leader Prof. Yangbo CHEN organized the publication of a special issue on the Typhoon Commission Journal “Tropical Cyclone Research and Review (TCRR)” with funding support. The special issue contented following papers:
 - Osman Sazali, Lingfang Chen, Abdul Hafiz Mohammad, Lixue Xing, Yangbo Chen. Flood modeling of Sungai Pinang watershed under the impact of urbanization
 - Rhonalyn V. Macalalad, Shichao Xu, Roy A. Badilla, Socrates F. Paat, Bema C. Tajones, Yangbo Chen, Bema C. Tajones. Flash Flood Modeling in the Data-poor Basin: A Case Study in Matina River Basin
 - Zhou Feng, Chen Yangbo, Wang Liyang, Wu Sheng, Shao Guangzhe. Flood forecasting scheme of Nanshui reservoir based on liuxihe model
 - Jiayang Zhang, Yangbo Chen, Chuna Li. Typhoon Hato’s precipitation characteristics based on PERSIANN
 - Jixin YU, Jinping LIU, Youngkwang CHOI. Review and Prospects of Strategies and Measures for Typhoon-Related Disaster Risk Reduction under Public Emergencies in TC Region

37. Participants expressed their highest appreciation on the funding support from China for the publication of the special issue of TCRR.

38. The implementation plan is scheduled in pilot river basins for 2022 as:

- By 30 May 2022, complete the hydrological data collection for the pilot studies in Malaysia, Philippines, and China.
- By 31 July 2022, complete parameter optimization of the pilot studies in Malaysia, Philippines, and China.
- From 1 August to 31 December 2022, complete the trial operation of real-time flood forecasting of the pilot studies in Malaysia, Philippines, and China.
- By 31 March 2023, complete project conclusion and workshop in Guangzhou, China.

39. Due to the impact of Covid-19, some activities of OSUFFIM project were postponed. Based on the communication between leading country and participating Members, China-side agreed to extend this project one more year to the end of 2023 to support participating Members to complete scheduled pilot studies.

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

40. At TC 52nd Session, the following activities for the project on Impact Assessment of Climate Change on Water Resource Variability in TC Members were scheduled for 2021 as:

- Improve RCCC-WBM model by adding flow duration curve module.

- Organize online/offline training workshops.
- Extend the application in interested members or different river basins.

41. The implementation status and progresses in 2021 were described as:

- The one-day online training workshop was organized jointly by the Information Centre of the Ministry of Water Resources (MWR) of China in cooperation with the Research Centre for Climate Change (RCCC) of MWR and the Nanjing Hydraulic Research Institute (NHRI) on 15 December 2021. Over 60 participants from 7 countries, namely China, Ethiopia, Malaysia, Myanmar, Korea, Thailand, and Vietnam, attended the virtual training course and were issued the Participation Certificates jointly by TCS and RCCC.
- The technical report of Impact Assessment of Climate Change on Water Resources Variability is under drafting.

42. The implementation plan is scheduled for 2022 as follows:

- To organize 1-2 online or offline (face-to-face) training workshops, subject to the situation of COVID-19. Participating Members will be invited to share their successful case studies and lessons learnt from using the RCCC-WBW model in their countries.
- To improve RCCC-WBM model by adding flow duration curve module.
- To publish the technical report of Impact Assessment of Climate Change on Water Resources Variability before 17th IWS of 2022.

43. Malaysia-side delivered its comments on AOP5's future collaboration. At TC 15th IWS Meeting held on 1 to 2 December 2020, China Water Expert committed to support the AOP5 activities with Water Balance Modeling application in Members in the year of 2022. Malaysia is also looking forward Water Resources Real Time Monitoring (Water in and out or Real Time Water Accounting Monitoring in selected Shared/unshared river basin). Meanwhile, Malaysia noted that the RCCC of China, MLIT of Japan and K-Water of Republic of Korea have established robust decision management system for real-time drought monitoring system. Malaysia suggested that China, Japan and Korea to consider a proposal for future capacity building enhancement on Water Resources real Time monitoring (Real Time Monitoring for Drought Warning) for example in year 2023-2025 activities. Malaysia expressed its sincerely expectation on that China, Japan and Korea would render their tools, knowledge, and experience to help Malaysian Water Managers to enhance the existing drought real time monitoring.

44. The representative from RO Korea informed that KICT has conducted a project in Vietnam on real-time water resources monitoring and establishment decision support system, and expressed it is possible to share the information of the project with interesting Members.

45. Following the request from Members, China agreed to extend the project on Impact Assessment of Climate Change on Water Resource Variability in TC Members two more years to the end of 2024 for further training on RCCC-WBM and its application in TC Members.

AOP6: Flood Risk Watch Project for Life-saving

45. At TC 52nd Session, the following activities for the project on Flood Risk Watch Project for Life-saving were scheduled in 2021 as:

- Malaysia and Japan resumed preparatory activities for test installation in Malaysia during early 2021.
- Testing will be conducted for more than 6 months to confirm observation performance and maintenance performance.

46. The implementation status and progresses in 2020 were described as:

- The worldwide pandemic of Covid-19 from early 2020 forced the suspension of 3L WLGs test installation plans in Malaysia.
- Japan and Malaysia were discussing detailed conditions for test installation plans in preparation for resuming overseas travel after the Covid-19 infection had subsided.
- At the same time, MLIT Japan recruited WLG manufacturers to participate in the 3L WLGs test installation plan, and four companies decided to participate in the test installation.

47. The implementation plan is scheduled for 2022 as:

- Malaysia and Japan will proceed with concrete activities toward the start of 3L WLGs observation in early 2022.
- The draft schedule is schedule as below subject to the situation of Covid-19:
 - Until the end of 2021: WLG manufacturers participating in test construction develop 3L WLG to meet Malaysian specifications
 - January 2022: WLG manufacturers bring 3L WLG to Malaysia and install it on the test site
 - After February 2022: Start test observation (6 months or more), check the accuracy of observation data and operability of equipment

48. The participants of working meeting noted with gratitude that, Japan-side expressed that WLG manufacturers are planning to proceed with development and on-site installation work for test observations in early 2022. Japan and Malaysia like to provide information about 3L WLGs if TC Member are interested in. Japan-side consider the possibility to extend this project one more year to the end of 2023 due to the impact of COVID-19.

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

49. At TC 52nd Session, the following activities for the project on Platform on Water Resilience and Disasters under IFI were scheduled in 2021 as:

- 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.
- To organize a thematic session of AOP7 during the 10th WGH meeting in 2021 in Japan.
- To make bridges between TC WGH and PTC through implementing the IFI Platform activities in the Philippines, Myanmar, Sri Lanka, and Indonesia.

50. The implementation status and progresses in 2021 were described as:

- Establishing the platform on water resilience and disasters and developing the flood forecasting system in Philippines. Building the Online Synthesis System (OSS) for Davao city, Philippines.
- Conducting e-learning workshops in Philippines with lectures including:
 - April 19, Opening Session and Introduction session of CC-1-3
 - April 20, Q & A Session of CC-1-3 and Introduction session of FM-1-3
 - April 22, Q & A Session of FM-1-3 and Introduction session of Exam
 - April 26, Review of CC & FM and Introduction session of DRR-1-4
 - April 28, Q & A Session of DRR-1-4 and Introduction session of Assignment
 - April 30, Q & A Session of Assignment

- Conducting e-learning workshops in Indonesia with contents as:
 - October 5, Opening Session & CC introduction
 - October 12, Workshop Session-1 & GOV introduction
 - October 19, Workshop Session-2 & OP introduction
 - October 26, Workshop Session-3 & Assignment:
 - November 5, The Closing Session

51. The implementation plan is scheduled for 2022 as:

- Hands-on Training Workshop is scheduled as the Second Phase, including:
 - How to use Online Synthesis System (OSS)
 - Training on 2D & 3D flood mapping
 - Training on contingency planning
 - Communication planning

52. The WGH AOPs for 2022 and beyond were summarized in Table 2, and the success indicators of AOPs for 2022 are shown in Annex 2.

Table 2: The list of WGH AOPs in 2022 and beyond

Item	Projects	Driver	Duration
AOP1	Knowledge Sharing on Storm Surge Inundation Mapping	USA	2020-2025
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	2018~2023
AOP5	Impact Assessment of Climate Change on Water Resource Variability in TC Members	China	2018~2024
AOP6	Flood Risk Watch Project for Life-saving	Japan	2019~2023
AOP7	Platform on Water Resilience and Disaster under IFI	Japan	2019~2022

IV. Discussion of Proposals for New AOPs

53. The participants discussed how to enhance the cooperation among Members through the implementation of AOPs and potential proposals for WGH AOPs in 2022 and beyond.
54. 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 under the situation of COVID-19.
55. The following keywords were recommended by TCS hydrologist for consideration of new AOPs for WGH in future: Virtual (E-) training course; AI and Big data application; flash flood (nowcasting-warning); urban flood monitoring and forecasting; Dam operation; Impact based forecasting, etc.
56. Following topics were suggested for consideration of new AOP proposals:
- 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
 - Application of the big-data and AI technology in aspect of flood-related disaster early warning
57. Considering all on-going AOPs will be closed in end of 2022, the Members are encouraged to consider the initial proposals for new cooperation projects under the updated TC Strategic Plan 2022-2026 for discussion in WGH parallel session at coming 16th IWS to be held on 2-3 December 2021. The detail road map and implementation plan can be submitted and discussed at 11th WGH working meeting and 17th IWS in 2022, and report at 54th Annual Session in early 2023 for approval.
58. HRFCO in cooperation with KICT presented proposals of two new AOPs for 2023 and beyond for further discussion, namely “Improvement of Hydrological Data Quality Control System by using AI technology” and “Improvement of Flood Forecasting modelling by using AI technology”.

Proposal 1: Improvement of Hydrological Data Quality Control System by using AI technology

59. Hydrological data is essential and basic in flood forecasting. High quality hydrological data is strongly needed to reduce the forecasting uncertainty. The on-going project on “Application of Hydrological Data Quality Control System” led by Republic of Korea analyzed the basic status on hydrological data quality control among participating Members, and initially developed the data processing system focusing on rainfall and water stage. The achievement of the project will assistant Members to enhance their capacity on data quality control, and consequently improve their hydrological forecasting and social service. However, through the implementation of the project, Members further recognized that it needs to further upgrade and improve hydrological data quality control system covering more hydrological elements (such as discharge, sedimentation, tide, etc.) by using advanced technology of big data and Artificial Intelligent (AI) and apply the system in the practical and real-time operation. In this connection, HRFCO in cooperation with KICT proposed “Improvement of Hydrological Data Quality Control System by using AI technology” as new AOP for 2023 and beyond.
60. The objectives of “Improvement of Hydrological Data Quality Control System by using AI technology” is to develop an advance hydrological data quality control system by using technology of big data and Artificial Intelligent (AI) so as to enhance TC Member’s capacity on managing and monitoring hydrological data (Rainfall, Water Level, Discharge, tide, etc.) and reduce the uncertainty of input data for flood forecasting.
61. The proposed implementation period for the project on “Improvement of Hydrological Data Quality Control System by using AI technology” if 5 years from 2023 to 2027 with preliminary roadmap as:
- 2023: TC Member apply Hydrology Data Quality Control System in practical operation
 - 2024: Establishment of Advancement Plan for Hydrology Data Quality Control System; drafting and publishing technical report

- 2025: Development of AI Optimization Techniques for Hydrology Data Management
- 2026: Improvement and Advancement of the Hydrological Data Quality Control System (1) and drafting and publishing system manual
- 2027: Improvement and Advancement of the Hydrological Data Quality Control System (2)

Proposal 2: Improvement of Flood Forecasting modelling by using AI technology

62. To improve flood forecasting modelling and upgrade the accuracy of hydrological forecasting is the perpetual goal of hydrologists in Members. In the past years, WGH have continually conducted several cooperation projects as its AOPs on this aspect, including Extreme Flood Forecasting System (EFFS) led by Republic of Korea. Those AOPs achieved good results and played a positive role on improving Members' capacity of flood forecasting and early warning. Due to the uncertainties of flood forecasting, the real time operational flood forecasting could be further upgraded and improved with the progresses of the application of the technology of big data and Artificial Intelligent (AI). In this connection, HRFC in cooperation with KICT proposes the project on Improvement of Flood Forecasting modelling by using AI technology as WGH AOP for 2023 and beyond.
63. The objectives of the proposal of Improvement of Flood Forecasting modelling by using AI technology is to develop advanced flood forecasting system by using the technology of big data and AI so as to enhance TC Member's capacity on real-time operational flood forecasting.
64. The implementation period for proposed AOP is 5 years from 2023 to 2027 with preliminary roadmap as:
- 2023: Establishment of Linkage Plan with EFFS and Practical Application
 - 2024: Establishment of Advancement Plan for Flood Forecasting System; drafting and publishing technical report
 - 2025: Development of AI, Optimization Techniques for Flood Forecasting
 - 2026: Improvement and Advancement of the Flood Forecasting System (1) and drafting and publishing system manual
 - 2027: Improvement and Advancement of the Flood Forecasting System (2)

Proposal 3: Knowledge Sharing on the Southeast Asia Flash Flood Guidance System (SeAFFGS)

65. Due to climate change and urbanization, extreme hydro-meteorological events happened more frequently in past decades, especially the flash flood and landslides caused by local heavy rainstorm has become a major disaster risk, and its forecasting and warning rises big challenge in Asia and Pacific region. Every year huge economic damage and life losses caused by flash flood and landslides in TC Members. WMO Secretariat and National Meteorological and Hydrological services (NMHSs) have paid close attention and made great efforts on promoting the capacity of flash flood disaster forecasting and early warning. WMO has agreed to deliver Vietnam National Meteorological and Hydrological Administration (VNMHA) as a Regional Center for developing and implementing the SouthEast Asian Flash Flood Guidance System (SeA FFGS) include members: Cambodia, Lao PDR, Thailand, and Viet Nam under Global Flash Flood Guidance System of WMO. The implementation of SeA FFGS includes: (1) System development and implementation; (2) Support for online FFG-related courses; (3) Operational training at HFC; (4) Regional operations training; (5) Operations sustainability training, and (6) Operation support. Vietnam-side advocated and recommended to apply advanced technologies in real-time warning and forecasting in operation for flood, flash flood, landslide, and inundation. In this connection, Viet Nam Meteorological and Hydrological Administration (VNMHA) presented the proposal of Knowledge

Sharing on the Southeast Asia Flash Flood Guidance System (SeAFFGS) as a new AOP for 2023 and beyond for further discussion.

66. The objective of Knowledge Sharing on the Southeast Asia Flash Flood Guidance System (SeAFFGS) as an AOP of WGH is to share the knowledge of flash flood guidance system among TC Members to enhance the capacity building on flash flood forecasting and early warning through combining the activities of the VNMHA regional center of SeA FFGS (including training course, workshop, and application) with the activities of TC WGH annual operation plan.
67. The implementation period for proposed AOP will be last for 3 years from 2023 to 2025. As the implementation strategy, the annual implementation plan of the AOP of **SeAFFGS** will be combined with the annual activities of VNMHA regional center of SeA FFGS focusing on sharing knowledge, information and experience gained through the process of organizing and operating the system in practice by on-line and/or off-line seminars and workshops.

Proposal 4: Flood Monitoring for Risk Reduction (tentative)

68. Water-related disaster risk is increasing significantly in many parts of the world, most likely due to climate change. Water-related disaster impacts people, ecosystems and economies. In recent years, due to the record-breaking amount of and extensive area of rainfalls, Japan has experienced levee breaches of river levees, long-lasting inundations and unexperienced landslides. For example, the July 2018 Heavy Rains caused extensively river inundation, inland inundation and debris flows simultaneously around Western Japan. This did serious damage including 224 dead, 8 people missing, 21,460 houses totally or partially collapsed, and 30,439 houses inundated. Local governments issued emergency evacuation orders for 915,849 families or 2,007,849 people, and evacuation advisories for 985,555 families or 2,304,296 people; in October 2019, river collapses and landslides occurred in a very extensive areas due to the heavy rains from the Typhoon Hagibis, which caused a severe damage including 77 dead, 8 people missing, 7,231 totally or partially collapsed houses and 66,938 inundated houses; in July 2020, unprecedented rainfall from July 3rd to 31st in Japan's Kumamoto Prefecture and elsewhere caused extensive flooding and levee breaches. At least 80 people died or remained unaccounted for, and around 14,000 houses were inundated. Considering concerns about the intensification and frequent occurrence of water disasters due to the effects of climate change, a committee composed of experts made recommendations to MLIT regarding water disaster countermeasures based on climate change in July 2020. Based on this recommendation, MLIT is reviewing the hydraulic control plan in consideration of climate change, and is proceeding with the conversion to "River Basin Disaster Resilience and Sustainability by All" in which all parties concerned work together throughout the basin.

In order to carry out appropriate river management and disaster prevention measures against water related disasters caused by cloudburst and localized downpour (so-called "guerrilla" downpour), MLIT is promoting an innovative initiative using a low-cost water level gauge (3L WLG). Current on-going WGH AOP6 on "Flood Risk Watch Project for Life-saving" aims to conduct field verification tests in TC Member in order to share 3L WLG installation procedures and data usage methods with TC Member. Currently, the verification tests have been implementing in Malaysia, and we hope to expand this project to move TC Member in the future to contribute to the improvement of water related disasters prevention capacity. In parallel to the domestic policy, the MLIT would share this new approach with TC Members to install the basic and practical effort to develop more accurate flood forecasting and activate more effective evacuation. In addition, the Asia-Pacific Water Summit will be held in April 2022, and we would like to refer to the results obtained there and consider measures to contribute to other countries as necessary.

On this connection MLIT-Japan is willing to propose a cooperation project on "Flood Monitoring for Risk Reduction (tentative)" as a new AOP for WGH.

69. The Objective of the proposed new AOP for WGH will target building resilient communities in the Asia-Pacific region, and assist developing water level observation network in selected river basins of collaborative Members.
70. The implementation period for the proposed AOP is 4 years from 2023 to 2026 with a preliminary roadmap as:
- 2023: Meeting, filed survey, workshop on how to contribute
 - 2024: Workshop to select the target countries
 - 2025: Workshop on how to apply the plan
 - 2026: Workshop on how to exploit the plan

Proposal 5: Flood Resilience Compatible with Sustainable Development (tentative)

71. Enhancing disaster resilience is indispensable to mitigate the hazard and recover from the damage due to typhoons, under the concept of Sendai Framework for Disaster Risk Reduction, Paris Agreement, and Sustainable Development Goals (SDGs). From the perspective that disaster resilience, climate change adaptation, and sustainable development are closely interlinked, proper disaster management and capacity development involving all relevant stakeholders must lead to the city/region's continuous prosperity. To implement this concept, "Platform on Water Resilience and Disasters" has been established in some Asian countries including the Philippines with the support of the International Flood Initiative (IFI) which is a joint initiative of international organizations such as UNESCO-IHP, WMO, and so on. As a secretariat of IFI, ICHARM has been contributing to enhancing disaster resilience. On this connection, ICHARM of Japan is willing to propose a cooperation project on "Flood Resilience Compatible with Sustainable Development (tentative)" as a new AOP for WGH.
72. The objectives of proposed new AOP on "Flood Resilience Compatible with Sustainable Development" are listed below.
- To develop an Online Synthesis System for Sustainability and Resilience (OSS-SR), achieving prevention and mitigation efforts of water-related disasters by synthesizing data, knowledge, information, experience, know-how, and technology for relevant stakeholders such as city office, regional/local governmental agencies, academia, and community leaders
 - To foster "Facilitators" capable of leading the accumulation of dialogues and science communications to improve disaster resilience and sustainable development by the effective use of OSS-SR.
 - To enlarge the scope of disaster resilience beyond the one of typical flood control to be compatible with sustainable development.
 - To disseminate the AOP achievements to the world as one of the best practices.
73. The implementation period for the proposed AOP is 5 years from 2023 to 2027 with a preliminary roadmap as:
- 2023: Development of OSS-SR and fostering "Facilitators"
 - 2024: Incorporation of biodiversity into OSS-SR and model-coupling
 - 2025: Incorporation of environment into OSS-SR and model-coupling
 - 2026: Incorporation of agricultural productivity into OSS-SR and model-coupling
 - 2027: Integration and policy recommendation

V. Review TCTF allocation for WGH activities in 2021 and Proposed Request for 2022

74. WGH reviewed the allocation of TCTF (\$30000USD) for WGH activities in 2021 shown in table 3. Due to the impact of pandemic of COVID-19, all allocated TCTF did not spend in the year.

Table 3 The summary of TCTF Budget Requested for 2021 Activities

Item	Activities	Driver	Budget	Usage
1	Support the activities related to Knowledge Sharing on Storm Surge Inundation Mapping	USA	4000	0
2	Support the activities related to Application of Hydrological Data Quality Control System in TC Members	Korea	4000	Publication
3	Support the activities related to Enhancement of Flood Forecasting Reliability with Radar Rainfall Data and Stochastic Technique	Korea	3000	0
4	Support the activities related to OSUFFIM Phase-II: Extension of OSUFFIM Application in TC Members	China	8000	0
5	Support the activities related to Impact Assessment of Climate Change on Water Resource Variability in TC Members	China	4000	0
6	Support the activities related to Platform on Water Resilience and Disaster under IFI and hosting WGH 10 th Working Meeting in Japan	Japan	7000	0
	Total		30,000	0

75. WGH participants were informed by TCS hydrologist the following message from AWG meeting about TCTF:

- AWG noted the importance of keeping a healthy budget in the near future to reduce deficits and maintaining sustainable TCTF expenses.
- AWG requested WG Chairs to consider reducing their expenditures of around 10% in the coming years, including the option for Members to self-fund attending the IWS. In parallel, AWG may also encourage Members to increase their contributions in the next Session.
- AWG Chair invited WG Chairs to discuss with their working group members and propose the preliminary suggestions on reducing the budget for next year. All WG Chairs agreed to help review their WG activities and identify areas with potential reduction in the budget request.
- The AWG Chair will cooperate with TCS in finding ways to reduce the IWS expenditure and further discuss the possible options.

76. The Members and project leaders recognized the situation of TCTF and agreed to support the request of AWG on TCTF usage and management. The requested TCTF for supporting WGH activities in 2022 is reduced more than 10% from the budget of 2021.

77. The Participants expressed their highest appreciation to China, Japan, RO Korea, and other Members for their in-kind contribution in the year, and encouraged all Members continue their strong support.

78. Based on the discussion, WGH proposed the budget request of \$25,000USD for supporting its activities in 2022 shown in table 4.

Table 4 The summary of TCTF Budget Requested for 2022 Activities

Item	Activities	Driver	Budget
1	Support the activities related to Knowledge Sharing on Storm Surge Inundation Mapping	USA	---

2	Support the activities related to Application of Hydrological Data Quality Control System in TC Members	Korea	3000
3	Support the activities related to Enhancement of Flood Forecasting Reliability with Radar Rainfall Data and Stochastic Technique	Korea	3000
4	Support the activities related to OSUFFIM Phase-II: Extension of OSUFFIM Application in TC Members	China	7000
5	Support the activities related to Impact Assessment of Climate Change on Water Resource Variability in TC Members	China	5000
6	Flood Risk Watch Project for Life-saving	Japan	---
7	Support the activities related to Platform on Water Resilience and Disaster under IFI, including hosting the potential face to face WGH 11 th working meeting in 2022	Japan	7000
	Total		25000

VI. Discussion of Draft Updating TC Strategic Plan 2022-2026

79. TCS hydrologist briefed the situation of updating TC Strategic Plan 2022-2026 with highlight of hydrological component for participants' discussion.
80. Participants was informed the changes of new version of TC Strategic Plan on Targets, Key Result Areas (KRAs) and Priorities, and noted that the draft Strategic Plan will be tabled for discussion during 16th IWS before presenting the final draft for consideration/approval in the TC 54th Annual Session to be held in early 2022.
81. Participants were requested to review the draft updating Strategic Plan 2022-2026 with focusing on Targets, Key Result Areas (KRAs) and Priorities related to hydrological component in advance for discussion during 16th IWS on 2-3 December 2021.
82. WGH proposed the new version of hydrological priorities for updating Strategic Plan 2022-2026 shown as in the table 4.

No	Hydrological Priority	KRA						
		1	2	3	4	5	6	7
1	Improve typhoon-related flood (including river flood, urban flood, mountainous flood; flash flood and storm surge, etc. the same below) monitoring data collection, quality control, transmission and processing.			X	X			
	New version: Improve typhoon-related flood (including riverine flood, flash flood, urban flood, and costal flood) monitoring, data collection and archiving, quality control, transmission, processing, and sharing framework.	X	X		X	X	X	
2	Enhance capacity in typhoon-related flood risk management (including dam operation), integrated water resources management and flood-water utilization.		X	X	X			
	New version: Enhance capacity in typhoon-related flood risk management (including land-use management, dam operation, etc.) and integrated water resources management by all relevant stakeholders.			X			X	X
3	Enhance capacity in impact-based and community-based operational flood forecasting and early warning, including methodology research, hydrological modelling, and operation system development.		X	X	X			
	New version: Strengthen capacity in effective flood forecasting and impact-based early warning including hazard mapping and anticipated		X		X		X	X

	risk based on methodological and hydrological modelling, and operation system development.								
4	Enhance capacity in flood risk (hazard, inundation) information, mapping and its application. (integrated into No.3)	X	X	X					
5	Enhance capacity in assessment and dealing with the impacts of climate change, urbanization and other human activities on typhoon-related flood disaster vulnerability and water resources availability.	X	X	X					
	New version: Develop capacity in foresight the impact of climate change and social change such as urbanization and other human activities on typhoon-related flood disaster risk and water resources variability.			X	X	X	X	X	X
6	Enhance capacity in advanced technology (including satellite data, GIS, RS, QPE/PQF, ensemble, parallel computing) utilization in typhoon-related flood forecasting and early warning, and hydrological modeling.	X	X	X					
	New Version: Increase capacity in utilization of advanced science and technology for typhoon-related flood forecasting, early warning, and management.					X	X	X	

VII. Conclusions

83. On the basis of the discussion and outcomes at 10th WGH working meeting, participants recognized the importance in following aspects for further direction of WGH:

- It is a consensus on that, the impact of COVID-19 may become a normal situation in a certain period. TC Members may need to consider how to coexist with COVID-19. In this connection, it is needed to analyze the new countermeasures under public emergencies on typhoon-related disaster risk reduction in TC Members in this typhoon season, including monitoring, data collection, forecasting and warning, information sharing and emergency response; summarize the experience and coping strategy on typhoon-related disaster risk reduction in the region of TC and other regions in the world; and provide reference and guidance for TC Members on typhoon-related disaster risk reduction under public emergencies in future. Members also may need to consider how to push the Working-Group's annual operation plan (AOP) forward under the situation of COVID-19. It is recognized that it should be an effective measure to establish a regular mechanism for on-line activities instead of face-to-face interaction including training course, workshop, and etc.
- It is a consensus on that, the working meeting of WGH is very important to review and push forward hydrological activities and is very necessary to prepare IWS and annual session. WGH appreciated the generous contribution from Republic of Korea and Japan in the past years for hosting WGH working meetings. WGH also encouraged more Members to host its working meeting.
- Due to the impact of COVID-19, the virtue conference has become a normal format for WGs' annual meeting and TC integrated workshop (IWS). Due to the limited agenda, it is very hard for AOP leaders to have enough time for deep technical discussion and explanation on WGs' meetings and TC IWS. To resolve this problem, HRFCO in cooperation with KICT organized virtual workshops special for Korea-led AOPs in past two years. Following this good example, all AOP leading Members may need to consider on-line AOP workshop or training course annually for their led AOPs with the purpose of deep discussion of AOP's implementation so as to keep its momentum and sustainability.
- 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 2022-2026 in a linkage with the initiatives and activities of ESCAP and WMO would be an urgent matter at present for WGH. To conduct the

cooperation projects sustainably in TC Members, WGH discussed and determined the list of potential topics and keywords as the priority cooperation activities for long-term direction to develop the Member's capacity on water-related disaster risk forecasting and warning.

- WGH members recognized that the application of big data and AI technology in flood forecasting and early warning will become a mainstream and development direction in future. WGH should consider a cooperation project as its AOP on this area to enhance the application study.
- WGH agreed to continue enhancing 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 working meeting.

VIII. Recommendations to the Committee

84. On the basis of the deep discussion and communication, participants agreed to submit the following recommendations to the Committee at TC 54th Annual Session to be held in early 2022:

- to request US\$25,000 from TCTF for supporting overall WGH activities for 2022 calendar year.
- to thank MLIT, Japan in cooperation with ICHARM and IDI for hosting the video conference for WGH 10th Working Meeting on 22 October 2021.
- to request USA to extend the project of AOP1 (Knowledge Sharing on Storm Surge Inundation Mapping) three more year to the end of 2025.
- to request China to extend the project of AOP4 (OSUFFIM Phase-II: Extension of OSUFFIM Application in TC Members) one more year to the end of 2023.
- to request China to extend the project of AOP5 (Impact Assessment of Climate Change on Water Resource Variability in TC Members) two more years to the end of 2024.
- to request Japan to extend the project of AOP6 (Platform on Water Resilience and Disaster under IFI) one more year to the end of 2023.
- to request MLIT, Japan to host the face-to-face WGH 11th working meeting in Japan subject to the situation of COVID-19 in 2022.
- to request HRFCO, Republic of Korea in cooperation with KICT to further refine the proposals of “Improvement of Hydrological Data Quality Control System by using AI technology” and “Improvement of Flood Forecasting modelling by using AI technology” for approval at TC 55th Session as WGH AOPs for 2023 and beyond.
- to request VNMHA, Viet Nam to further refine the proposal of “Knowledge Sharing on the Southeast Asia Flash Flood Guidance System (SeAFFGS)” for approval at TC 55th Session as WGH AOP for 2023 and beyond.
- to request MLIT and ICHARM of Japan to further refine the proposals of “Flood Monitoring for Risk Reduction (tentative)” and “Flood Resilience Compatible with Sustainable Development (tentative)” for approval at TC 55th Session as WGH AOP for 2023 and beyond.
- 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, Mr. Yo-Han CHO, as the liaison to PTC and WMO RA II for WGH of the Committee for enhancing hydrological cooperation between TC and other regional bodies under the supervision of Dr. Hyo-Seob CHO as the Chairperson of the RAI Coordination Panel on Hydrology and Water Resources of WMO.

- 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 2021

Annex 2. Successor Indicators of WGH AOP 2022

Annex 1. Implementation Status of WGH AOP 2021

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 1 KRA 2 KRA 3 KRA 4 KRA 7	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	4000	WFO Guam	No No No
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	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; 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	3000	HRFCO, ME	Yes Yes
KRA 1 KRA 2 KRA 3 KRA 4 KRA 5 KRA 7	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	(a) Yes (b-d) NO (d) Yes
KRA 3 KRA 6	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	
KRA 1 KRA 2 KRA 3 KRA 4 KRA 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	(a)Yes (b)No (c-d)On-going
KRA 1 KRA 2 KRA 3 KRA 4 KRA 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	WGM WGDRR	See above	(a) First (b) Second (c) Third (d) Fourth	PAGASA DPWH, OCD TMD	(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	7000	ICHARM MLIT	(b) Ongoing (b) Yes (b-d) Yes

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
			further improved flood management through collecting data, transferring knowledge and enhancing the capacity				RID	(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 10th in October 2020 in Japan			(c-d) Ongoing (d) Yes (c-d) Ongoing (d) Yes

- KRA 1: Enhance capacity to monitor the impacts of tropical cyclone related disasters, including reduction of mortality rates and direct economic losses, and strengthen tropical cyclone related disaster risk reduction (DRR) activities in various sectors.
- KRA 2: Enhance capacity in tropical cyclone forecast and disaster risk prediction using multi-hazard impact-based forecasts, risk-based warnings, understandable information designed in collaboration with users, and cutting-edge information technology, leveraged from the latest advances in big data analytics, artificial intelligence, machine learning, and social science to support early warning systems, decision making and disaster response.
- KRA 3: Improve flood mitigation measures and integrated water resource management to reduce the impacts of flooding caused by tropical cyclones.
- KRA 4: Strengthen capacity development activities in meteorology, hydrology, DRR and civil protection sectors, to enhance nationally to locally coordinated mechanisms for tropical cyclone early warning information to reach the last mile; and combine public awareness with the appropriate response to protect life and property from tropical cyclones.
- KRA 5: Promote visibility and enhance Typhoon Committee's Regional and International collaboration mechanisms to build partnerships, enhance capacity development, share best practices, and encourage active participation of international organizations in the disaster risk reduction programmes.
- KRA 6: Create a framework for cooperative scientific research on tropical cyclone and related disciplines, particularly in relation to climate change, and include support for translating research outcomes to services by developing relevant experiments, research projects, conducting field surveys, and publishing and promoting research findings.
- KRA 7: Enhance the resilience of vulnerable communities, especially coastal communities, to tropical cyclone impacts.

Annex 2. Success Indicators of WGH AOP 2022

KRA	Objective Number	Objective	Action	Other WGs Involved	TCS Responsibility	Expected Quarter Completed	Other Organizations Involved	Success Indicators	Funding Required	Funding Sources
KRA 1 KRA 2 KRA 3 KRA 4 KRA 7	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-c) Finalize the establishment of the hydrological data quality control system (PC-version) (d) Publication of the hydrological quality control system manual	3,000	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, TMD, Thailand	(a-c) Develop the Stochastic Flood Forecasting System (d) Publication of the stochastic flood forecasting system manual	3,000	HRFCO, ME
KRA 1 KRA 2 KRA 3 KRA 4 KRA 5 KRA 7	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) OSUFFIM trial systems to be installed and trial operated in China. (b-d) OSUFFIM trial systems to be installed and trial operated in Malaysia or/and Philippines. (d) workshop in SYS Uni. or online.	7,000	HFC; SYS Uni. China
KRA 3 KRA 6	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	(b) improvement of RCCC-WBM model by adding flow duration curve module. (c, d) Online or/and offline training workshops on model application (c) publish the technical report on cases study of RCCC-WBM model application	5000	HFC and NHRI of China
KRA 1 KRA 2 KRA 3 KRA 4 KRA 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) Understanding Malaysia's required specifications (b) Customize 3L water level gauge to Malaysian specifications (c) Conducting test observations in Malaysia (d) Obtained performance certification from Malaysia DID		MLIT
KRA 1 KRA 2 KRA 3 KRA 4 KRA 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	WGM WGDRR	See above	(a) First (b) Second (c) Third (d) Fourth	PAGASA DPWH, OCD TMD RID	(a-b) Hold the capacity development programs (b-c) Organize the session on the platform in the Philippines (b-c) Promote collaboration with the other WGs as a cross-cutting project (c-d) Organize the workshops for demonstration	7000	ICHARM MLIT

KRA	Objective Number	Objective	Action	Other WGs Involved	TCS Responsibility	Expected Quarter Completed	Other Organizations Involved	Success Indicators	Funding Required	Funding Sources
			further improved flood management through collecting data, transferring knowledge and enhancing the capacity					and dissemination at some major international events (d) Organize WGH 11 th working meeting in October 2022 in Japan		

- KRA 1: Enhance capacity to monitor the impacts of tropical cyclone related disasters, including reduction of mortality rates and direct economic losses, and strengthen tropical cyclone related disaster risk reduction (DRR) activities in various sectors.
- KRA 2: Enhance capacity in tropical cyclone forecast and disaster risk prediction using multi-hazard impact-based forecasts, risk-based warnings, understandable information designed in collaboration with users, and cutting-edge information technology, leveraged from the latest advances in big data analytics, artificial intelligence, machine learning, and social science to support early warning systems, decision making and disaster response.
- KRA 3: Improve flood mitigation measures and integrated water resource management to reduce the impacts of flooding caused by tropical cyclones.
- KRA 4: Strengthen capacity development activities in meteorology, hydrology, DRR and civil protection sectors, to enhance nationally to locally coordinated mechanisms for tropical cyclone early warning information to reach the last mile; and combine public awareness with the appropriate response to protect life and property from tropical cyclones.
- KRA 5: Promote visibility and enhance Typhoon Committee's Regional and International collaboration mechanisms to build partnerships, enhance capacity development, share best practices, and encourage active participation of international organizations in the disaster risk reduction programmes.
- KRA 6: Create a framework for cooperative scientific research on tropical cyclone and related disciplines, particularly in relation to climate change, and include support for translating research outcomes to services by developing relevant experiments, research projects, conducting field surveys, and publishing and promoting research findings.
- KRA 7: Enhance the resilience of vulnerable communities, especially coastal communities, to tropical cyclone impacts.