MEMBER REPORT [Republic of Korea]

ESCAP/WMO Typhoon Committee
17th Integrated Workshop
(Video Conference)
29 – 30 November 2022

CONTENTS

I. Overview of tropical cyclones which have affected/impacted Member's area since the last Committee Session

1. Meteorological Assessment (highlighting forecasting issues/impacts)

Twenty-four typhoons have occurred until November 15, 2022 in the Western North Pacific basin. The number of typhoons in 2022 was near normal compared to the 30-year (1991−2020) average number of occurrences (25.1). Five out of twenty-four typhoons, including AERE (2204), SONGDA (2205), TRASES (2206), HINNAMNOR (2211), and NANMADOL (2214), have influenced the Korean Peninsula and HINNAMNOR (2211) made landfall on the Korean Peninsula. The tracks of the typhoons affecting the Peninsula are presented in Fig. I-1.

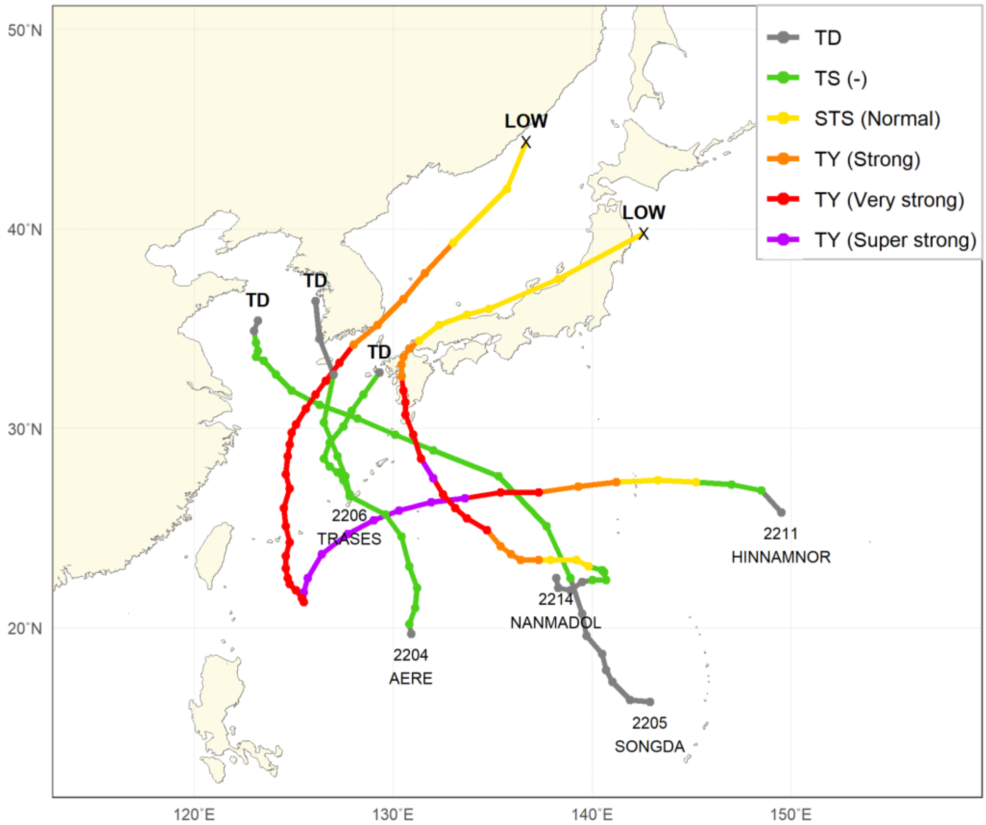


Figure I-1 TC tracks that affected the Korean Peninsula in 2022

Typhoon AERE (2204) developed as a fTD (forecast tropical depression) at 18 UTC on June 30, and it was upgraded to a TS (tropical storm) after 6 hours while moving north-west to Okinawa. Then it turned northeast in the south sea area of Jeju Island and landed northwest of Kagoshima, Japan, weakening into a TD. AERE affected the southern sea area of Jeju Island. Because of the influence of TUTT, the upper layer divergence initially contributed to the development of the typhoon. But afterwards, the inflow of dry air from TUTT interfered in the typhoon's intensify.

Typhoon SONGDA (2205) developed as a fTD at 18 UTC on July 26, moved northwest, and it was upgraded to a TS at 12 UTC on July 28. SONGDA moved northwest through the southern sea area of

Kagoshima, Japan, and moved northwest from the southern sea of Jeju Island. At 18 UTC on July 31, it weakened to a TD in the western sea area of Mokpo. SONGDA formed east of Monsoon gyre. As there is no divergent component from the upper, it did not intensify. From July 30 to August 1, heavy rainfall of 852.5 mm was recorded and a peak gust of 34.0 m/s was observed on Mt. Halla on Jeju Island.

TRASES (2206) was declared a named TS at 03 UTC on July 31, in the convection developed by southwest winds on the right edge of the Monsoon gyre. The CI was analyzed to be 1.5. The wind speed was observed at 15 m/s (based on SCAT) far from the center, but it was weak near the center. As it moved northward near Jeju Island, it could not be intensified under unfavorable thermodynamic conditions. It landed in Mokpo as a TD at 00 UTC on August 1. On August 1, accumulated precipitation of 143.5 mm was recorded and a peak gust of 32.9 m/s was observed on Mt. Halla on Jeju Island. Considering the observations, it is analyzed that TRASES did not meet the typhoon criteria. From this case, it is suggested that the conditions need to be more clearly defined for typhoons occurring in the Monsoon gyre.

Typhoon HINNAMNOR (2211) developed as a fTD in the ocean near 25.8N and 149.5E at 06 UTC on August 28, was upgraded to a TS after 6 hours and moved west-south-west to near the sea of Okinawa under the expanding STR north of it. HINNAMNOR had rapid intensification and on August 30, it developed a super strong intensity (higher than 54 m/s) with environmental conditions such as weak vertical shear around the typhoon, strong divergence in the upper layer, high sea level temperature, and fast movement of the typhoon. Since then, HINNAMNOR began to almost stay in the eastern sea of Taiwan on September 1 and slowly moved south. The size of the typhoon was expanded by merging with the TD and the intensity was made weaker by an upwelling effect. The typhoon moved to the north again on September 3. It passed the east sea of Jeju Island and landed southeast of the Korean Peninsula at 20 UTC on September 5. The southern part of the Korean Peninsula and Jeju suffered heavy rainfall from September 4 to 6. During the passage of HINNAMNOR, accumulated precipitation of more than 931 mm was recorded on Mt. Halla on Jeju Island and more than 370 mm at Pohang in the southeast of the Korean Peninsula.

Typhoon HINNAMNOR (2211) was a challenging task for typhoon forecasting, as it showed many characteristics, such as forming at mid-latitude over 25N, an unusual track northward after moving west-south-westward, development with super-strong intensity, and expansion by merging with a TD. When passing the Korean Peninsula, it unleashed flooding because of very strong convection clouds formed by converging with cold and dry air from the north, causing a number of casualties.

Typhoon NANMADOL (2214) developed as a fTD at 18 UTC on September 12, moving slowly and developed into a TS at 18 UTC on September 13. The typhoon passed through the eastern sea of Okinawa, and developed a super-strong intensity with a central minimum pressure of 915 hPa. The typhoon landed in Kagoshima, Japan, around 09 UTC on September 18, weakened after passing Kyushu, moved northeast along the coast of the Honshu Jugoku region, and transitioned into an extratropical cyclone around 00 UTC on September 20. From September 17 to 19, accumulated precipitation of 112.5 mm was recorded and a peak gust of 29 m/s was observed in the southeastern Korean Peninsula.

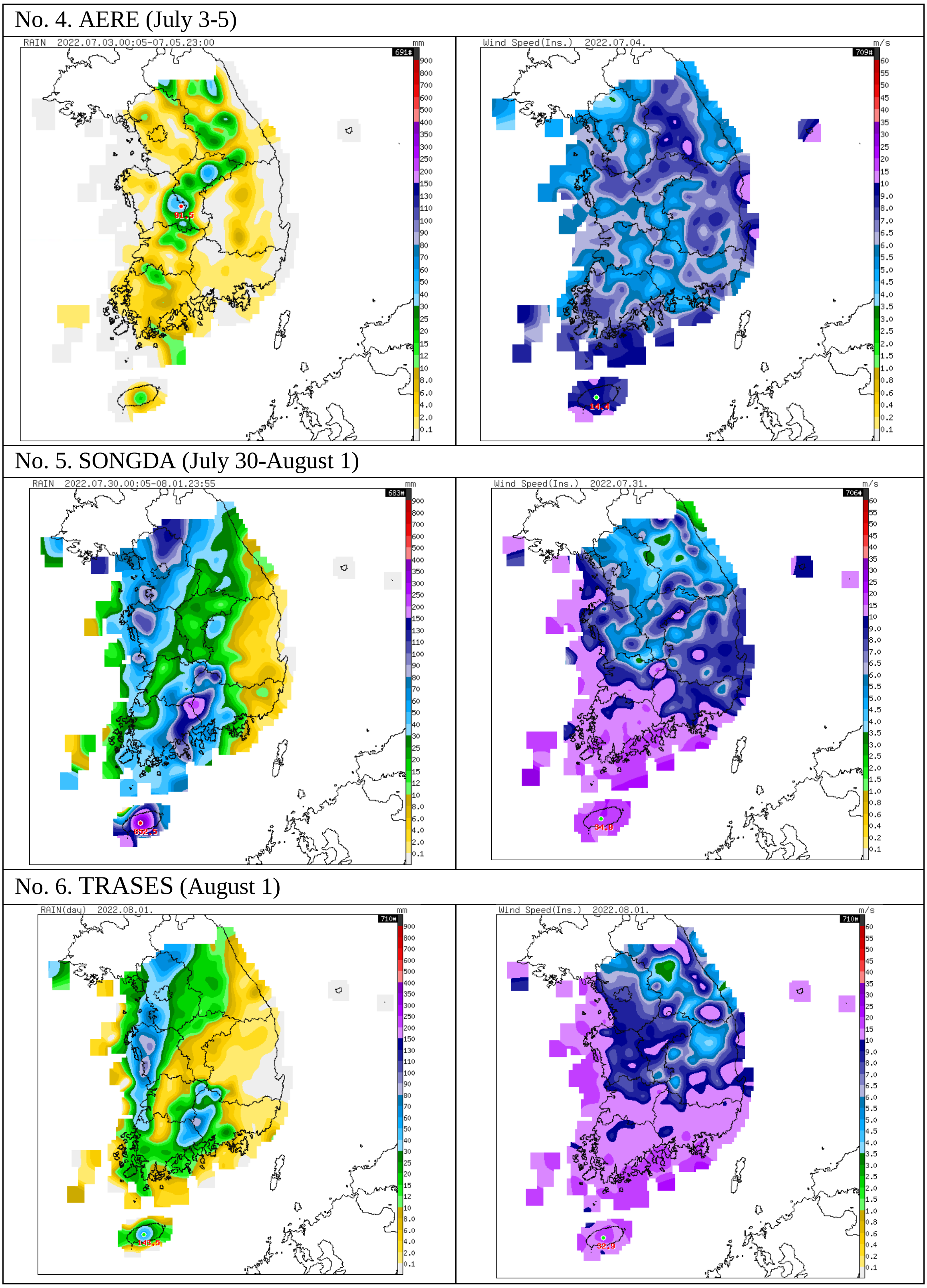
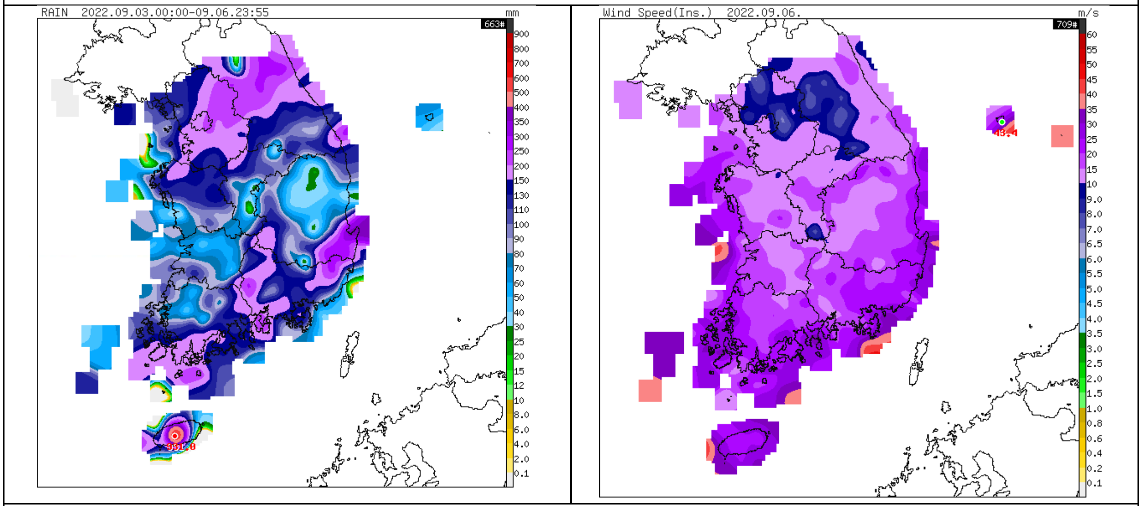


Figure I-2 Distribution of accumulated rainfall (left) and gust (right) during the passage of five typhoons affecting the Korean Peninsula.

No. 11. HINNAMNOR (September 3-6)



No. 14. NANMADOL (September 17-19)

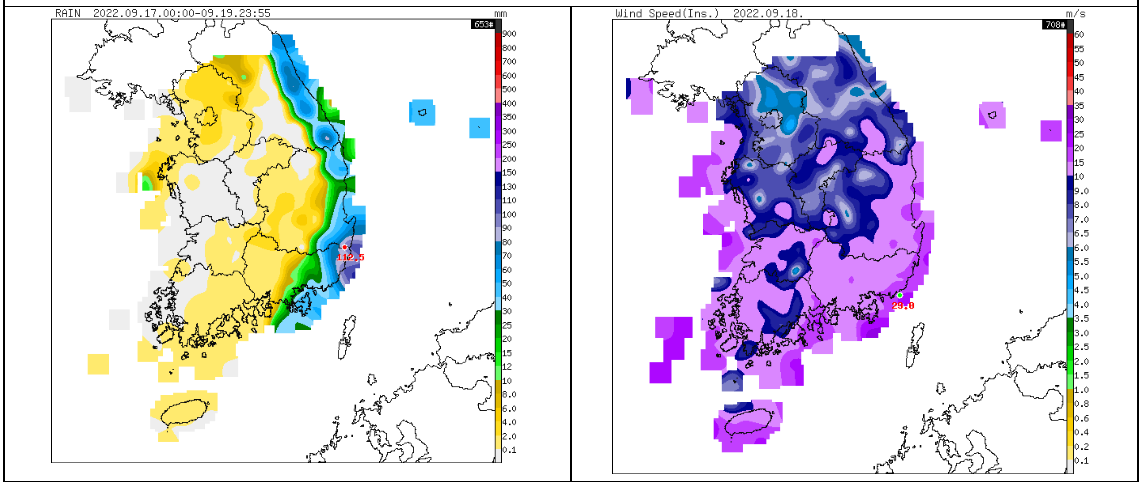


Figure I-2. Continued

2. Hydrological Assessment (highlighting forecasting issues/impacts)

Of the 23 typhoons occurred this year (as of 1 November 2022), there were a total of 5 typhoons that directly or indirectly affected South Korea, which are Typhoon AERE, SONGDA, TRASES, HINNAMNOR, and NANMADOL from July to September. However, the only typhoon that landed on the country was Typhoon No.11 HINNAMNOR from August 28 to September 6, 2022.

Prior to the landing of Typhoon HINNAMNOR, many media outlets compared it with Typhoon SARA (1959), RUSA (2002), and MAEMI (2003) which caused the worst lives and property damage in Korea in the past. It was forecasted that the intensity and moving path of HINNAMNOR would seem very similar with the worst cases and emphasized that the importance of preparing in advance and raising the public's awareness. Local governments across the country entered into an emergency system; especially, some schools in Jeju Island and Gyeongsang-do, which were directly affected, notified schools of closure.

Typhoon HINNAMNOR caused damage to cities in the southern region of South Korea, but fortunately the worst damage expected did not occur. Depending on the HINNAMNOR's moving route, damage occurred one after another in southern regions such as Jeju Island, Busan, and Pohang. On the day of its landing, the damage estimated for one day on September 6 alone approached 4 billion won, and the damage to the agricultural and fisheries sectors was large in terms of simple property damage.

As it approached Jeju Island in the southern sea of Korea prior to landing, it already caused damage such as damage to facilities, flooding, and power outages in various places in the city. All schools in the Jeju area decided to close or remote online learning, and to adjust school hours. After causing casualties including 11 dead and 1 missing, HINNAMNOR passed through the southern coast of Jeollanam-do, South Korea, and landed near Geoje, Gyeongsangnam-do, and escaped through the eastern coast. The estimate of total property damage caused by Typhoon HINNAMNOR was 244 billion won.

In 2022, four Flood Control Offices of Ministry of Environment issued the total of 28 flood watches and 8 flood warnings nationwide between June and September. In the case of 2021, there were not many flood watches due to the heatwave that lasted from mid-July to earl September last year. On the other hand, this year, flood watch and warning were issued not only due to the typhoons accompanying rainfall from July to September, but also due to record-breaking heavy rainfall and localized flooding in August and September.

3. Socio-Economic Assessment (highlighting socio-economic and DRR issues/impacts)

From January to October 2022, total five typhoons have affected the Republic of Korea*(Table 1)*. Two of them, one is HINNAMNOR(2211), and the other one is NANMADOL(2214), caused casualties and economic damages. In 2022, there were more life damages caused by heavy rainfall during monsoon season(2022.08.08.~08.17.). Total 14 have been died, 6 were missing, and 26 were injured between 8th to 17th August. On the other hand, total 15 were dead and 2 were injured by typhoon HINNAMNOR and NANMADOL.

Table I-1 List of typhoons which have affected the Republic of Korea in 2022

No.	Typhoon Name	Period
2204	AERE	2022.07.01. ~ 2022.07.05.
2205	SONGDA	2022.07.28. ~ 2022.07.31.
2206	TRASES	2022.07.31. ~ 2022.07.01.
2211	HINNAMNOR	2022.08.28. ~ 2022.09.06.
2214	NANMADOL	2022.09.14. ~ 2022.09.20.

(By the courtesy of KMA web site, www.weather.go.kr)

Typhoon HINNAMNOR made landfall in Geoje and moved to Busan and Gyungbuk from 3rd to 7th September forming long and narrow rain clouds which caused localized heavy rainfall. In some areas, damage to shopping malls and houses was concentrated due to the river flooding in downtown. Total 15 were killed by Typhoon HINNAMNOR and most of the accidents happened in the underground parking lot. It also caused damage to property estimated at 177 million dollars which include flood damage to 5,105 houses and 10,042 small business and loss of 338.6ha of farmland. The Central Disaster and Safety Countermeasures Headquarters(CDSCH) has established the recovery plan as calculated the total damage and recovery cost (Table I-2).

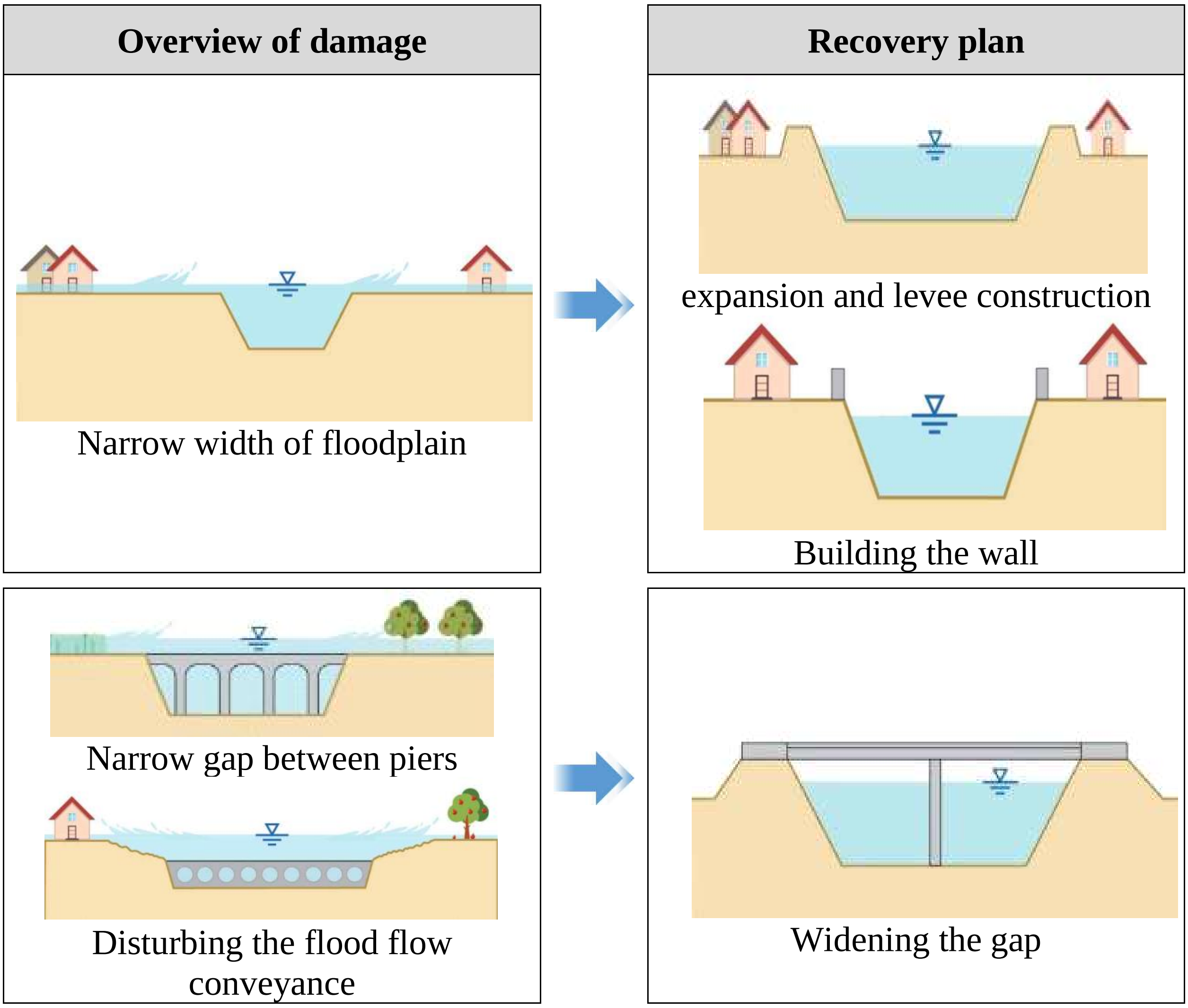
Table I-2 Total damage and recovery cost by Typhoon HINNAMNOR

Province	City / Town	Damage (million)	Recovery Cost (million)
Ulsan	5	4.86	16.41
Gyungbuk	21	143.31	448.31

Gyungnam	18	8.71	20.16
miscellarneous	133	14.09	63.98
Total	177	170.97	548.86

(By the courtesy of MOIS official document on October)

Especially, CDSCH has made the plan to solve the problem ultimately such as river expansion and bridge widening which caused the life damage and flooding around the area (Fig. I-3).



(By the courtesy of MOIS official document on October)

Figure I-3. The recovery plan on typhoon HINNAMNOR

Typhoon NANMADOL was moving northeast from Osaka, Japan. It was concerned that there might be further damage in Pohang and Ulsan which had been affected by typhoon HINNAMNOR already. CDSCH released the alert to prepare typhoon NANMADOL which was heading to South Korea on 18th September. Field situation supervisors had been dispatched to support situation management of 7 provinces including Busan and Ulsan. In conclusion, there is no fatality but 2 were injured, 429 ha of farmland were damaged, and 7,065 houses were blacked out.

II. Summary of Progress in Priorities supporting Key Result Areas

1. Improve the Algorithm of Typhoons Summer Prediction (POP1)

Main text:

The KMA has shared typhoon seasonal prediction results with WGM member countries via e-mail. The information about the number of typhoons and their track patterns is provided based on the results of four types of models: multi-regression model, global dynamical model, and two hybrid models of statistical and dynamical methods. To improve its ability to predict typhoon genesis, the KMA has developed a brand new statistical model — ordinary least square regression model using predictors such as Western North Pacific (WNP) trade wind (April), Pacific Meridional Mode (March), Canadian Sea Ice (March), and others. The model produces the predicted TC frequency for the two respective domains of the WNP. The WNP is divided by the 140°E longitude line since the predictors show differences of the spatio-temporal correlation with TC frequency.

In early June 2022, the KMA provided WGM member countries with summer predictions for WNP typhoon-activities via e-mail. The summer seasonal outlook (June to August) predicted 9.7 typhoons, which is close to the actual number of typhoons, 9. The track density was predicted to be higher in the southern sea of Japan and the eastern sea of China through the eastern sea of Taiwan.

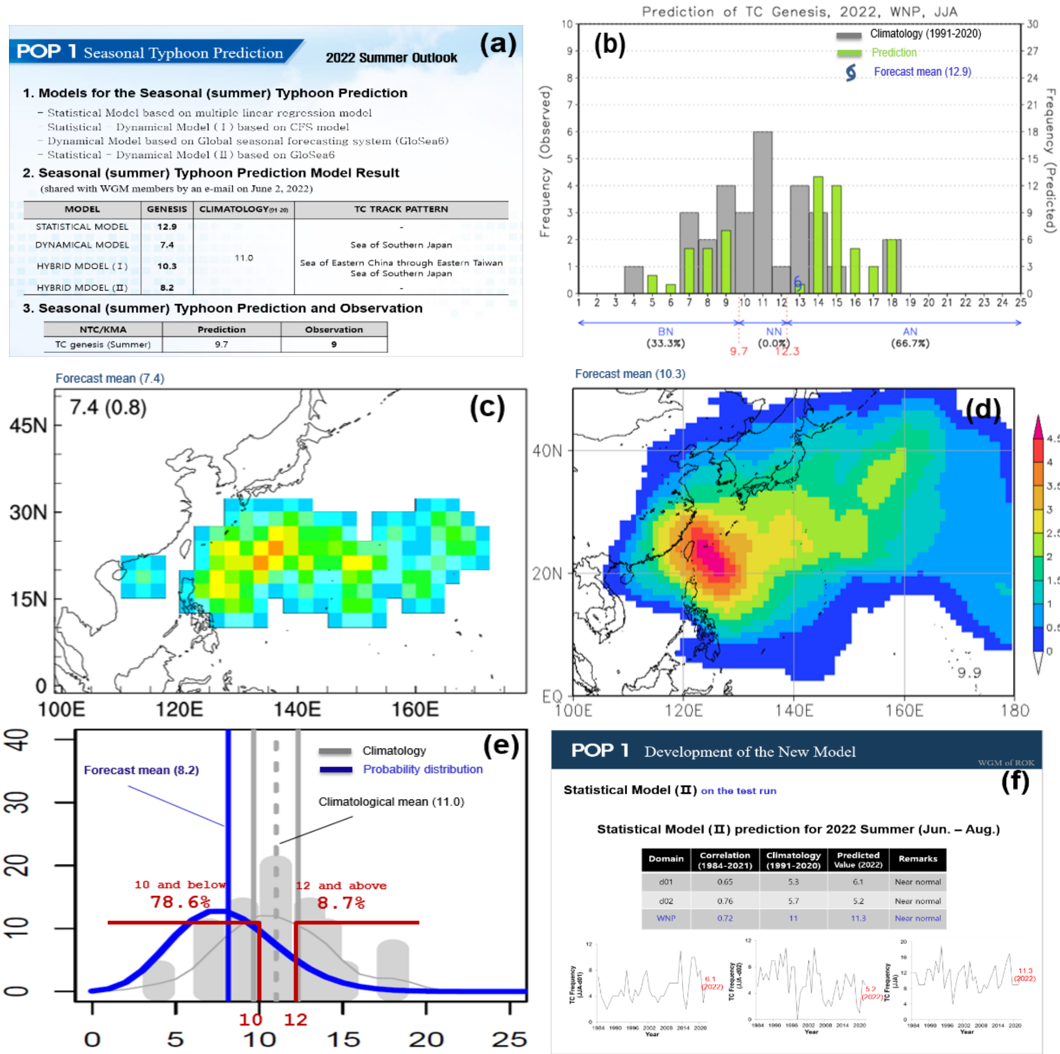


Figure II-1 Sample of KMA's typhoon summer activity outlook: (a) summer prediction results with (b) statistical model, (c) dynamical model, (d) statistical-dynamical model (I), (d) statistical-dynamical model (II), and (f) statistical model (II) on the test run.

Identified opportunities/challenges, if any, for further development or collaboration:
An algorithm of statistical-based typhoon season prediction using climate factors is under development. The new statistical model will be used for forecasting from the summer of 2023.

Priority Areas Addressed:
Meteorology

- Develop and enhance typhoon analysis and forecast techniques from short-to long-term.

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2. Deployment of Drifting Buoys for Typhoon Forecasts and Analysis

Main text:

The KMA has deployed seven drifting buoys in the Western North Pacific (WNP) in July this year to fill in the region of missing ocean observation and analyze the mechanism of tropical cyclones (TCs) intensification over the WNP (Fig. II-2). The observed information of sea surface temperature (SST) over the WNP by drifting buoys is transmitted every 20 minutes and their operation period can last more than two months. The KMA has a plan to share with WGM member countries the information about the observed SST over the WNP by drifting buoys via GTS next year.

It would be helpful for operational typhoon forecasts in the main region of typhoon generation, especially for the influence of SST variation in the typhoon intensification. The observed data from drifting buoys over the WNP are valuable for assisting in the decision-making process for typhoon forecasting in real-time. Compared to the utilization of satellite data, the accuracy of heat energy estimation for typhoon intensification is expected to improve.

Several drifting buoys did well at observing the SST (including pressure) near typhoons during the passage of typhoons this year. In the case of Typhoon NANMADOL (2214), a drifting buoy (dw22-003) located on the west side of the typhoon detected a temperature drop (1°C) and the lowest pressure of 985 hPa during the passage of the typhoon.

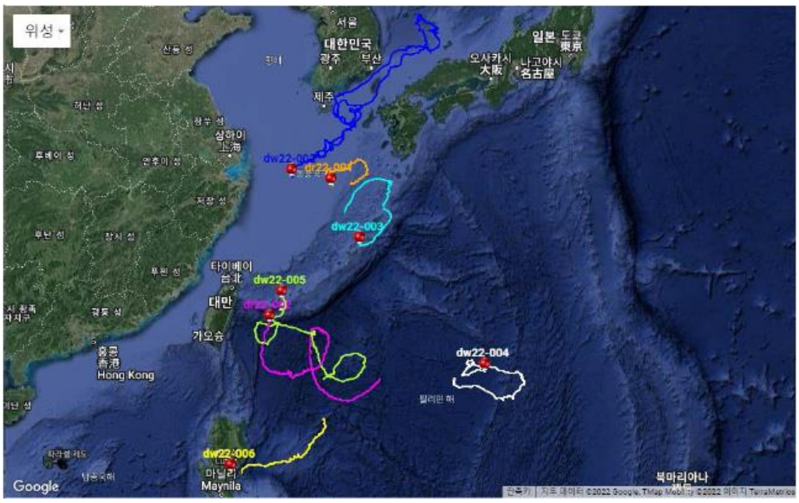

Figure II-2 Track of the seven drifting buoys deployed in the Western North Pacific

Identified opportunities/challenges, if any, for further development or collaboration:

The KMA has a plan to share drifting buoy data with WGM member countries via GTS in 2023.

Priority Areas Addressed:

Meteorology

- Enhance the capacity to monitor and forecast typhoon intensification.

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3. KMA/NTC's Improved Typhoon Forecast Services

Main text:

In 2022, the KMA has enhanced its typhoon forecast services by improving GIS-based typhoon information for users' better understanding. Users can find various typhoon information on the website (https://www.weather.go.kr/w/typhoon/ko_/weather/typhoon_02.jsp) such as when a typhoon gets closest to land, areas most at risk for typhoons, as well as a typhoon forecast track overlapped by satellite images (Fig. II-3). In addition, it has improved the graphical depiction of the track so that users can easily recognize changes in the intensity at the typhoon center with different icons showing different categories. The fax-type notification for public institutions was converted into GIS-based detailed information. These services will be available on the KMA's website starting from July 2022.

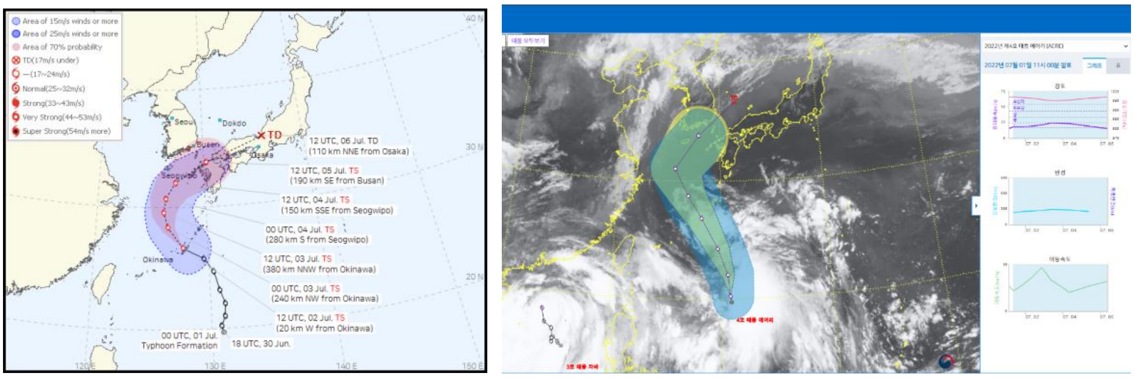

Figure. II-3 Sample of KMA/NTC's detailed typhoon forecast information

Identified opportunities/challenges, if any, for further development or collaboration:
The typhoon forecast service will be improved continuously.

Priority Areas Addressed:
<u>Meteorology</u>

- Enhance the capacity to monitor and forecast typhoon activities, particularly in terms of genesis, intensity and structure change.
- Develop and enhance typhoon analysis and forecast techniques from short- to long-term.

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4. Invitational Training on Capacity Building for Typhoon Monitoring and Forecasting Platform

Main text:

The KMA invited two forecasters from Lao PDR to conduct TOS technology transfer from November 14 to 22. The training consisted of lectures and practices on typhoon forecasting using TOS and lectures on guidance for typhoon forecasting based on numerical models of the National Typhoon Center. This training program was carried out as part of a project "Enhanced Severe Weather Response Utilizing an Integrated Typhoon Monitoring and Forecasting Platform" between the KMA and the DMH. The project consists of installation of integrated TOS and invitational training from 2020 to 2023. The two forecasters also visited the National Weather Satellite Center to practice using satellite analysis systems ahead of the TOS technology transfer.

Figure. II-4 Two forecasters invited from Lao PDR and NTC staffs.

Identified opportunities/challenges, if any, for further development or collaboration:
Regarding ODA projects, the KMA plans to expand them to other member countries.

Priority Areas Addressed:

Meteorology

- Enhance the capacity to monitor and forecast typhoon activities, particularly in terms of genesis, intensity and structure change.

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5. GEO-KOMPSAT-2A Utilization for Tropical Cyclone (PP2)

Main text:

Since the launch of COMS in 2010, the KMA has developed and improved its own satellite operation skills and data analysis capabilities over the past 10 years. In December 5, 2018, it launched GK2A, a follow-on satellite to COMS. GK2A has 16 channels and a next-generation advanced meteorological imager. GK2A generates a full disc image every 10 minutes, and when necessary, it also provides special observation images for a targeted area at two-minute intervals, allowing us to monitoring TC tracks. Furthermore, GK2A provides 52 types of basic level-2 meteorological products including sea surface temperature and high level products for TC analysis. Those satellite products are greatly helping us to understand more details of typhoon structures, as well as contributing to decision-making of TC analysts.

The National Meteorological Satellite Center is providing basic TC information based on the Dvorak techniques, including TC center, intensity, wind radii and moving information. Various new imageries, such as SWIR (3.8 μm) for finding night-time low-level cloud circulation and several RGB composites with better spatial-temporal resolution, are giving more confidence in center of storms and their intensity. The KMA has been using its own web-based satellite imagery analysis system with KMA-ADT, which is applying GK2A characteristics to the objective ADT as well as updated KOBA table to apply better information in the Western North Pacific basin. High-level products combined with data from other satellites, numerical weather prediction, and ground observations are available to support satellite TC analysis. The products include GK2A winds, SST, ocean heat content, maximum potential intensity, potential intensity, wind shear, convergence, divergence, vorticity, rain/wind percentile, etc.

The KMA/NMSC also provides rapid scan service using local area observation mode, which covers a 1,000 km x 1,000 km area every 2 minutes with flexibility for location changes. In order to support national and international services over the Asia-Pacific region (RA II and RA V), official requests for this rapid scan service are available on the designated web page (http://datasvc.nmsc.kma.go.kr/datasvc/html/special/specialReqMain.do). This will provide significant improvements in real-time monitoring of tropical cyclones.

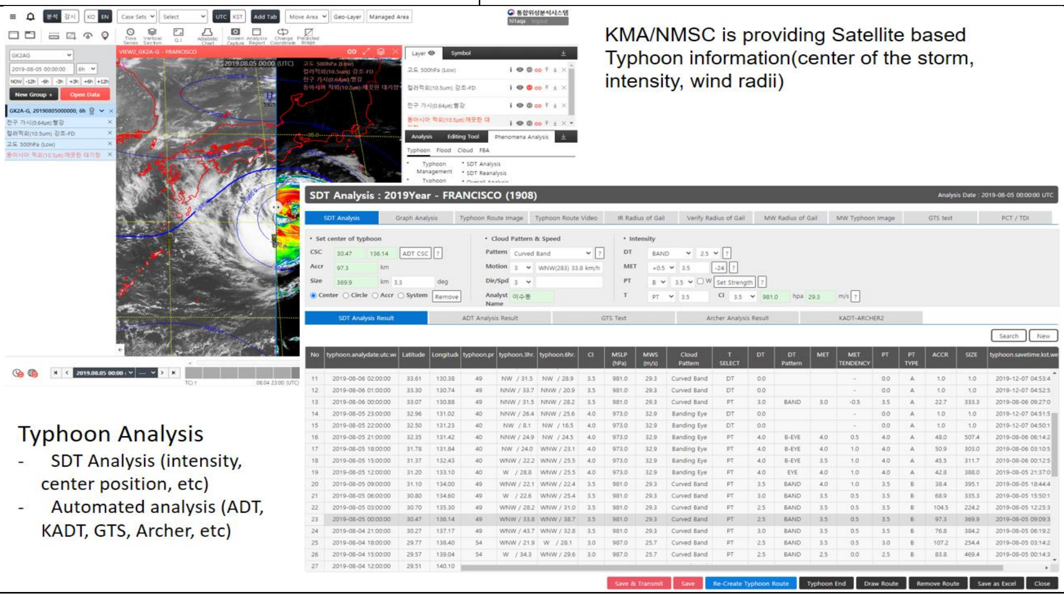
Since the COVID-19 pandemic, GK2A typhoon-related products for typhoon forecasting were introduced and typhoon analysis techniques were shared with member states at four different international workshops. The workshops are:

1. Introduce the GK2A TC products, International Workshop on Satellites for Tropical Cyclones on December 9, 2021 (Teleconference)
2. Analysis of Satellite Data in Tropical Cyclone at Typhoon Forecasting Techniques Workshop on October 12, 2022 (Teleconference)
3. Typhoon Training Courses at Meteorological Satellite Data Utilization over Asia Region, October 17–28, 2022 (Teleconference)
4. Satellite-based Typhoon Analysis, 2022 Invitational Training Course on capacity building for the GK2A satellite data receiving and analysis system for Forecasting and Warning of Natural Disaster in Cambodia, November 2, 2022 (Face to Face)

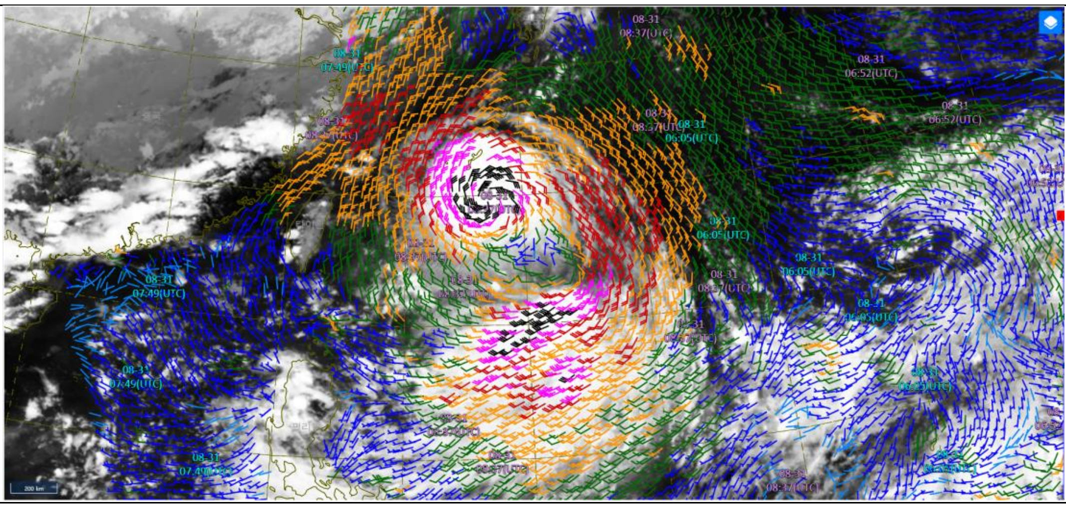
During the workshops, the KMA shared the web-based GK2A typhoon analysis system by using subjective/objective Dvorak techniques and adding a couple of Chinese microwave scatterometer data from HY-2B/C because of the end of active sensors such as MetOp-A and ScatSat-1.

Meteorological Satellite Data Utilization over Asia Region, October 17–28, 2022

2022 Training Course on Forecasting and Warning of Natural Disaster in Cambodia, November 2, 2022



Web-based GK2A typhoon analysis system



HY-2B/2C composite ocean vector winds

Identified opportunities/challenges, if any, for further development or collaboration:
Lack of chance to introduce GK2A TC-related products to the member states because of the COVID-19 pandemic.

Priority Areas Addressed:
Meteorology

- Enhance the capacity to monitor and forecast typhoon activities, particularly in genesis, intensity and structure change.

DRR

- Promote international cooperation in DRR implementation projects.

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6. Research Project on Construction of Hydrological Data Quality Control System in TC Members

Main text:

The project for improvement of hydrological data quality control in TC Members is a five-year project that started in 2018 and finished in this year. The goal of the project is to the improvement of flood prediction and forecasting performance in TC Members through securing quality control of hydrological data. The detailed objectives are to diagnose the current state in the target member countries (Lao P.D.R, Malaysia, Philippines, Republic of Korea, and Thailand), to provide the direction and guidelines for hydrological data quality control, and to develop the PC-version hydrological data quality control system in TC Members.

Sequentially, the baseline survey and studies on the hydrological data quality management for target countries in TC region was completed in 2018. The first and second expert missions (field surveys) for target countries in order to determine the status and analyze the needs of each Member were successfully conducted in 2019. To emphasize the outcomes of expert missions and finalize the technical report with consent by TC Members, there was an online pre-meeting of wrap-up on November 27, 2020 and the final wrap-up meeting was held in November 2021.

In 2019, process of hydrological data quality control and the development direction of system were already confirmed. Also, quality control techniques and quality tag were selected with agreement of target TC Members. The computing module of stand-alone PC version system has started to develop in 2020 and almost finished in last year. Technical report of hydrological data quality control was published in this year 53th TC session.

The stand-alone PC version system of hydrological data quality control in TC Members will be finally developed in this year and will publish the official version in 17th IWS. Tentatively, the virtual workshop of the hydrological data quality control system is planned to be held on November 18, 2022 hosted by Republic of Korea. In that meeting, the developed system will be finally checked and demonstrated. In addition to the system, a system user manual will be finalized in 54th TC session after reviewing among member countries.

Identified opportunities/challenges, if any, for further development or collaboration:

There were some restrictions on face-to-face project discussions with pilot target members of TC. Nevertheless, this situation was secured through online meetings and virtual communications. In the next step, there will be a face-to-face meeting of this project and practical application, directly linkage to DB of hydrological data in TC Members.

Through the project, it is expected that capacity building for hydrological data quality control of TC Members will be improved and qualified hydrological data can be reduced the uncertainty of flood forecasting.

Priority Areas Addressed:

Integrated

- Strengthen the cooperation between TRCG, WGM, WGH, and WGDRR to develop impact-based forecasts, decision-support and risk-based warning.

Meteorology

- Enhance training activities with TRCG, WGH, and WGDRR in accordance with Typhoon Committee forecast competency, knowledge sharing, and exchange of latest development and new techniques.

DRR
N/A

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- Strengthen the cooperation between TRCG, WGM, WGH, and WGDRR to develop impact-based forecasts, decision-support and risk-based warning.

7. Comprehensive National Strategy for Urban and River Flooding by Localized Heavy Rainfall

Main text:

In August 2022, localized torrential downpours caused major damage to life and property in the metropolitan area of South Korea. More than 100 mm of rainfall per hour exceeding the disaster prevention performance target in the downtown area of Seoul. 8 people were killed and more than 15,000 homes and 10,000 vehicles were flooded.

Especially, for just two days on August 8 and 9, the maximum rainfall at 1 hour was observed to be 141.5 mm in the southern part of Seoul based on the Han River, and the flood damage in the low-lying underground space due to the concentration of surface water on roads was very serious. As surface water intensively flowed into the lowlands in the city along the road, underground spaces such as subway stations, underground parking lots, and semi-basement houses were quickly flooded, leading to casualties. During urban flooding, manholes on the road also became a major risk factor.

Most experts diagnosed that the cause of these unprecedented localized heavy rainfall was due to the strongly-dense rain cloud belt formed by the stagnant front. This stagnation line was caused by an accelerated phenomenon of stagnant air flow due to huge high pressure staying for a long time throughout the earth this year due to climate change.

With the record-breaking heavy rainfall caused by the impact of abnormal climate, it was pointed out that the drainage system with insufficient water flow capacity in the urban area increased flood damage. Also, damage is aggravated in areas where the urban topography, architecture, and demographic vulnerabilities overlap, so it is necessary to prepare comprehensive measures.

The Ministry of Environment, Republic of Korea urgently announced the comprehensive preventive measures to prevent the recurrence of human and property damage caused by record-breaking heavy rains in the metropolitan area, such as the local heavy rains in August this year;

Until the flood season of 2023 (June to September), a pilot project was established to build an Artificial Intelligence (hereafter with AI) flood forecasting system linked with a digital twin in a part of the city's river basin where frequent flood damage occurs due to repeated flooding, and a plan was established to spread it nationwide.

At the same time, even before the establishment of the AI flood forecast, the existing flood risk map will be used nationwide to prepare a response system applicable to the field, such as setting an evacuation route for the vulnerable.

As a measure for infrastructure to prevent flooding in urban areas and rivers, it is planned to prioritize the installation of underground sluiceway for urban rivers and the installation of rainwater tunnels (underground storage facilities) in the central area of the city. A large-scale rainwater tunnel is a facility that installs a large reservoir (tunnel) underground to trap rainwater from downtown and discharges it to a nearby river through a pumping station when the heavy rain is over.

Identified opportunities/challenges, if any, for further development or collaboration:

In recent years, the importance of responding to urban flooding is growing in many member countries of TC. The importance of flood countermeasures in urban areas considering the characteristics of flooded areas (drainage system, impervious area, and population density etc.) is being emphasized due to the expansion of flood management from river flood control in the past to urban flood. In this respect, it is expected that the establishment of Korea's strategy for urban flooding and its performance can be a reference for urban flood management in TC Members.

Priority Areas Addressed:

<u>Integrated</u>

- Strengthen the cooperation between TRCG, WGM, WGH, and WGDRR to develop impact-based forecasts, decision-support and risk-based warning.

<u>Meteorology</u>

N/A

<u>DRR</u>

- Enhance Members’ disaster risk reduction techniques and management strategies.

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8. A Service Blueprint for National Flood Forecasting with Artificial Intelligence

Main text:

Uncertainty about the climate crisis and changes in social and demographic structures act as negative factors for flood forecasting, but technological innovation can act as a positive factor for the globe. In South Korea, the national flood forecasting system has developed along with the introduction of the latest information, communication technologies and equipment. Likewise, new technologies and advanced equipment will have to be actively introduced and utilized in the flood forecasting system in the future. Recently, AI techniques has been in the spotlight again and application cases are increasing in various specialized fields related to data learning, generation, and management. AI is a technique that enables machines to learn from experiences, adapt existing knowledge based on new inputs, and perform tasks in the same way as humans.

The Flood Control Office (FCO) of the Ministry of Environment, Korea has also been constantly introducing cutting-edge equipment and new technologies in the field of flood forecasting. However, due to the fact that flood forecasting at the national level is a critical issue that directly leads to loss of life and damage to property, the government operates conservative forecasting rather than immediate practical use of the latest technology. When the stabilization of technology is confirmed, it is reflected in practice step by step.

In the context, the FCOs launched the research project nationwide for strengthening preemptive capacity for responding to floods. The project aims to verify the applicability and effectiveness before applying the latest AI-based technology to practical flood forecasting. One of major vision is to apply the advance techniques for managing the dataset which is the AI.

Conservatively, the flood forecasting is mainly focused on prevention of large-scale flood damage such as levee collapse or overflow centered on large-size rivers. At this time, it is also important to prepare in advance for potential risks of small and medium-sized river and basins through the use of new technologies and cutting-edge equipment in response to changes in society and population, as well as environmental changes such as climate crisis.

Under the leadership of the Ministry of Environment, the concrete plans for building an AI-based flood forecasting system, improving the flood forecasting system, and developing and introducing new technologies for AI flood forecasting and infrastructure improvement are as follows.

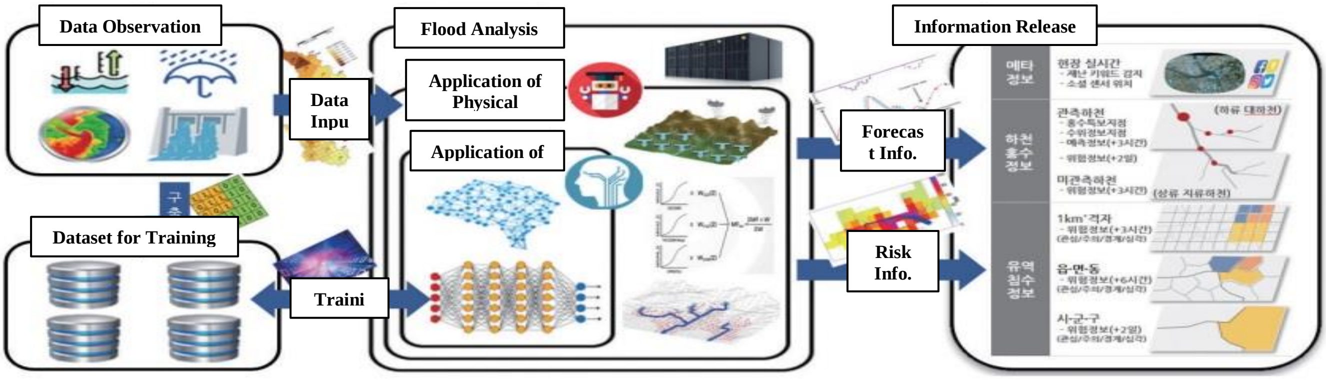

Figure. II-8. Framework for Improving Flood Forecasting with AI Technique

First, by improving the current flood prediction system, it is intended to calculate the prediction results necessary for securing the reliability of the flood warning and expanding branches. It is intended to improve the reliability of the flood warning by improving the method of using the hydrological model in operation and developing an error correction method applying the AI technique.

The 554 water level observation stations currently operated by the FCOs have set the standard water level for each crisis stage and provide flood information when the current water level exceeds the standard water level. In the future, it is planned to strengthen the flood forecasting system of observed rivers so that the current water level and the ultra-short-term predicted water level can be provided so that the flood forecasters and local governments can use them. The production of this predicted water level is to build a learning database from observation and operation data such as upstream precipitation stations, water level stations, and dam operations, and to build a foundation for applying AI technology based on big data.

Using the grid rainfall data of rainfall radar and grid-based physical model for unobserved rivers, the flow rate of the target grid is calculated from the rainfall amount of a 1km² grid and the outflow and flow process according to time, and compared with the pre-calculated risk standard. It is intended to produce and provide very short-term flood risk information.

The entire AI learning data generation module, AI rainfall and AI-introduced infrastructure include not only the display of various predictions and forecasts described so far, rainfall status and predicted rainfall, water level status and prediction/risk information, but also flood risk information and In connection with the flood hazard map providing system, etc., it is intended to build and install a shared system and provision system that can display comprehensively.

Identified opportunities/challenges, if any, for further development or collaboration:

Recently, the application performance of AI and big data can be confirmed in various fields, and it is expected that the applicability can also be confirmed in the aspect of flood management, where securing sufficient data is important. If the effect of AI technique is applied to flood forecasting in Korea to be confirmed, it may be applicable to flood management in TC Members in the future.

Priority Areas Addressed:

<u>Integrated</u>
N/A

Meteorology

- Enhance training activities with TRCG, WGH, and WGDRR in accordance with Typhoon Committee forecast competency, knowledge sharing, and exchange of latest development and new techniques.

DRR

- Enhance Members' disaster risk reduction techniques and management strategies.

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9. Capacity Building / Knowledge sharing in DRR

Main text:

NDMI and NOAA hosted the Capacity Building / Knowledge sharing in DRR program in Guam on 26th July 2022. The objective of the Capacity Building / Knowledge Sharing is to strengthen not only a host country's disaster management capability, but also participants' as well by sharing information and experiences including policies, technologies, and researches results related to DRR among the Members.

NDMI dispatched 7 experts and total around 20 experts attended the program including NDMI, NOAA, OCD Guam, and the Red Cross. 7 experts from NDMI made a presentation on disaster management and the detailed subject is as follows.

- NDMI Overview and main work (Ms. Seo, Eunji)
- National integrated drought forecasting-warning system (Dr. Choi, Woojung)
- Disaster Management System and Response Cases in Korea (Dr. Rheem, Sangkyu)
- Application Plan of satellite imagery for disaster management (Mr. Lee, Dalgeun)
- Landslide resident evacuation management criteria of Korea based on measurement data(Dr. Choi, Sungyu)
- Sharing Disaster Scientific Investigation System and Techniques(Ms. Kim, Yeonju)
- Introduction on international cooperation project in NDMI(Dr. Chihun Lee)

Figure II-9 Picture of attendees in Capacity Building and Knowledge Sharing in DRR program

NDMI will continue this program and it is planning to be held in the Philippines and Lao PDR in 2023.

Identified opportunities/challenges, if any, for further development or collaboration:

- NDMI suggested to integrate SSOP-Ⅲ project which is what Typhoon Committee is planning fo r into the knowledge sharing program.

Priority Areas Addressed:

Integrated

- Strengthen cross-cutting activities among working groups in the Committee.
- Enhance collaborative activities with other regional/international frameworks/organizations, incl uding technical cooperation between TC/AP-TCRC and TC/PTC cooperation mechanism.

Meteorology

- Promote communication among typhoon operational forecast and research communities in Typh oon Committee region.

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10. Setting up Early Warning and Alert System

Main text:

Since 2013, NDMI has been implementing Global DRR project to strengthen the countries' capability of flash flood preparedness. NDMI conducted the project with the Philippines from 2013 to 2015 and the Philippines has requested NDMI to implement DRR project again for other areas. After conducting a feasibility study, NDMI has decided to install ARWS in Toledo and Dumanjug Province through discussion with the Philippine Atmospheric, Geophysical and Astronomical Services Administration(PAGASA). The whole process of DRR project, which is carried by NDMI installing Flood Alert System and Automatic Rainfall Warning System (ARWS*), consists of three steps:

- Conducting Field Survey
- Installation and Inspection
  * Warning Post (WP), Rainfall Gauge (RG), Water Level Gauge (WG)
- Operating Educational Program

NDMI conducted a field survey to choose sites for constructing WP, RG, and WG. Through the meeting with PAGASA and the local government of Toledo and Dumanjug province, NDMI chose the six places for WP, the six places for RG, and the six places for WG in Toledo and Dumanjug Province. In addition, NDMI conducted the training and educational program in October for local officials and the residents in the Philippines (Fig. II-12).

Figure II-10 Pictures of having meeting with PAGASA

Figure II-11 Pictures of Conducting Field Survey in the Philippines

Figure II-12 Pictures of Training and Educational Program in the Philippines

Identified opportunities/challenges, if any, for further development or collaboration:

- Next year, NDMI will continue the DRR project on installing ARWS and FFAS in the Philippine.

Priority Areas Addressed:

<u>Integrated</u>

- Enhance collaborative activities with other regional/international frameworks/organizations, incl uding technical cooperation between TC/AP-TCRC and TC/PTC cooperation mechanism.

<u>Meteorology</u>

- Enhance the capacity to monitor and forecast typhoon activities particularly in genesis, intensity and structure change

Hydrology

- Improve typhoon-related flood (including riverine flood, flash flood, urban flood, and coastal flood) monitoring, data collection and archiving, quality control, transmission, processing, and sharing framework.

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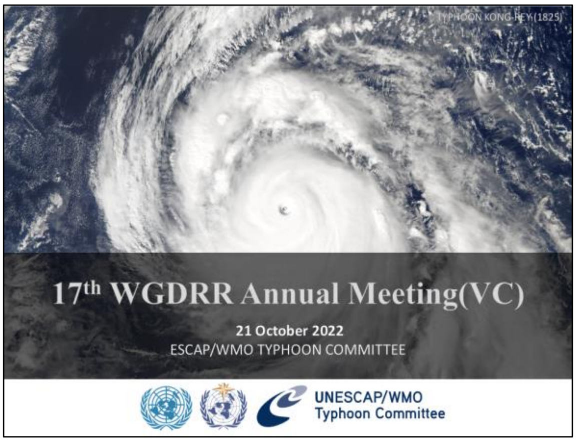
11. The 17th Annual Meeting of Typhoon Committee Working Group on Disaster Risk Reduction(VC)

Main text:

The 17th Annual Meeting of Typhoon Committee Working Group on Disaster Risk Reduction (TC WGDRR) led by NDMI was held virtually on 21st of October. Including WMO, ESCAP, TCS, and TC members, total 24 were participated in the meeting. The meeting featured the review of activities & budget in 2022 and discussed Annual Operations Plans (AOPs) & budget for 2023. As a discussion result, WGDRR decided tentative 2023 AOPs & Budget.

Table II-1. Tentative Annual Operations Plans (AOPs) with budget in 2023

No.	Items	Budget (USD)	No.	Items	Budget (USD)
1	Capacity Building / Knowledge Sharing in DRR	12,500	2	Setting up Early Warning and Alert System	-
3	TC WGDRR Annual Meeting	-	4	Benefit Evaluation of Typhoon DRR	-
5	Sharing Information related to DRR	-	6	Making Educational Video	3,000
Total Budget (USD)					**15,500**



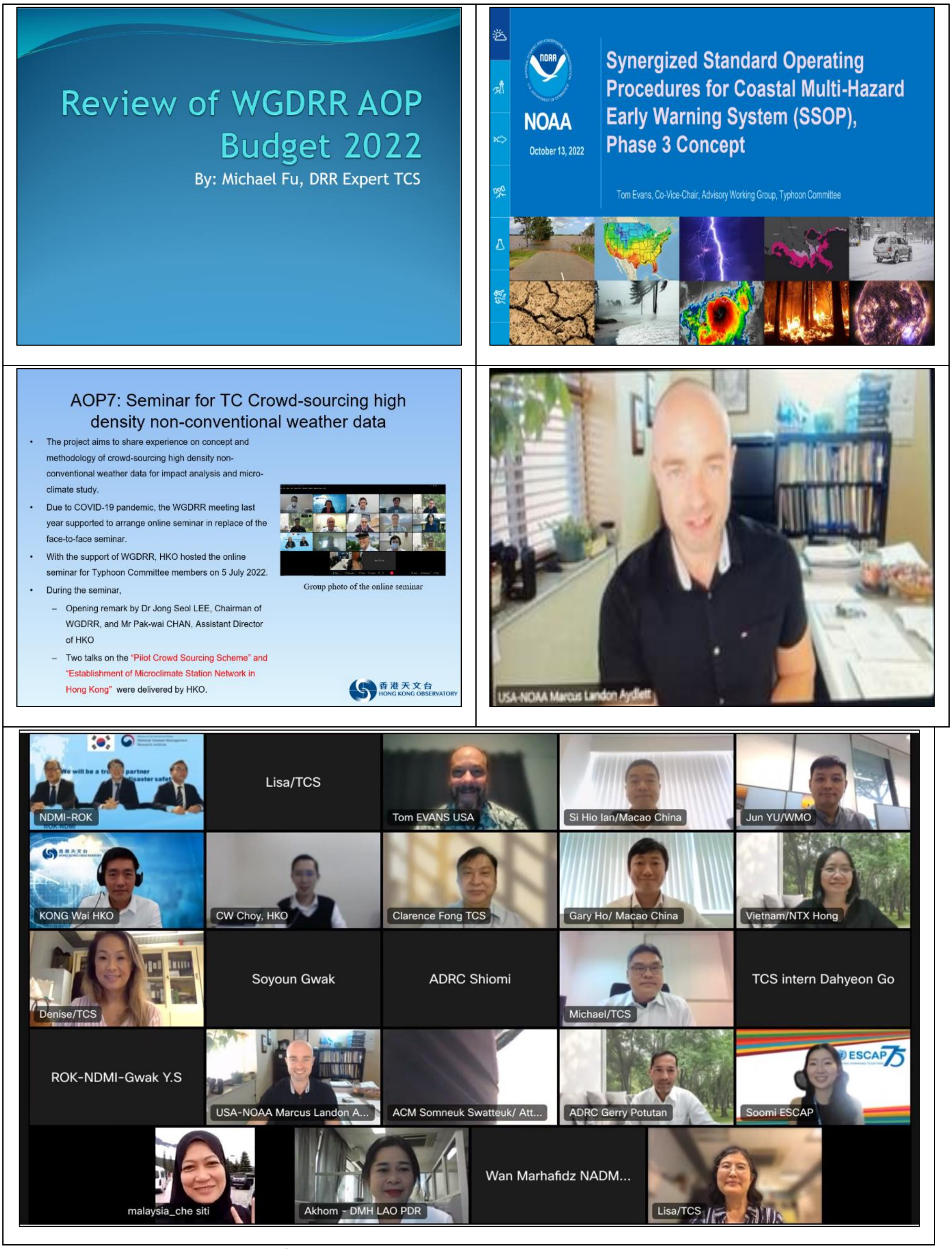


Figure II-13 Pictures of the 17th Annual Meeting of TC WGDRR (VC)

Identified opportunities/challenges, if any, for further development or collaboration:

By 17th TC WGDRR Annual Meeting, WGDRR could review WGDRR's achievements in 2022 and build strategic plans for 2023. It was a great chance to find ways for advancement of WGDRR as well as for contribution to strengthen the capability of disaster risk reduction on the member countries.

Priority Areas Addressed:

Integrated

- Strengthen cross-cutting activities among working groups in the Committee.
- Enhance collaborative activities with other regional/international frameworks/organizations, including technical cooperation between TC/AP-TCRC and TC/PTC cooperation mechanism.

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12. Sharing Information Related to DRR

Main text:

As one of the AOPs of TC WGDRR, NDMI has been trying to share information related to disaster risk reduction at the ESCAP/WMO Typhoon Committee website. At the website, there is a Typhoon Committee (TC) Forum Session, which consists of two parts:

- Shanghai Typhoon Institute Typhoon BBS: A discussion platform for typhoons, moderated by Shanghai Typhoon Institute (STI) and Typhoon Committee Secretariat (TCS)
- Typhoon Committee Forum: A discussion platform among the working groups of TC
  * Three Working Groups: Working Group on Meteorology (WGM), Working Group on Hydrology (WGH), Working Group on Disaster Risk Reduction (WGDRR)

NDMI has been responsible for the WGDRR session to share information related to DRR. The Topics in the session are:

- ENFORCEMENT DECREE OF THE FRAMEWORK ACT ON THE MANAGEMENT OF DISASTER AND SAFETY
- Framework act on the management of disaster and safety in the Republic of Korea
- Thailand’s Act 2007 and National Plan 2015

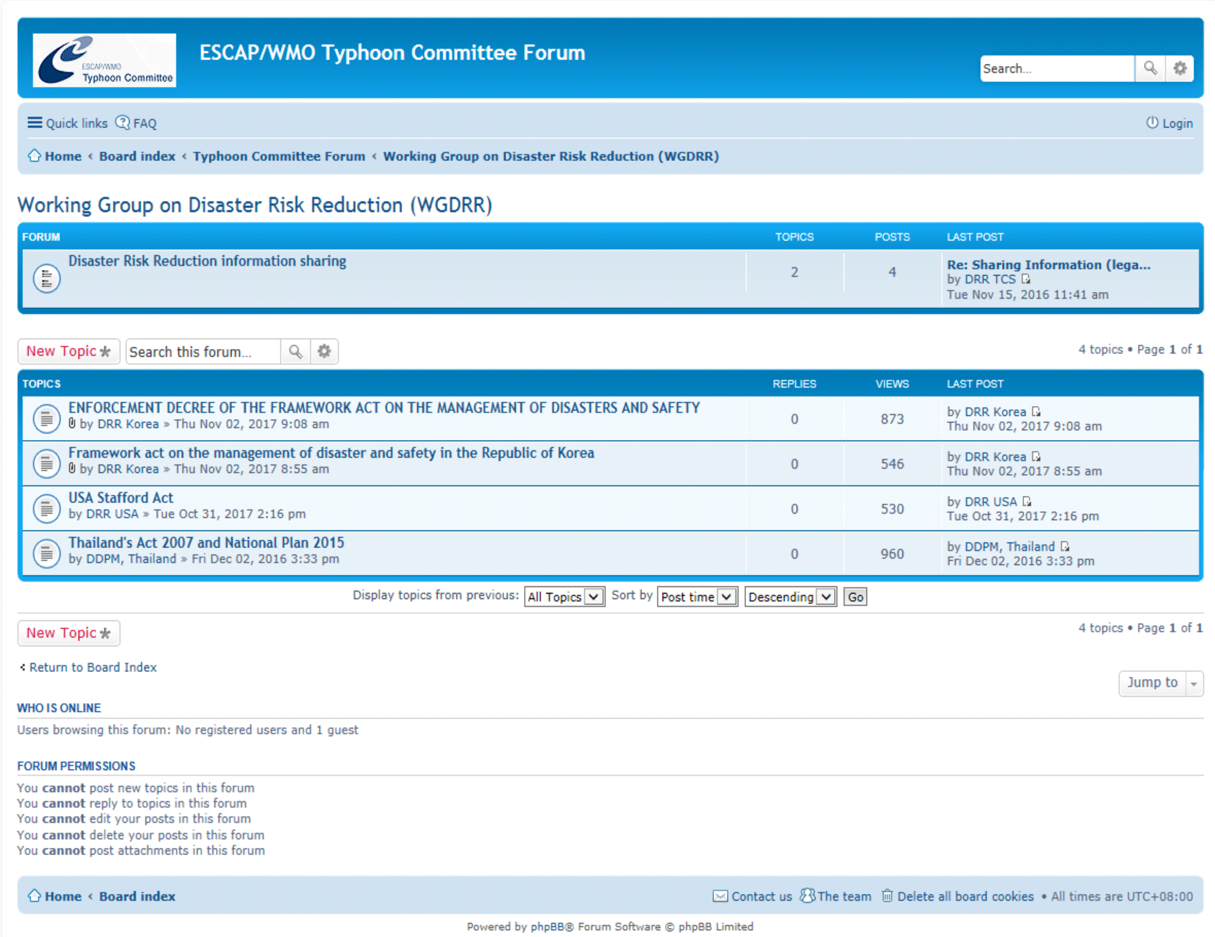

Figure II-14 TC WGDRR Forum Website (http://www.typhooncommittee.org/forum/viewforum.php?f=12)

Identified opportunities/challenges, if any, for further development or collaboration:

Sharing information related to DRR through the TC forum website could be a good example framework to promote knowledge sharing among TC member countries. Also, it could be a good opportunity to share information regarding disaster risk management to the public. Therefore, NDMI will keep promoting the use of the website so that all information about the related knowledge and experience from the TC members could be a good chance to draw continuous attention of the public in the field of disaster risk reduction.

Priority Areas Addressed:

Integrated

- Strengthen cross-cutting activities among working groups in the Committee.
- Enhance collaborative activities with other regional/international frameworks/organizations, including technical cooperation between TC/AP-TCRC and TC/PTC cooperation mechanism.

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Appendix I - Priority Areas of Working Groups for the Strategic Plan 2022-2026

WG	Priorities
Integrated	1. Strengthen the cooperation between TRCG, WGM, WGH, and WGDRR to develop impact-based forecasts, decision-support and risk-based warning.
	2. Strengthen cross-cutting activities among working groups in the Committee.
	3. Enhance collaborative activities with other regional/international frameworks/organizations, including technical cooperation between TC/AP-TCRC and TC/PTC cooperation mechanism.
Meteorology	4. Enhance the capacity to monitor and forecast typhoon activities particularly in genesis, intensity and structure change.
	5. Develop and enhance typhoon analysis and forecast techniques from nowcast to medium-range, and seasonal to long-range prediction.
	6. Enhance and provide typhoon forecast guidance based on NWP including ensembles, weather radar and satellite related products, such as QPE/QPF.
	7. Promote communication among typhoon operational forecast and research communities in Typhoon Committee region.
	8. Enhance training activities with TRCG, WGH, and WGDRR in accordance with Typhoon Committee forecast competency, knowledge sharing, and exchange of latest development and new techniques.
	9. Enhance RSMC capacity to provide regional guidance including storm surge, in response to Member's needs.
Hydrology	10. Improve typhoon-related flood (including riverine flood, flash flood, urban flood, and coastal flood) monitoring, data collection and archiving, quality control, transmission, processing, and sharing framework.
	11. Enhance capacity in typhoon-related flood risk management (including land-use management, dam operation, etc.) and integrated water resources management and flood-water utilization.
	12. Strengthen capacity in effective flood forecasting and impact-based early warning, including hazard mapping and anticipated risk based on methodological and hydrological modelling, and operation system development.
	13. Develop capacity in projecting the impacts of climate change, urbanization and other human activities on typhoon-related flood disaster vulnerability and water resource availability.
	14. Increase capacity in utilization of advanced science and technology for typhoon-related flood forecasting, early warning, and management.
DRR	15. Provide reliable statistics of mortality and direct disaster economic loss caused by typhoon-related disasters for monitoring the targets of the Typhoon Committee.
	16. Enhance Members' disaster risk reduction techniques and management strategies.
	17. Evaluate socio-economic benefits of disaster risk reduction for typhoon-related disasters.
	18. Promote international cooperation of DRR implementation project.
	19. Share experience/knowhow of DRR activities including legal and policy framework, community-based DRR activities, methodology to collect disaster-related information.