

ESCAP/WMO Typhoon Committee

17th Integrated Workshop

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Organized by TCS and ESCAP

ESCAP UNCC, Bangkok • Thailand

FOR PARTICIPANTS ONLY

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ENGLISH ONLY

**WORKING GROUP ON HYDROLOGY (WGH) ACTIVITIES
PROGRESS REPORT 2023**

(For TC 18th IWS)

(Drafted and Submitted by WGH)

I. ORGANIZATION OF THE WGH 12th WORKING MEETING

1. Referring to the decision of the 55th Session of the ESCAP/WMO Typhoon Committee (TC), the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), Japan and and Royal Irrigation Department (RID), Thailand co-hosted the 12th working meeting of TC Working Group on Hydrology (WGH) on 20-22 September 2023 in Bangkok, Thailand.
2. The on-site meeting was held at the Quarter Hotel Ari. Considering the some participants might not be available for taking part in the meeting in-person, the Joint Organization Committee (JOC) also provided a hybrid way for the meeting via Zoom with the links available below:
 - Day 1_Topic: Opening Remarks and Technical presentations
 - Time: Sep 20, 2023 09:30 AM Bangkok
 - Join Zoom Meeting
 - <https://zoom.us/j/99196716005?pwd=VGFic2diUTI2c1pzNzV0djN4Vi81dz09>
 - Meeting ID: 991 9671 6005
 - Passcode: 319303
 - Day 1_Topic: Country Report
 - Time: Sep 20, 2023 01:00 PM Bangkok
 - Join Zoom Meeting
 - <https://zoom.us/j/91771015464?pwd=V2NBMWVQWG1zaC9ybnlEVnloMUlnUT09>
 - Meeting ID: 917 7101 5464
 - Passcode: 404406
 - Day 2_Topic: AOP Presentations
 - Time: Sep 21, 2023 09:00 AM Bangkok
 - Join Zoom Meeting
 - <https://zoom.us/j/91660277609?pwd=ajFET200WTJzWnQ3UVFwS0JsWWd5UT09>
 - Meeting ID: 916 6027 7609
 - Passcode: 240543
3. The proposed theme of the meeting was “ Community outreach and multi-stakeholder engagement – Boosting Early Warning for All – ” with the following purposes:
 - to review and present the status, achievements and progresses in hydrological components in Members in 2023;
 - to review the implementation status and progresses of WGH Annual Operating Plans (AOPs) in 2023;
 - to propose the implementation plan and success indicators for WGH AOPs for 2024, including budget requirement;
 - to discuss the assessment of WGH AOPs with UN’s Early Warnings for All (EW4All) initiative;
 - to discuss the enhancement of cooperation with WMO RA II;
 - to discuss the preparation and hydrological contribution to prepare the 18th Integrated Workshop with the 4th TRCG Forum and TC 56th Annual Session 2024.

4. The working meeting was chaired by Mr. Mamoru MIYAMOTO, and attended by 58 participants in total from 11 out 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; Thailand; USA and Viet Nam. Typhoon Committee Secretariat (TCS) also participated in the meeting in-person. The representatives from Office of the National Water Resources (ONWR), the Thailand Meteorological Department (TMD), and Department of Disaster Prevention & Mitigation (DDMP) of Thailand also appeared the meeting.
5. At opening ceremony, Mr. Adisorn Champathon, Senior Expert on Hydrology, Royal Irrigation Department (RID), Thailand delivered welcome speech on behalf of Thailand; Mr. Kikuta TOMOYA, Director for International Coordination of River Engineering, River Planning Division, Water and Disaster Management Bureau, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), Japan delivered opening remark on behalf of Japan as one of two co-hosts of working meeting; Mr. Daisuke MARUICHI, Economic Affairs Officer at UN ESCAP delivered opening speech on-site on behalf of ESCAP; TC Secretary Dr. Yihong DUAN attended the opening session virtually and delivered a speech; WGH Chairperson Mr. Mamoru MIYAMOTO gave his speech on behalf of WGH.
6. The meeting had four technical reports including: (1) Mr. Thada SUKHAPUNNAPHAN from RID Thailand presented “Using Floodmarks for Community Flood Early Warning”; (2) Mr. Fatah MASTHAWEE from Thailand Meteorological Department (TMD) presented “ Technologies in Disaster Prevention and Mitigation for community outreach and multi-stakeholder engagement”; (3) Mr. Soranata LUESOPON from Department of Disaster Prevention and Mitigation (DDPM) of Thailand presented “Community Engagement on Disaster Risk Management”; and (4) Mr. Budarto Ahamado Solihin from Department of Irrigation and Drainage (DID) Malaysia introduced “3L Water Level Gauge (3L WLG) Testing Programme”
7. The participant expressed their highest appreciation to Japanese and Thailand governments through MLIT and RID, respectively, for co-hosting the WGH 12th working meeting.
8. The meeting was informed that, TCS received the official letter dated 30 June 2023 from Information Center (IC) of the Ministry of Water Resource (MWR) of China, in which China expressed its willingness to host the WGH 13th working meeting in 2024. The participants expressed their sincerest appreciation to the generous offer from China, and agreed to submit it to the TC 56th Annual Session for approval in early 2024.
9. Japan expressed its willingness to co-host the working meeting with China as the same case with Thailand in 2023. The China expressed its appreciation to the willingness of Japan and agreed to consider the possibility of co-hosting the 13th working meeting with Japan.
10. The meeting also noted with appreciation that MLIT of Japan and Guam, USA will consider the possibility to co-host WGH 14th working meeting in 2025.

II. The Summary of Member Report on Hydrological Component in 2023

11. The WGH reviewed the flood-related disaster happened in 2023 and hydrological activities conducted in Members in the year, and also noted the special measures took in Members for community outreach and multi-stakeholder engagement for boosting Early Warning for All (EW4All).

12. In 2023 (up to 27 September), a total of 7 typhoons have landed in **China** in 2023. The Haihe River experienced basin-wide super flood and 258 rivers across China witnessed floods exceeding the warning level. Among them, Typhoon "Doksuri" has the greatest impact, mainly presenting the following three characteristics: 1.The rainfall coverage is very wide. From July 27 to August 1, nine provinces including Fujian, Zhejiang, Anhui, Henan, Shandong, Hebei, Beijing, Tianjin and Shanxi experienced heavy rainfall due to the joint influence of the "Doksuri" and the cold air, among which some part of Fujian, Zhejiang, Henan, Shandong, Hebei, Beijing, Tianjin and Shanxi provinces witnessed extremely heavy rainfall. 2.The rainfall intensity is very high. The maximum cumulative rainfall during the process is 841 millimeters in the Jiaoxi station of Putian of Fujian, 791 millimeters in the Duofeng station of Hebi of Henan, 715 millimeters in the Lingxi station of Baoding of Hebei, 654 millimeters in Wuyang of Wenzhou of Zhejiang, 608 millimeters in Huaishupu of Yangquan of Shanxi, and 594 millimeters in the Wangjiayuan Reservoir of Beijing. 3. The flood caused is historical. A basin wide super flood occurred in the Haihe River Basin, including the Daqing River and Ziya River, and the Yongding River. 31 rivers experienced floods exceeding the warning level with a range of 0.04-4.38 meters, 7 rivers experienced floods exceeding the guaranteed level with a maximum range of 0.35-3.18 meters, and 8 rivers claimed the historical records.

China has developed the new generation of national flood forecast system forced by multi-source spatial information from satellite to UAV and ground stations, and integrated NWP product, hydrological model, hydraulics model and reservoir dispatching model to predict the flood routing process in hill slope, river channel and flood retention and detention area on a daily basis, which played an important role in the defence of the Haihe "23.7" basin wide super flood. The project of Training Course on Hydrological Monitoring and Flood Management for Developing Countries from 2023 to 2025, proposed by IC of MWR of China in cooperation with Nanjing Research Institute of Hydrology and Water Conservation Automation (NIHWA), was launched officially at TC 55th Session. It was approved that, as the annual activities/implementation plan for the project, a two-week training course will be held annually with funding support from China government in forms of video, hybrid or face-to-face, depending on the situation of the COVID-19. From Sep 13 to 26, the first training course was held via the internet with 65 participants from 25 countries including Cambodia, Laos, Malaysia, Philippines, Thailand, Vietnam. Dr. Duan yihong, the Secretariat of Typhoon Committee and Dr. Liu Zhiyu, the Deputy Director of Hydrology Division of the Water Resources Ministry, delivered welcome speech on the opening ceremony.

13. In 2023, DPRK was directly affected by typhoon "Khanun", but there was no any hydrological damage caused.
14. In 2023 (up to the end of October), there were five tropical cyclones affected **Hong Kong, China**. Super Typhoon Saola necessitated the issuance of the highest tropical cyclone warning, Hurricane Signal No. 10, again since Super Typhoon Mangkhut hitting Hong Kong in September 2018. Severe Typhoon Koinu necessitated the issuance of Increasing Gale or Storm Signal No. 9. Typhoon Talim necessitated the issuance of No.8 Gale or Storm Signal. Super Typhoon Doksuri and Severe Typhoon Haikui necessitated the issuance of Standby Signal No. 1. With a maximum sustained wind of 230 km/h near its centre, Super Typhoon Saola is the second most intense tropical cyclone affecting the South China Sea since 1950. While more than 80 people were injured, there was no fatality in Hong Kong during the passage of Saola. In terms of rainfall,

Haikui was the wettest tropical cyclone affecting Hong Kong so far in 2023. A trough of low pressure associated with the remnant of tropical cyclone Haikui brought a phenomenal rainstorm to Hong Kong on 7 and 8 September 2023. During the torrential rain, the Hong Kong Observatory Headquarters registered a record-breaking hourly rainfall of 158.1 mm from 11 p.m. to midnight on 7 September 2023, the highest since records began in 1884. According to preliminary reports, there were 75 reports of landslides and 60 reports of flooding. At least two people were killed and more than 140 were injured during the rainstorm. Moreover, Severe Typhoon Koinu brought squally heavy showers to Hong Kong on 8 – 9 October. The daily rainfall recorded at the Observatory on 9 October 2023 reached 369.7 mm, more than 3 times of October's monthly total normal figure of 120.3 mm and the highest daily rainfall on record for October.

For hydrological activities, the Drainage Services Department (DSD) has developed a smart flood warning system to utilize smart systems to provide weather information and flood warnings to the public. Smart poles and display panels installed near Shing Mun River offer real-time water level images, weather updates, tidal information, and flood warning messages. Smart cameras on the smart pole monitor flooding and pedestrian conditions to enhance public awareness and safety. Also, DSD has developed an online flood warning system, linked to QR code sign plates installed along the promenade and near subway entrances, to provide accessible information on weather, tide, and flood warnings.

15. In 2023, the number of torrential rains and larger typhoons has increased in Japan, resulting in more frequent flood damage. The effects of global warming are becoming obvious, and water-related disasters are expected to become severe and more frequent. An active seasonal rain front caused record-breaking heavy rainfall and damage mainly in Akita prefecture from July 15, 2023. Total 18 rivers of eight river systems administrated by Akita prefecture and the national government were flooded at areas without levees, and eight landslides occurred in affected areas. In addition, flood control operation was implemented at 22 dams, including two dams with pre-flood discharge. Three dams out of 22 dams shifted to emergency flood control operations (emergency discharge) as approached to the full of dam capacity due to prolonged heavy rainfall.

Japan attended the UN 2023 Water Conference held in New York on 23rd March 2023. Japan co-chaired the Interactive Dialogue 3 (ID3), entitled “Water for Climate, Resilience and Environment”. As the co-chair's key messages; (a) Changing Climate; (b) Resilience to water disasters; (c) Working for the future; and (d) Commitment, Actions, and Coalitions were delivered. Japan proposed an “Action Workflow” to realize practices encompassing six steps; (a) risk awareness; (b) risk identification; (c) designing of countermeasures; (d) funding; (e) multi-stakeholder participation; and (f) on-site implementation.

16. In 2023, Lao PDR remained unaffected by any direct impacts of tropical cyclones. Nevertheless, the nation confronted considerable challenges arising from elevated levels of monsoonal precipitation, primarily influenced by the southwest monsoon system. Data for the year indicated that monthly rainfall consistently surpassed historical averages, most notably in the months of July and August. This anomalous weather pattern led to the overflowing of rivers and the occurrence of flash floods and landslides, affecting 12 out of the 18 provinces as of August 2023. The regions most severely affected were the northern and central areas, where flash floods were recurrent during the period extending from July to August 2023.

17. In 2023, as compared with 6 rainstorms (red or black level) in Macao, China, there were only five rainstorm warning signals (red or black level) issued in 2023. One of the most occurred public emergency in Macao SAR was flooding caused by rainstorm. Flooding occurs in flooding blackspots and sometimes landslide occurs during heavy rainstorm. In recent years, Macao SAR Government has taken flood control and drainage improvement measures to alleviate the problem. This year, the Civil Protection Operation Center collected comments from different departments and will update the related emergency plan. And will continue educating citizens about actions to be taken during rainstorm occurs, and also broadcast rainstorm warning signals in serious situation to the public.
18. In 2023, **Malaysia** multiple flood disasters: especially monsoon floods and urban floods, have consistently occurred and been recorded since 1960. As of January to August 2023, 286 flood events has been recorded with an annual average of 310 per year. To date the Department of Irrigation and Drainage (DID) has 1,312 hydrological telemetry stations (rainfall and water level), 1,571 flood gauges and 526 flood warning sirens in flood prone areas. Meanwhile, twenty five flood forecasting models have been developed on selected river basin to support flood forecasting tasks in DID. Currently, another eleven flood forecasting models also being developed by DID, namely the National Flood Forecasting and Warning System for the state of Selangor, Negeri Sembilan, Melaka and Johor and expected to be completed by mid of 2025.
19. In 2023, **the Philippines** suffered from the occurrence of nine (9) tropical cyclones that entered the Philippine Area of Responsibility (PAR). Those tropical cyclones, albeit not too strong in intensity and some did not make landfall, enhanced the southwest monsoon that induced floods and landslides in different parts of the country. The Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) has issued several flood warnings and information to the would-be affected communities. However, although these rainfall episodes brought some damage to properties, it has also beneficial effect to the community and livelihood. Rainfall from tropical cyclones and monsoons contributed much to the domestic water supply of the Philippines.

This year also marks the completion of the establishment of the Flood Forecasting and Warning Systems (FFWS) in the eighteen (18) Major River Basins of the Philippines which has been a top priority of PAGASA. We are now transitioning to the establishment of FFWSs to Principal River Basins and other smaller river systems. As of today, PAGASA has already completed the installation of hydrometeorological monitoring equipment in some principal and smaller river systems. We have now a FFWSs for; Aklan River Basin, four (4) river systems in the Province of Cebu, two (2) river systems in Bohol, and two (2) river systems for the Province of Biliran. Aside from the installation of an automated FFWSs, PAGASA is also into the installation of X-Band RADARs to be used mainly for flood forecasting and warning services. Right now, we have an ongoing installation of 11 units of X-Band RADARs. The program of PAGASA is to install two (2) X-Band RADARs per Major River Basin.

20. In 2023, **Republic of Korea (ROK)**, of the 12 typhoons occurred this year (as of September 2023), the only typhoon that landed in the Korean Peninsula and had a direct impact was No.6 KHANUN. After it, 6 typhoons occurred in August alone, accounting for 50% of the total number of typhoons this year, but there was no direct or indirect impact.

As Typhoon KHANUN passed through South Korea on August 10th, accumulated rainfall exceeded 100 mm in most areas of the country. As it was the first typhoon to cross the Korean Peninsula from north to south since 1951, there was great concern about damage depending on the predicted timing of its landing. In particular, along KHANUN's northward path after landing, the eastern region recorded the heaviest rainfall in August since observations began in 1968. Nationwide, 361 cases of facility damage were recorded, and 2 casualties occurred. More than 15,000 people were temporarily evacuated. Typhoon KHANUN swept the entire Korean Peninsula, but analysis suggests that the damage to life and property was not as great as initially feared. This is believed to be the result of prior preparations such as evacuating residents in vulnerable areas, refraining from going out, and controlling traffic.

Normally, rainfall in summer in Korea have been characterized by continuous raining around June and July caused from the seasonal rain front, but recently, there has been a change due to the unstable atmosphere. Starting in 2021, rainfall pattern in Korea has been noticeably different from the past and seems more closely tropical heavy rainfall. In particular, this year, in mid-July, as record-breaking heavy rainfall occurred in the central region of South Korea and the river embankment collapsed, 17 vehicles passing through an underpass near a river were submerged in water, resulting in the death of 14 people on the spot. At this time, the cumulative number of deaths reached 41 due to localized heavy rainfall for about a week nationwide, and there were 740 reports of facility damage (slope loss, road damage, building collapse, river bank loss, etc.). 1,976 people from 6,532 households were temporarily evacuated. In August, heavy rain with a cumulative rainfall of 1,000 mm over 10 days occurred in the eastern region, causing the banks of tributary rivers to collapse and four villages to be completely submerged.

21. In 2023, **Singapore** was not directly affected by tropical cyclones/storms. However, its weather may have occasionally been influenced indirectly by tropical cyclones/storms located over the western Pacific and the Indian Ocean. During the 2023 Pacific Typhoon season, there were a few occasions during which tropical storms resulted in the convergence of prevailing winds around the surrounding region of Singapore. On 17 July 2023, Tropical Storm Talim made landfall over at Guangdong, China, before dissipating on 18 July as it moved further inland. Possibly due to the influence of Tropical Storm Talim making landfall, Singapore experienced two spells of widespread heavy thunderstorms on 18 July 2023.

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

- Southeast Asia Regional Climate Centre Network (SEA RCC-Network).
 - ASEAN Climate Outlook Forum (ASEANCOF).
 - Subseasonal-to-Seasonal Predictions for Southeast Asia (S2S-SEA).
22. In 2023, **Thailand**, there are no tropical storm directly attack Thailand. The influence of Northeast monsoon over The Gulf of Thailand and the Southern of Thailand in the first 2 months of 2023, it caused heavy rain in the Southern part. In the beginning of rainy season, the accumulate rainfall was less than average about 20% until the end of August. However, in September the monsoon trough lies across the Northern, Northeast and upper the Central. In addition, the southwest monsoon is quite strong, covering the Andaman Sea, Thailand and the Gulf of Thailand. Moreover, the strong low pressure area in the central of South China Sea.

Meanwhile, the Southwest monsoon over the Andaman Sea, the Southern and the Gulf of Thailand is strengthening cause the flood occurred in 56 provinces out of 77 provinces in Thailand. There are more than 55 hydrological observation stations was affected.

The Office of National Water Resources announce 12 Countermeasures for Wet Season in 2023 approved by the Cabinet as 1) Forecasting and identifying risk area. 2) Managing lowland areas for flood retention. 3) Reviewing and adjusting water management criteria. 4) Preparing repairing and renovating structure, system and tools. 5) Preparing and planning machinery and equipment. 6) Checking the security of levees, dams and dykes. 7) Increasing efficiency of water distribution in waterway. 8) Practicing the incident action plan, Establishing incident command post and Recovering to normal condition. 9) Accelerating the development and retention. 10) Strengthening public sector network by sharing situation data. 11) Raising awareness and public relations. And 12) Monitoring, evaluating, and adjusting.

Challenges/Needs

- The utilization of rain-water induced by Typhoon as a resources
 - How to balance water resources utilization and flood control by structure and non-structure, dam operation.
 - Develop AI technology for flood control
23. In 2023, the region of Guan, USA, the end of 2022 throughout 2023 saw above to well above normal rainfall across the Marianas and Micronesia. Rainfall amounts through October 31, 2023 for Micronesia are: Majuro - RMI 107.13 inches (2721 mm), which is 101% of normal and 82% of the yearly normal; Kosrae - 184.04 inches (4675 mm), which is 117% of normal and 94% of the annual normal; Pohnpei - 223.68 inches (5682 mm), which is 147% of normal and 122% of the annual normal; Chuuk - 141.1 inches (3584 mm), which is 120% of normal and 99% of the annual normal; Yap - 118.58 inches (3012 mm), which is 114% of normal and 96% of the annual normal; and Palau - 144.12 inches (3661 mm). The Marianas ranged from a high at Guam with 128.34 inches (3260 mm), which is 152% of normal and 131% of the annual normal; Saipan - 67.42 inches (1713 mm), which is 111% of normal and 97% of the annual normal; Rota - 92.71 inches (2355 mm), which is 116% of normal and 100% of the annual normal; and Tinian - 72.23 inches (1835 mm). So far this year, there are no problems with drought nor low water levels across the region.

An El Nino neutral pattern transitioned into a weak El Nino early in 2023 and is now strong. The result of this pattern is the above normal rainfall across Micronesia and the Marianas. So far, only a few Tropical Cyclones have affected the region through the end of October, 2023. The strongest of these was Super Typhoon Mawar. Tropical Storm Sanvu and Super Typhoon Bolaven.

The hydrologic impacts from these three tropical cyclones were as follows:

- Tropical Storm Sanvu – April 19 – 21 2023; Sanvu was very short-lived and only affected a couple of three islands in Pohnpei State. No warnings were issued for Sanvu and only a Tropical Storm Watch was issued for Pohnpei, Sapwaufik and Pakin in Pohnpei State. This system did produce beneficial rainfall across these islands.

- Super Typhoon Mawar – May 20 – June 3, 2023
 - Mawar resulted in two Tropical Storm Warnings being issued across western Chuuk State for Ulul and Polowat and 1 in eastern Yap State for Satawal. These islands received tropical storm force winds along with periods of heavy rainfall.
 - As Mawar approached the Marianas, it became obvious that a major Typhoon was likely. A Typhoon Watch was issued for Guam and the Commonwealth of the Northern Mariana Islands (CNMI) on May 20.
 - A Typhoon Warning was issued for Guam and Rota and a Tropical Storm Warning for Tinian and Saipan the morning of May 22, 2023.
 - Very heavy rainfall occurred as STY Mawar moved through the Marianas. Guam took the brunt of the storm, which produced rainfall amounts of 16.01 inches (407 mm) to 28.12 inches (714 mm) over a 72 hour period. Much lower rainfall occurred across the CNMI.
 - This rainfall resulted in extensive flash flooding across Guam.
- Super Typhoon Bolaven – October 7 – 14, 2023
 - STY Bolaven formed to the east of the Marianas and only affected Guam and the CNMI. A Typhoon Watch was issued for Guam, Rota Tinian and Saipan during the morning October 8, 2023.
 - A Tropical Storm Warning was issued for Guam the morning of October 9, with a Tropical Storm Warning being issued for Rota, a Typhoon Warning being issued for Tinian and Saipan and a Tropical Storm Watch being issued for the northern CNMI islands later in the afternoon.
 - Rainfall amounts of up to 7.39 inches (188 mm) were reported across Guam and the CNMI. This resulted in localized flooding and flash flooding.

Other hydrologic events in the Mariana Islands have resulted in the issuance of several hydrologic products over the past year, mostly during the past six months. These products ranged from Hydrologic Outlooks to Urban and Small Stream Flood Advisories to Flash Flood Watches and Warnings.

24. In 2023, **Vietnam** was affected by 03 Typhoons entering the East Sea, in which , the TY Talim directly hit to Vietnam territory. Although only indirectly affecting Vietnam, two other TYs Doksuri and Saola circulations caused significant damage to people and property. Severe flash flood, lanslide in the Northern part and Center Highland area of Viet Nam are the most prominent disasters in the 2023 rainy season. From the 17th June to the 23rd August, 35 flash flood and lanslde were recorded, of which the most sereve duration occurences of these disasters was from the 30th July to 8th August. Urban flooding due to heavy rainfall is a disaster occurred frequently, especially in urban areas of mountainous provinces.

The challenges in flash flood warning and needs exit as below:

- Lacking information of flash flood and landslide events in near-real time situation.
- Limitation of provision as well as direct sharing of information from various sources (especially during critical weather pattern occurrences or emergency situation).
- Need to develop a EWS with community-based orientation in flash floods, landslides warning and applying of advanced technologies in real-time warning and forecasting in operation for urban flooding are necessary requiments in the VNMHA.

The solution to the challenges in flash flood warning and needs has been adopted in Vietnam as :

- The project is being implemented with Community-based orientation.

- The EWS is established by web-based and mobile application demonstration for interacting, collecting and updating flash flood, landslide information between operational forecast agencies, research and survey agencies, local authorities, local community as well.

The Southeast Asia Flash Flood Guidance System (SeAFFGS) has been providing products with good reliability, useful for reference in flash floods and landslides warning in Vietnam. Current challenges existing are mentioned as below:

- Still development on structure of Regional Center;
- No coordination and cooperation mechanism among member countries in sharing information and data, especially telemetry rainfall, radar and warning information exchanges.

III. Progresses of WGH AOPs in 2023 and Implementation Plan for 2024

25. The project leaders and/or their representatives from China, Japan, RO Korea presented the progresses in 2023 and the implementation plan for 2024. The participants reviewed and discussed the implementation status in 2023 and the success indicators for 2024 of WGH AOPs.
26. The WGH AOPs in 2023 and beyond was summarized in the table 1. The implementation status of WGH AOP 2023 is summarized in the Annex 1.

Table 1 The list of WGH AOPs in 2023 and beyond

Item	Projects	Driver	Duration
AOP1	Knowledge Sharing on Storm Surge Inundation Mapping	USA	2020~2025
AOP2	Improvement of Hydrological Data Quality Control System by Using AI technology	ROK	2023~2027
AOP3	Improvement of Flood Forecasting modelling by Using AI technology	ROK	2023~2027
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	Flood resilience enhancement through Platform on Water Resilience and Disasters	Japan	2023~2027
AOP8	Training Course on Hydrological Monitoring and Flood Management for Developing Countries	China	2023~2025
AOP9	Synergized Standard Operating Procedures for Coastal Multi-Hazard Early Warning System (SSOP)-Phase III	USA	2023~2025

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,
- China and Thailand sent the formal request to take part in AOP1 after 55th Session.
 - AOP1 team in Guam, USA received approval through the International Affairs to proceed with the project of AOP 1, "Knowledge Sharing on Storm Surge Inundation Modeling- the Pacific Ocean Storm Surge Inundation Modeling (POSSIM)", with China and Thailand.
 - Following the discussion at WGH 12th working meeting, an online kick-off meeting for AOP1 training course was held on OCT 12, 2023 joining by China, Thailand, USA and TCS.
 - AOP1 training course is under processing in Nanjing, China from 18 to 22 December 2023 with support from WMO Regional Training Center (RTC), Nanjing and Nanjing Research Institute of Hydrology and Water Conservation Automation (NIHWA), China.
 - AOP1 team in Guam provided preliminary agenda and related technical documentations.
28. Two Members, namely Macao, China, and the Philippines, expressed their willingness to take part in this cooperation project. The AOP1 leader expressed his welcome.
29. The implementation plan of the project for 2024 was proposed for approval as blow:
- pilot study in China; Macao, China; Philippines and Thailand;
 - **Training course in selected Members in 2024.**

AOP2: Improvement of Hydrological Data Quality Control System by Using AI technology

30. The project on Improvement of Hydrological Data Quality Control System by Using AI technology with 5 years period from 2023 to 2027, proposed by HRFCO in cooperation with KICT, was launched officially at TC 55th Session. Development of hydrological data quality control system using AI will be completed in 2027 and the technical report & system manual will be published.
31. The activities/implementation plan for the project in 2023 which was approved at 55th Session was described as below:
- To conduct application and practical testing in 4 pilot target TC Members (Malaysia, Lao P.D.R, Philippines, Thailand);
 - To conduct requirement analysis and gathering the opinions and comments from TC Members;
 - To update and modify the hydrological quality control system and select the new technique for system upgrading.
32. The implementation status and progresses of the project achieved in 2023 were described as:
- Applied and tested the hydrological data quality control system (PC-version) in 4 target TC Members:
 - Testing the System with the data collected from 4 pilot target TC Member (Malaysia, Lao P.D.R, Thailand, Philippines) and gathering the user's demand;

- Finalizing the improvement and modification of HDQCS.
 - Drafting the hydrological quality control system manual for publishing:
 - Submit the draft system manual to TCS in November 2023;
 - Finalizing the system manual and the PDF version of system manual will be distributed at TC 56th session.
 - Establishment of advancement plan of HDQCS using AI technique
 - Using AI technique in establishing the unusual data screening criteria and modification data
33. The implementation plan of the project for 2024 was proposed for approval as blow:
- To develop and select the suitable AI technologies for screening the unusual hydrological data and modification the missing and unusual data
 - To launch the development of hydrological data quality control system

AOP3: Improvement of Flood Forecasting Modelling by Using AI Technology

34. The project on Improvement of Flood Forecasting modelling by Using AI technology with 5 years period from 2023 to 2027, proposed by HRFECO in cooperation with KICT, was launched officially at TC 55th Session. Development of flood forecasting system using AI will be completed in 2027, and the technical report and the system manual will be published.
35. The activities/implementation plan for the project in 2023 which was approved at 55th Session are described as below:
- To conduct the application and practical testing in TC Members
 - To conduct requirement analysis and gathering the opinions and comments from TC Members
 - To establish the modification plan of the Extreme Flood Forecasting System (EFFS) and select the upgrade item for operating system
36. The implementation status and progresses of the project achieved in 2023 were described as:
- To rearrange and restructure EFFS and user demand analysis in TC Members
 - Level 1 (Stage Method), Level 2 (Storage Function Model), Level 3 (AI)
 - LSTM sample testing using Lao P.D.R
 - Report the final results of testing and establishment plan in 18th IWS
 - Establishment of advancement plan of FFS
 - Using LSTM (AI Deep Learning Technique) for flood forecasting
37. The implementation plan of the project for 2024 was proposed for approval as blow:
- To develop and select the suitable AI technologies (Deep-Learning Technology) for flood forecasting

- AI technologies can directly simulate the flood stage with training the historical rainfall couple with stage data sets
- To launch the development of flood forecasting system

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

38. The project on OSUFFIM Phase-II: Extension of OSUFFIM (Development Operational System for Urban Flood Forecasting and Inundation Mapping) Application in TC Members was launched officially at TC 50th Session in 2018, and will be closed at 56th Session in early 2024.
39. The activities/implementation plan for the project in 2023 which were approved at 55th Session were described as below:
 - Improving parameter optimization for the pilot studies in Malaysia, Philippines, and China;
 - Conducting trial operation of real-time flood forecasting of the pilot studies in Malaysia, Philippines, and China;
 - Organizing project workshop, online or offline (TBD);
 - Final project conclusion
40. The implementation status and progresses of the project achieved in 2023 were described as:
 - New pilot study, the Modaoxi watershed in southwest China has been proposed, and Liuxihe model has been set up for the flood forecasting of Longju station considering Yubeishan reservoir regulation. Trial operation was done in the summer of 2023, and good results was achieved.
 - Model parameters of Buji watershed in China has been improved with new observation data, and trial operated with satisfactory results
 - New hydrological data from Malaysia pilot study was collected and analyzed, as there is no discharge observation, rating curve needs to be proposed and tested, so to optimize model parameters
 - Past study on Viet Nam pilot study was checked, and it was found that hydrological data is not sufficient to support model parameter optimization
 - Virtual workshop for discussing Malaysia pilot study progress and works beyond was carried out, and field survey to Malaysia pilot study will be organized in middle December, to survey river cross-section size, and validate the rating curve
 - Workshop about OSUFFIM model training and working plan for conclusion has been scheduled to be held in Guangzhou later this year
41. The main achievements of OSUFFIM in its entire implementation period were briefed as:
 - Field survey in 5 participating Members
 - Flood forecasting models and flood forecasting systems for Chebei watershed, Buji watershed and Modaoxi watershed of the Chinese pilot studies has been set up and put into trial operation.

- Flood forecasting models for Penang watershed of Malaysia pilot study and Matina watershed of Philippines pilot study has been set up.
 - Journal papers for the modeling work of Chebei watershed, Pinang watershed and Matina watershed have been published.
42. Based on the full communication between OSUFFIM Chinese team and Malaysia team in consultation with TCS hydrologist Dr. Jinping LIU, considering the pilot study in Penang river basin has not yet fully completed due to the impact of COVID-19 in past years, **as requested by Malaysia team, OSUFFIM-II was proposed to extend one more year to the 57th Session in early 2025** to fulfill its expected goals entirely.
43. Implementation plan in 2024:
- to further polish the model parameters of the Chinese pilot studies, and trial operate the real-time flood forecasting system.
 - to calibrate the rating curve of Malaysia pilot study and improve the model parameters, set up the real-time flood forecasting system and trial operate it.
 - to improve model parameters for the pilot studies in Philippines, and in Vietnam if needed.
 - to organize a training workshop in Malaysia for Penang river pilot study in 2024.
 - to organize the conclusion workshop in Guangzhou in the end of 2024.

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

44. The project on Impact Assessment of Climate Change on Water Resource Variability in TC Members was launched officially at TC 50th Session in 2018, and will be closed in next year (2024).
45. The activities/implementation plan for the project in 2023 which were approved at 55th Session were described as below:
- to organize face to face training workshops in 2-3 TC countries (approximately 7-9 days in total). Training workshops will focus on (1) Data acquisition and evaluation, (2) Model calibration and application.
 - to extend RCCC-WBM model application in interested TC members for assessing climate change impact, and exchange experiences and lessons of model application.
 - to provide guidance on case studies of typical catchments in interested TC members by using the RCCC-WBM model and understanding practical situation of catchments for supporting climate change adaptation and water resources management.
46. The implementation status and progresses of the project achieved in 2023 were described as:
- Based on the full consultation and discussion with the focal points of participating Members, an on-line (hybrid) training course before TC 56th Session is under consideration and planing. The information note and concerned technical documents will be distributed to TC Members in January 2024.
 - Have extended the application of RCCC-WBM model to many different basins worldwide. Based on the application results, experiences and lessons of model application have been summarized.

47. The implementation plan of the project for 2024 was proposed for approval as blow:
- To organize face to face training workshops in 2-3 TC Members (approximately 4-5 days in total). Training workshops will focus on (1) Global data resources and data fusion, and (2) Model calibration and application.
 - To provide technical assistance to TC Members with capacity building of climate impact assessment on water resources in their countries, if needed.
 - To provide technical support to TC Members on water management policy reports to the Government with addressing climate change.
 - To summarize all the work and experiences of AOP 5 and share the knowledge.

AOP6: Flood Risk Watch Project for Life-saving

48. The project on Flood Risk Watch Project for Life-saving proposed by MLIT of Japan was launched officially at TC 51st Session in 2019, and will be closed at 56th Session in early 2024.
49. The activities/implementation plan for the project in 2023 which were approved at 55th Session were described as below:
- After July 2022: Start test observations (at least six months) to check the accuracy of observation data, operability of equipment, etc.
 - Until March 2023: Adjustment of observation accuracy, status of data transfer to the server, and evaluation of observation accuracy.
 - April 2023: removal of Water Level Gauges (WLGs)
 - Opportunities are provided to inform other Member States of the results of the test observations.
50. The implementation status and progresses of the project achieved in 2023 were described as:
- Study Areas: Sg. Batu at Sentul Hydrological Station of Klang river basin, Kuala Lumpur
 - Testing Period: 6 month (October 2022 to March 2023)
51. The main achievements of the project on Flood Risk Watch Project for Life-saving in its entire implementation period were briefed as:
- Background: MLIT Japan has been promoting innovative initiatives using 3L (Low cost, Long Life, and Localized) Water Level Gauge (WLG) to support flood management. The project was corroborated with Water Resources Management and Hydrology Division, Department of Irrigation and Drainage, Malaysia.
 - Objectives: sharing the product feature, installation procedure and data utilization of 3LWLG/ study on 3LWLG functionality and data performance by comparing with DID WLG/ report the result and findings to Typhoon Committee Members.
 - Achievement: the test observations were carried out and the compliance to the requirement of water level gauges was verified. As a result of the test observations, all 3L WLGs from 4 participating companies were proved to be comparable with the water level gauge of the Department of Irrigation and Drainage (DID), Malaysia. In evaluating the water level gauges in actual project development supervised by DID, four processes shall be done before it can be accepted, which are; (a) Product/ material specification check; (b) Testing

of backup station at DID testing facility at Ampang Kuala Lumpur, before the development work at site; (c) Pre-test by the contractor, after development work at site; and (d) Testing and commissioning, for final acceptance that should be conducted before it can be accepted.

AOP7: Flood Resilience Enhancement through Platform on Water Resilience and Disasters

52. Following the decision at TC 54th Session, the project on Flood resilience enhancement through Platform on Water Resilience and Disasters with 5 years period from 2023 to 2027, proposed by ICHARM, was launched officially at TC 55th Session.
53. The activities/implementation plan for the project in 2023 which were approved at 55th Session were described as below:
 - To develop and improve OSS-SR which will integrate knowledge, technology, know-how, and experience of different disciplines related to flood disasters
 - To conduct capacity development to foster local Facilitators utilizing OSS-SR as an E-learning tool
 - To cooperate with Facilitators for disseminating scientific knowledge and technology to local stakeholders relevant to water-related disaster management
 - To cooperate to implement the activities above with other working groups of the Typhoon Committee
54. The implementation status and progresses of the project achieved in 2023 were described as:
 - The OSS-SR has been improved to mobilize all available rainfall inputs for real-time flood forecasting. As a result, satellite-based rainfall input, GSMaP, can be utilized even if the rain gauge input is unavailable.
 - Facilitators in Davao City were invited to Japan and attended to the ninth International Conference on Flood Management (ICFM9) in Tsukuba City, Japan. They also held meetings and inspections with ICHARM, the University of Tokyo, the Research Institute for Humanity and Nature (RIHN), and Kumamoto City.
 - The training for OSS-SR users and administrators was held at the office of DENR XI on June 30, inviting various stakeholders in Davao City
 - The national-scale plenary meeting of the Platform on Water Resilience and Disasters in the Philippines was conducted in Davao City on July 3.
 - The deployment of AOP7 in Thailand has been discussed and planned.
55. The implementation plan of the project for 2024 was proposed for approval as blow:
 - to improve the OSS-SR in Davao City and initiate to deploy it in other cities and countries
 - to design the Facilitators' cascaded training to various target audiences in local society
 - to develop cross-sectoral and consolidated governance for water management among relevant stakeholders in Thailand

AOP8: Training Course on Hydrological Monitoring and Flood Management for Developing Countries

56. The project on Training Course on Hydrological Monitoring and Flood Management for Developing Countries with 3 years period from 2023 to 2025, proposed by IC of MWR of China in cooperation with Nanjing Research Institute of Hydrology and Water Conservation Automation (NIHWA), was launched officially at TC 55th Session.
57. It was approved at 55th Session that, as the annual activities/implementation plan for the project, a two-week training course will be held annually with funding support from China government in forms of video, hybrid or face-to-face, depending on the situation of the COVID-19.
58. The implementation status and progresses of the project achieved in 2023 were described as:
- The training class was comprised by four main parts: online presentations, online technical visit, online seminar and online cultural experience. The training course was mainly convened to allow participants to learn about China's hydrological monitoring technology, acquire general ideas on how to apply the automatic system of hydro-meteorological data observation and transmission, and have further cooperation between participating countries and China.
 - By 13 Sep. 2023, complete the registrations of participants of training class, total 65 participants from 25 countries will engage in the training, some participants attended class after Typhoon Committee Secretary's invitation.
 - The opening ceremony was held on 13 Sep. 2023 successfully and the Secretary-General of Typhoon Committee Secretariat of UN ESCAP/WMO delivered welcome speech on the opening ceremony as well.
 - More and more participating countries come from Typhoon Committee Member, such as Cambodia, Laos, Malaysia, Philippines, Thailand, Vietnam, etc.
 - There is a wide spread of participation in different countries and more and more countries pay attention to the training course
59. The implementation plan of the project for 2024 was proposed for approval as blow:
- To apply for the 4th Training Course Flood Control and Early-Warning and Forecasting and Hydrological Monitoring for Developing Countries in 2024
 - To conduct the **4th training course as a face-to-face gathering in September 2024** at NIHWA in Nanjing, China.
 - To strengthen international exchanges and cooperation, truly embed our own development in global development, achieve mutual benefit and win-win cooperation in benign interaction with other countries under the support of Typhoon Committee Secretary.
 - **to compile and share the training materials with TC Members. The edited training materials may be published as TC publications in future..**

AOP9: SSOP-III

60. The project on Synergized Standard Operating Procedures for Coastal Multi-Hazard Early Warning System (SSOP)-Phase III with 3 years period from 2023 to 2025, led by USA, was launched officially at TC 55th Session.
61. The implementation status and progresses of the project achieved in 2023 were described as:
- Drafting the Proposal of SSOP-III

- Drafting the Agreement between ESCAP and TC.
 - Reporting and discussing at AWG meeting, and was agreed to submit to ESCAP.
 - ESCAP suggested that the submitted proposal needs to be considered a wider level than the proposed community-level.
62. The implementation plan of the project for 2024 was proposed for approval as below:
- **To re-writing the proposal based on the comments from ESCAP.**

New AOP6: Flood Risk Mapping with Ground/Satellite Observation Data

63. Mr. Kishida, Prime Minister of Japan, announced “Kumamoto Initiative for Water” at the 4th Asia-Pacific Water Summit in 2023, which was the commitment by the Government of Japan to the Asia-Pacific region until 2027 in the field of hydrological observation and water-related disaster risk reduction. MLIT will work to produce Flood Risk Maps that show the potential inundations in target areas in some Asian countries. Therefore, MLIT proposed “Flood Risk Mapping with Ground/Satellite Observation Data” as a new AOP6.
64. The objective of this proposal is to create flood risk maps (FRM) that show the potential and frequency of inundations in target areas in participating TC Member so that to increase the capacity on flood-related disasters risk reduction.
65. The expected outcomes of this proposal is to enhance the capacity of TC Members for handling of ground observation data and satellite data for assessment of flood risk appropriately, which aligns with KRA2 of TC Strategic Plan and contribute to UN EW4All Pillar of “Detection, observation, monitoring, analysis, and forecasting”.
66. This AOP will implemented in 4-year period from 2024 to 2027. It will provide the computer flood simulations by combining the satellite data with ground observation data, and applying the climate change projection if possible. The general road map is proposed as below:
- In 2024: Determination of pilot river basin(s), data collection and other preparatory works
 - In 2025: Hydrological analyses and creation of prototype flood risk maps
 - In 2026: Verification of the differences between using ground data and satellite data
 - In 2027: Preparation of manual and guideline
67. Implementation Plan in 2024
- To select the participating Members and pilot river basins.
 - Commencement of the study, determination of target river basin(s), consideration of the methods, data collection and other preparatory works
68. Participants recognized that “Flood Risk Mapping with Ground/Satellite Observation Data” as a new AOP6, and agreed to report this proposal at TC 56th Session for approval.

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

69. Following the discussion at WGH 11th working meeting and 17th IWS, participants discussed the proposal of **Knowledge Sharing on the Southeast Asia Flash Flood Guidance System (SeAFFGS), which** was launched officially in Ha Noi, Viet Nam on 28 June 2022.
70. The participants recognized that flash flood is a common challenge in TC Members. To share the knowledge of flash flood guidance among Members is very important on promotion of the capacity of flash flood related disaster prediction and early warning. Meteorological and hydrological Administration (MHA) of Vietnam has initialed a very good project on the Southeast Asia Flash Flood Guidance System (SeAFFGS) which will definitely benefit all TC Members. The participants sincerely expressed their expectation to MHA of Vietnam to officially launch this project when it is ready to do so.
71. **WGH is waiting for the response from from MHA of Vietnam.**

Other Proposals

72. **Considering on-going AOP4 and AOP5, which are led by China, will be closed in 2024, China-side expressed that two new proposals will be considered from China as two new AOPs for 2025 and beyond, and submitted to the 13th WGH working meeting for discussion.**

Summary of WGH AOPs in 2024 and Beyond

73. The WGH AOPs for 2024 and beyond were listed in Table 2, and the success indicators of AOPs for 2024 are shown in Annex 2.

Table 2: The list of WGH AOPs in 2024 and beyond

Item	Projects	Driver	Duration
AOP1	Knowledge Sharing on Storm Surge Inundation Mapping	USA	2020~2025
AOP2	Improvement of Hydrological Data Quality Control System by Using AI technology	ROK	2023~2027
AOP3	Improvement of Flood Forecasting modelling by Using AI technology	ROK	2023~2027
AOP4	OSUFFIM Phase-II: Extension of OSUFFIM Application in TC Members	China	2018~2024
AOP5	Impact Assessment of Climate Change on Water Resource Variability in TC Members	China	2018~2024

AOP6	Flood Risk Mapping with Ground/Satellite Observation Data	Japan	2024~2027
AOP7	Flood resilience enhancement through Platform on Water Resilience and Disasters	Japan	2023~2027
AOP8	Training Course on Hydrological Monitoring and Flood Management for Developing Countries	China	2023~2025
AOP9	Synergized Standard Operating Procedures for Coastal Multi-Hazard Early Warning System (SSOP)-Phase III	USA	2023~2025

IV. Review of AOP Implementation (AOP Questionnaire)

74. The participants were informed that, the Advisory Working Group (AWG) members recognized the importance of aligning the TC efforts of the Typhoon Committee (TC) with UN's Early Warnings for All (EW4All) initiative which aims to strengthen early warning systems globally, and decided at its second meeting held on 14 June 2023 in Ulsan, Republic of Korea to initiate a monitoring on the ongoing or previous efforts of TC Members in contributing to the four important pillars of the EW4All initiative.
75. The participants were presented the Proposal of Work Plan for Typhoon Committee AOP Evaluation, the AOP Evaluation Questionnaire and its example which were drafted by TCS based on the advice from AWG. The participants expressed their understanding.
76. Participants noted that AWG at its meeting on 26 Nov. 2023 advised TCS to use a term other than "Evaluation" to enhance Members' understanding and interpretation of the questionnaire. WGH recognized that the review of AOP implementation is needed to ensure the efficient of activities of the working group and to increase the participation of Members.
77. Following the arrangement of the Work-plan, WGH took actions on AOP implementation review by TC 18th IWS as below:
 - TCS distributed the Questionnaire to all AOP leaders in the end of August;
 - All AOP leaders submitted the questionnaires by the end of September.
 - The initial progresses and information of WGH AOP implementation review were discussed at WGH 12th Working meeting which was held on 20-22 September 2023 in Bangkok, Thailand.
 - All AOP leaders updated their Questionnaires based on the discussion at WGH 12th Working meeting, and TCS distributed the filled-questionnaires by AOP leaders to WGH Chairpersons and Focal Points of all Members in the middle of October.
 - WGH Chairperson commented all filled-questionnaires by middle of November.
 - The focal points of 4 Members submitted their responses to all filled-questionnaires by middle of November, including: (1) Malaysia responded to AOP6; (2) Laos responded to all AOPs; (3) Philippines responded to AOP7; and (4) ROK responded to AOP2 and AOP3.
78. Based on the syntheses and analysis of the information from the questionnaires, the findings are summarized from WGH AOP implementation review as below:

- WGH AOP leaders have demonstrated excellent performance on responding to AOP questionnaires.
 - All WGH AOPs' leading Members made great efforts on AOP implementation and conducted a series of positive and practical activities in the past 5 years, to fulfill their annual success indicators which were approved at TC Annual Session.
 - The topics of all WGH AOPs closely aligns with the one or more KRA(s) of Typhoon Committee Strategic Plan. The implementation and achievements of all WGH AOPs have played very important roles on realizing the Mission and Goal of the Committee.
 - The topics of all WGH AOPs closely aligns with one or more pillar(s) of UN EW4All initiative. The implementation and achievements of all WGH AOPs contributed remarkably to the four important pillars of the EW4all initiative.
 - All WGH AOPs fulfilled the scheduled tasks, achieved the expected goals and results in the period of implementation. The rich outcomes and achievements boosted the capacity building in TC Members on typhoon-related disaster risk reduction, especially the flood forecasting and early warning, and water resources management.
 - The implementation of all WGH AOPs benefited TC Members remarkably in all aspects and enhanced extremely the cooperation on the aspects of technical exchange, personnel training, and knowledge sharing in hydrological component among TC Members.
 - The implementation of all WGH AOPs fully and effectively used the TCTF annual allocation as seed's money. AOP participating Members, particularly the AOP leading Members contributed huge in-kind contribution including funding and expertise, which is very important and should be encouraged for conducting the AOPs' activities in future.
 - The review of WGH AOP implementation clarified the potential areas to be enhanced for the AOPs to be linked to the pillar(s) EW4All, and identified how to enhance the alignment to contribute to the pillars of EW4All in future. This will greatly help WGH to improve its strategy and cooperation on the aspects of AOP proposal, Members' participation, implementation planning, budget estimation, and result review, etc.
79. Recommendations for a better and effective AOP implementation in future were raised as below:
- The new proposed AOP should be closely aligned with the KRAs of TC Strategic Plan and the pillars of UN EW4All initiative.
 - The proposed AOP could involve 2 or more Members (including leading Member).
 - The AOP leading Member should ensure the AOP leader and/or the leader's representative taking part in the WGH annual working meeting and/or TC IWS.
 - The approved implementation plan (implementation activities) of AOP at TC Annual Session should be conducted on the base of the schedule with the close cooperation of leading Member, participating Members and TCS.
 - The AOP implementation activities should be conducted on the platform of the Committee as far as possible and keep TCS informed.
 - The AOP implementation status should be reviewed annually by its working group targeting the success indicators which were approved at TC Annual Session.
 - Participants reached consensus on using "AOP Progress Review" instead of "AOP Evaluation Questionnaire".

80. The draft summary of WGH AOP implementation review was discussed at parallel sessions of the 18th IWS and reported at IWS. The finalized summary and recommendations will be reported to TC 56th Annual Session by TC Secretary.

V. WGH Web-page

81. The participants were informed that, following the decision of the TC 55th Session on that the WGH web-page may be considered to integrate with the TC web-page, TCS is upgrading its web-page and WGs have their own pages which will be managed by WGs' secretaries. <https://www.typhooncommittee.org/new/>
82. The participants watched the presentation of the WGH web-page, and expressed their high appreciation for the work of TCS staff. The participants also expressed their commitment to actively participate in the updating and maintenance of the content of the web-page, to make it become an excellent platform for the exchange of hydrological components among Members.

VI. Regional Cooperation with WMO RAI and ESCAP

83. The participants were informed that, TCS hydrologist was invited by WMO to have taken part in a short on-line meeting discussing the cooperation activity between TC WGH and WMO RAI CPH (Coordination Panel of Hydrology), following the decision of TC 55th Session.
84. The participants were informed with pleasure that, Dr. Hwirin Kim, Head of Hydrological and Water Resources Services Division (HWR) of WMO, is planning to attend TC 18th IWS. She will present WMO activities and the Dynamic Water Resources Assessment Tool (DWAT) for TC Members, and suggested to organize a 2-hour joint meeting on Wednesday (29 November 2023) afternoon during TC 18th IWS for discussing the cooperation of TC WGH and WMO RAI CPH.
85. The participants got consensus on enhancement of the cooperation with ESCAP and WMO RAI CPH, and discussed the preliminary proposals as the potential priority areas to be joint cooperation projects in future, including:
- Area 1: Flood/inundation/risk mapping
 - Area 2: Flash Flood /Debris Flow/Landslide forecasting/early warning
 - Area 3: Assessment of the Variability of Water Resources in a Changing Climate
 - Area4: AI and big data application in Hydrological data quality control and modelling
86. The chairperson of WMO RAI CPH Dr. Hyo Soeb CHO (Vice Chairperson of TC WGH) expressed that RAI CPH is willing to deepen the cooperation with TC WGH under the umbrella and initiatives of WMO.
87. The joint meeting discussed and identified the ten (10) action items for the cooperation between TC WGH and WMO RAI CPH in future as below:
- Experts from both WMO RA II Coordination Panel on Hydrology and Water Resources (RA II CP-H) and the Typhoon Committee – Working Group on Hydrology (TC-WGH) expressed the need for stronger collaboration. It is necessary to clarify the principle of TC-WGH and WMO RAI before starting this collaboration.

- WMO to organize a joint meeting with the RA II CP-H, the Typhoon Committee and RA V Working Group in Hydrology and Water Resources either virtually or in hybrid format in early 2024.
- Assign liaisons from each group (TC-WGH and RA II CP-H) to each other.
- WMO to share the available materials on flood risk mapping, flash flood, and AI applications, etc.
- TC-WGH to look into the application of the Assessment Guidelines on End-to-End Flood Forecasting and Early Warning Systems (E2E FFEWS)
- Invite one TC-WGH Member (working in flood forecasting) as focal point in the Flood Forecasting Initiative Advisory Group (FFI-AG)
- Consider collaboration between TC-WGH and the Panel on Tropical Cyclone (PTC) to include other RA II Members (Bangladesh, Iran, and Myanmar) which are not covered by TC-WGH. TC-WGH to share request/willingness to join to TC Secretariat
- Support WMO hydrological-related survey, together with the TC-WGH
- Start collaboration with simple items, such as a joint training course for experts and Members
- Review the progress against the action items

VII. Review TCTF allocation for WGH AOP Activities in 2023 and Proposed Request for 2024

88. WGH reviewed the allocation of TCTF (\$25000USD) for WGH activities and usage (up to September) in 2023 shown in table 3.

Table 3 The summary of TCTF Budget Allocated for 2023 Activities

Item	Activities	Driver	Allocated	Usage
1	Knowledge Sharing on Storm Surge Inundation Mapping	USA	6000	On-going
2	Improvement of Hydrological Data Quality Control System by Using AI technology	ROK	---	
3	Improvement of Flood Forecasting modelling by Using AI technology	ROK	----	
4	OSUFFIM Phase-II: Extension of OSUFFIM Application in TC Members	China	8000	On-going
5	Impact Assessment of Climate Change on Water Resource Variability in TC Members	China	5000	On-going
6	Flood Risk Watch Project for Life-saving	Japan	----	
7	Flood resilience enhancement through Platform on Water Resilience and Disasters	Japan	----	

8	Training Course on Hydrological Monitoring and Flood Management for Developing Countries	China	3000	No
9	Synergized Standard Operating Procedures for Coastal Multi-Hazard Early Warning System (SSOP)-Phase III	USA	----	
10	Supporting hosting WGH 12 th working meeting in 2023		3000	Yes
	Total		25000	

89. The participants expressed their highest appreciation to Japan, Thailand, China, RO Korea, and other Members for their in-kind contribution to WGH AOPs implementation in the year, and encouraged all Members continue their strong support.
90. Based on the discussion, WGH proposed the budget request of **\$26,000USD** for supporting its activities in 2024 shown in table 4.

Table 4 The summary of TCTF Budget Request for 2024 Activities

Item	Projects	Driver	Budget
1	Knowledge Sharing on Storm Surge Inundation Mapping	USA	9000
2	Improvement of Hydrological Data Quality Control System by Using AI technology	ROK	0
3	Improvement of Flood Forecasting modelling by Using AI technology	ROK	0
4	OSUFFIM Phase-II: Extension of OSUFFIM Application in TC Members	China	5000
5	Impact Assessment of Climate Change on Water Resource Variability in TC Members	China	5000
6	Flood Risk Mapping with Ground/Satellite Observation Data	Japan	0
7	Flood resilience enhancement through Platform on Water Resilience and Disasters	Japan	0
8	Training Course on Hydrological Monitoring and Flood Management for Developing Countries	China	7000
9	Synergized Standard Operating Procedures for Coastal	USA	0

	Multi-Hazard Early Warning System (SSOP)-Phase III		
10	Supporting hosting WGH 13 th working meeting in 2024		3000
		Total	29000

VIII. Conclusions

91. On the basis of the discussion and outcomes at 11th WGH working meeting, participants recognized the importance in following aspects for further direction of WGH:

- WGH 12th working meeting was held in face-to-face plus hybrid way. This is the first full face-to-face working meeting of WGH after COVID-19. The number of participants reached 60, the historical high. The meeting had remarkable effectiveness and efficiency. It is a consensus on that, the annual working meeting is very important for WGH to review and push forward hydrological activities and is very necessary to prepare IWS and annual session. WGH continue encouraging Members to host its working meeting, and the more Members now are willing to contribute to the working meeting.
- Typhoon Committee area is the region with the most severe natural disasters in the world, and floods are probably the most recurring, widespread, disastrous and frequent natural hazards in the region. In the practical flood control, the necessary actions cannot progress without accurately locating water-related disaster risks in an easy-to-understand manner for decision-makers and local communities. Flood Hazard/Risk Mapping (FHM/FRM) is a vital component for appropriate land use planning in flood-prone areas and emergency response in real-time flood events. It creates easily-read, rapidly-accessible charts and maps which facilitates the decision-makers, planners and dwellers in communities to identify areas of risk and prioritize their mitigation/response efforts. Therefore, as one of major non-structural measures for flood control, FHM/FRM play very important roles in reduction of flood-related disasters. Therefore, MLIT of Japan proposed “Flood Risk Mapping with Ground/Satellite Observation Data” as one AOP for WGH which will work to produce FRMs that show the potential inundations in target areas in TC Members, combining satellite data with ground observation data and applying climate change projection if possible, and then providing it to computer flood simulations. WGH recognized that the “Flood Risk Mapping with Ground/Satellite Observation Data” will be great benefit TC Members as an AOP, and encourage the interesting Members to take part in the meaningful cooperation project.
- WGH recognized that to continue enhancing the regional cooperation with ESCAP, WMO RAI CPH, PTC and other regions could be benefit the activities on hydrological component in TC Members. WGH is willing to make a synergy between TC WGH and WMO RAI CPH under WMO umbrella, and reached consensus on the four potential cooperation areas to align with WGH AOPs in future, including: (1)Flood/inundation/risk mapping; (2)Flash Flood /Debris Flow/Landslide forecasting/early warning; (3)Assessment of the Variability of Water Resources in a Changing Climate; and (4)AI and big data

application in Hydrological data quality control and modelling. In near future, TC WGH and WMO RAI CPH will take tangible measures and activities to realize the identified 10 action items.

- WGH recognized that the **review of AOP progresses** is needed to ensure the efficiency of activities of the working group and to increase the participation of Members.
- Typhoon Committee succeeded beyond expectations and other similar organizations around the world are looking are in emulation of its success. More countries in the region expressed their interests to become the membership of the Committee. WGH recognized the enhancement of the visibility of Typhoon Committees in the region is very important to keep the Committee as the pioneer inter-governmental body of its kind. WGH will take tangible measures in future on enhancing its regional and international cooperation under the umbrella of ESCAP and WMO.

IX. Recommendations to the Committee

92. On the basis of the deep discussion and communication, participants agreed to submit the following recommendations to the Committee at TC 56th Annual Session to be held in early 2024:

- to request **US\$29,000** from TCTF for supporting overall WGH activities for 2024 calendar year.
- to thank Thailand and Japan for co-hosting WGH 12th Working Meeting on 20-22 September 2023.
- to **thank China offers to host WGH 13th working meeting** with funding support in 2024, and **request China to consider the possibility of co-hosting the working meeting with Japan.**
- to request Japan and USA to consider the possibility of co-hosting WGH 14th working meeting in 2025.
- to request China to extend AOP4 (OSUFFIM-II) one more year to the TC 57th Session in the early of 2025.
- to approve the proposal on “Flood Risk Mapping with Ground/Satellite Observation Data” from MLIT, Japan as an AOP of WGH in the period of 4 years from 2024 to 2027.
- **To request MHA of Vietnam to consider the possibility of proposaing “Knowledge Sharing on the Southeast Asia Flash Flood Guidance System (SeAFFGS)” as one of WGH AOPs.**
- **To request China to submit two AOP proposals at 13th WGH working meeting in 2024 for discussion.**
- **to thank WMO for the coordination of cooperation between TC WGH and WMO RAI CPH.**
- **to approve WGH to appoint the liaison/focal point for enhance the cooperation with WMO RAI CPH.**
- **To approve WGH appoint one TC-WGH Member (working in flood forecasting) as focal point in the Flood Forecasting Initiative Advisory Group (FFI-AG).**

- 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 2023

Annex 2. Successor Indicators of WGH AOP 2024

Annex 1. Implementation Status of WGH AOP 2023

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 (b-c) Provide the copy of the program POSSIM to the interested Members (c-d) training on use and update of bathymetry data and determine necessary expert missions	6000		YES on-going on-going
KRA2 KRA3 KRA4	2	Improvement of Hydrological Data Quality Control System by using AI technology	To apply, test and modify the TC member Hydrology Data Quality Control System		See above	(a) First (b) Second (c) Third (d) Fourth	PAGASA, Phi; DID, Malaysia; DMH, Laos; RID, Thailand	(a-b) Apply and testing to pilot target TC Members (c) requirement analysis and gathering TC Members' opinion (d) Modify the hydrological quality control system		HRFCO, ME	YES YES YES
KRA2 KRA3 KRA4	3	Improvement of Flood Forecasting modelling by using AI technology	To establish the modification plan of EFFF and to apply in practical		See above	(a) First (b) Second (c) Third (d) Fourth	PAGASA, Phi; DID, Malaysia; DMH, Laos; RID, Thailand	(a-b) Apply and testing to TC Members (c) requirement analysis and gathering TC Members' opinion (d) Establish the modification plan of EFFF		HRFCO, ME	YES 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) Parameter optimization for the pilot studies in Malaysia, Philippines, Vietnam and China; and Project workshop online or offline(tbd) (a-c) Trial operation of real-time flood forecasting of the pilot studies in Malaysia, Philippines, and China (d) Project conclusion workshop	8000	SYS Uni.	on-going on-going on-going
KRA 3 KRA 6	5	Impact Assessment of Climate Change on Water Resource Variability in TC	Application of RCCC-WBM model at selected pilot catchments		See above	(a) First (b) Second (c) Third (d) Fourth	DID, Malaysia MHD, Laos	(a) training workshops in 2-3 TC countries (b) experiences and lessons of model application to the target TC Members (c) guidance on case studies of model	5000		NO Yes Yes

		Members						application for climate change adaptation			
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-b) Start test observations (at least six months) to check the accuracy of observation data, operability of equipment, etc. Adjustment of observation accuracy, status of data transfer to the server, and evaluation of observation accuracy.			YES
KRA 1 KRA 2 KRA 3 KRA 4 KRA 5	7	Flood resilience enhancement through Platform on Water Resilience and Disasters	Data collection and hydrological analyses, and other preparatory works	WGM WGDRR	See above	(a) First (b) Second (c) Third (d) Fourth	PAGASA, Philippines; RID & TMD, Thailand	(a) Training and bench-marking on OSS-SR development in Japan (b) Training for OSS-SR administrators and users in local implementation (c) Meeting and discussion on the further development among inter-agency participants (d) Plan of deployment to other cities and Members	-		Yes Yes Yes Ongoing
KRA 1 KRA 2 KRA 3 KRA 4 KRA 5	8	Training Course on Hydrological Monitoring and Flood Management for Developing Countries	Enhancement of capacity building of TC Members on flood monitoring and forecasting		See above	(a) First (b) Second (c) Third (d) Fourth	NHSs of all Members	(d) A two-week training course on-line or off-line in October/November	3000	NIHWA	YES
KRA1 KRA3 KRA4 KRA5	9	SSOP-III			See above	(a) First (b) Second (c) Third (d) Fourth	AWG WGM WGDRR	(b-c) Draft the Proposal of SSOP-III and the Agreement between ESCAP and TC.			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 2024

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	NIHWA, China; RID, Thailand	(a-d) pilot study in selected Members. (c-d) Training course for selected Member	9000	MWR, China; RID, Thailand; PAGASA, Philippines
KRA2 KRA3 KRA4	2	Improvement of Hydrological Data Quality Control System by using AI technology	To apply, test and modify the TC member Hydrology Data Quality Control System		See above	(a) First (b) Second (c) Third (d) Fourth	PAGASA, Philippines; DID, Malaysia; DMH, Laos; RID, Thailand	(a-c) Select AI techniques for HDQSS and testing with TC member data (c) Requirement analysis and gathering TC Members' opinion (d) Confirm the modification plan of hydrological quality control system		HRFCO, ME
KRA2 KRA3 KRA4	3	Improvement of Flood Forecasting modelling by using AI technology	To establish the modification plan of EFFS and to apply in practical		See above	(a) First (b) Second (c) Third (d) Fourth	PAGASA, Philippines; DID, Malaysia; DMH, Laos; RID, Thailand	(a-c) Select AI techniques for EFFS and testing with TC member data (c) Requirement analysis and gathering TC Members' opinion (d) Confirm the modification plan of EFFS		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	DID, Malaysia; PAGASA, Philippines; VMHA, Vietnam	(a-c)To further polish the model parameters of the Chinese pilot studies, and trial operate the real-time flood forecasting system (a-c)To calibrate the rating curve of Malaysia pilot study and improve the model parameters, set up the real-time flood forecasting system and trial operate it (a-c)To improve model parameters of the pilot studies in Philippines, and Viet Nam if needed (d)To organize a training workshop in Malaysia pilot study in later of 2024 (d)To organize the conclusion workshop in	5000	SYS Uni. China; DID, Malaysia; PAGASA, Philippines

								Guangzhou in the end of 2024		
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-b) help TC Members with capacity building of climate impact assessment on water resources and provide policy report (c) training workshops in 2-3TC countries (d) summarize all works of AOP5 and share knowledge	5000	
KRA 1 KRA 2 KRA 3 KRA 4 KRA 5	6	Flood Risk Mapping with Ground/Satellite Observation Data			See above	(a) First (b) Second (c) Third (d) Fourth	RID, Thailand; MOWRAM, Cambodia	(a-b) determination of target river basin(s), (a-c) consideration of the methods, (a-d) data collection and other preparatory works at the target river basin(s).		
KRA 1 KRA 2 KRA 3 KRA 4 KRA 5	7	Flood resilience enhancement through Platform on Water Resilience and Disasters		WGM WGDRR	See above	(a) First (b) Second (c) Third (d) Fourth	PAGASA, Philippines; RID & TMD, Thailand	(b) Improve the prototyping of the OSS-SR in Davao City, Philippines (c) Deeply the OSS-SR to Digos City, in the Philippines and Thailand (d) Training on flood resilience based on the OSS-SR		
KRA 1 KRA 2 KRA 3 KRA 4 KRA 5	8	Training Course on Hydrological Monitoring and Flood Management for Developing Countries	Enhancement of capacity building of TC Members on flood monitoring and forecasting		See above	(a) First (b) Second (c) Third (d) Fourth	NHSs of all Members	(a-d) to compile the training materials as TC publications; (c-d) A two-week training course face-to-face in October/November	7000	NIHWA
KRA 1 KRA 3 KRA 4 KRA 5	9	SSOP-III			See above	(a) First (b) Second (c) Third (d) Fourth	AWG WGM WGDRR	(a-b) re-writing the proposal; (c-d) submit the re-wrote proposal to ESCAP for approval		

- 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.

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- 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.