Flood Risk Management for Wide-area and Long-lasting Rainfall
- Multi-layered countermeasures for complex disasters -

Council Report

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River Council
for Social Infrastructure Development

Contents

1. Introduction

From the end of June toward the beginning of July 2018, a lingering rainy front hovered over the Japan Islands, which combined with Typhoon Prapiroon coming from the South, generated record-breaking rainfall over widespread areas of Western Japan. River flooding and debris flow occurred extensively and simultaneously. Two hundred people perished or went missing, 30,000 houses collapsed and huge socio-economic losses resulted from the suspension of urban lifeline services, such as electricity and water-sewer services and transportation interruptions.

After the Kinu River levee breaches stranded many people during the Kanto-Tohoku Torrential Rain in September 2015, MLIT had notified that “river infrastructure have limited capacities and large-scale floods can exceed them” and had initiated a policy vision of “Rebuilding Flood-conscious Societies” to prepare for flood disasters in coordination with all social sectors.

Following the tragedy of the Hokkaido-Tohoku Torrential Rain in August 2016, where the most vulnerable victims succumbed in a nursing home due to overdue evacuation, MLIT amended the Flood Risk Management Law and River Law to accelerate “Rebuilding Flood-conscious Societies” in small and medium river basins managed by prefectures.

While MLIT promoted emergency recovery projects in small-scale river basins after the July 2017 North Kyushu Heavy Rain, the July 2018 Western Japan Heavy Rain forced MLIT to further boost “Rebuilding Flood-conscious Societies”.

In this context, the Minister of Land, Infrastructure, Transport and Tourism requested the chair of the Council for Social Infrastructure Development to consider how to manage flood risks of wide-areas and long-lasting rainfall. The chair entrusted the bill to the chair of the River Council and the “Sub-panel on Flood Risk Management for Wide-area and Long-lasting Rainfall” started up in September 2018. After three intensive discussions, the River Council finalized a report with key concepts and recommendations to be implemented promptly.

2. Trends of July 2018 Heavy Rain

(1) Background of the rainfall

<Hydrological phenomenon>

+ Rainfall on widespread areas of Western Japan reached 1,800mm in Shikoku and 1,200mm in the Tokai region, during June 28th to July 8th. The amount was four times larger than July monthly averages at several stations.
+ The long-lasting rainfall broke the records of 24-hour rainfall at 77 stations, 48-hour rainfall at 125 stations, 72-hour rainfall at 123 stations among 1,300 AMeDAS Observatories. (AMeDAS: Automated Meteorological Data Acquisition System)
+ 125 stations with the 48-hour rainfall records were widely distributed in North Tokai, Hokuriku, Kinki, Chugoku, Shikoku and Kyushu Regions. 30-year data analysis identified over 100-year excess probability at 13 among 16 stations in Okayama, 18 among 19 stations in Hiroshima and 9 among 10 stations in Ehime Prefectures.
+ 1-hour rainfall also marked a new record at 14 AMeDAS Observatories in Gifu and Hiroshima Prefectures.
+ The total rainfall of the first 10 days in July 2018 throughout Japan was above the record for 10-day rainfall during January 1982 to June 2018. There was no such precedent in the observation archives. The new records were 208,035.5mm in total and 215.4mm on average for 966 AMeDAS Observatories.

<Meteorological factors>

+ Typhoon Prapiroon, born on June 29th, 2018, moved Northward on the East China Sea and turned Northeast near Tsushima Island to be categorized a tropical cyclone on the Japan Sea on July 4th. By July 8th, a rainy front lingering over Western Japan with extremely warm and wet air was on course for heavy rain.
+ The warm and wet air was supplied by Okhotsk Sea High Pressure enlarged by 2 meandering jet streams: the Tibet High Pressure and Pacific Ocean High Pressure. The Japan Meteorological Agency announced there was a “contribution of water vapor increased by climate change”. This was the first time the agency attributed a specific impact to climate change.
+ The Agency determined that the amount of water vapor was the largest since 1958.
+ In addition, 15 linear rainbands were formed during July 4th to 8th over Gifu, Hiroshima and Kochi Prefectures. Nine of them caused over 150mm during 3-hour rainfall, and some of them contributed over 50% of total precipitation.

<About Typhoon Jebi in September>

+ Typhoon Jebi was born near Minamitorishima Island on August 28th and made landfall in Tokushima and Hyogo Prefectures, with very strong force on September 4th. The typhoon brought strong winds and rain over Western to Northern Japan, and caused the highest recorded storm surge in Osaka Bay.

(2) Outline of the damage and response

In July 2018, Heavy Rain caused simultaneous river floods, waterlogging, debris flow, among others, in a wide area of Western Japan. As a result, 224 people died, 8 people went missing, 21,460 houses collapsed, and 30,439 houses were inundated. Local governments issued evacuation orders for 2,007,489 people (915,849 families), and evacuation advisories for 2,304,296 people (985,555 families). Lifeline infrastructures were also damaged, such as 263,593 households affected with disrupted water supply.

<River floods>

+ The number of rivers, in which the water exceeded the hazardous water level, was the largest ever, with 50 rivers in 26 basins under MLIT management and 234 rivers in 138 basins under prefectural management.
+ Levees were breached at 37 points in total. Of these, 2 breaches occurred on the Oda River in Takahashi River basin under MLIT management, and 35 breaches were in rivers under prefectural management; namely, 16 breaches in 10 rivers in Okayama and 16 in 12 rivers in Hiroshima.
+ Especially in Oda River and its 3 tributaries, levees were breached at 8 points due to the “backwater phenomenon” in which branch river floods synchronized with the major river flood.
+ Among 558 dams managed by MLIT, 213 dams conducted flood control operations. 22 dams used over 60% of their flood control capacity. 8 dams almost exhausted their flood control capacity and shifted to emergency discharge operations, under which the outflow was equal to the inflow. Some operations triggered floods in the downstream.

<Waterlogging>

+ Inundation, including waterlogging, occurred in 47 rivers in 22 MLIT-managed river basins and in 242 rivers in 69 prefecture-managed river basins.
+ Record breaking and long-lasting rainfall and intensive short-period squalls in widespread areas caused a mixture of river flooding and waterlogging at 88 municipalities in 19 prefectures in Western Japan. Municipalities reported that 18,853 houses were affected by waterlogging, and 90% of them were in areas undergoing construction of sewage drainage systems.

<Sediment disasters>

+ Sediment disaster warnings were issued to 505 municipalities in 34 prefectures. Sediment disasters occurred in 31 prefectures especially in Hiroshima and Ehime Prefecture. The total number of 2,512 was 2.3 times higher than the annual sediment disaster occurrence of the past 10 years.
+ Sediment-water synergistic floods, wherein preceding sedimentation in the downstream dammed up subsequent sediment and water, hit Oya-ohkawa and Sozu rivers in Hiroshima Prefecture.
+ Many masonry sabo dams in Hiroshima Prefecture, which had passed periodical inspections, collapsed or were flushed away by debris flows.

<Human loss>

+ 232 people perished or went missing during the July 2018 Heavy Rain. This is the first time a human toll exceeding 200 occurs since 1982.
+ Fatalities and reports of missing people occurred in 14 prefectures, concentrating in Okayama, Hiroshima and Ehime Prefectures. 80% of the deaths (87 of 109 people) in Hiroshima perished in sediment disasters. Almost all deaths (59 of 61 people) in Okayama were from drowning in floodwaters.
+ A half of the victims in the Hiroshima sediment disasters and 90% of victims in the Mabi Town inundation were people over 65 years old.

<TEC-FORCE >

+ MLIT dispatched the Technical Emergency Control Force (TEC-FORCE) to affected municipalities. The number of MLIT members who worked on these disasters amounted to 10,820 man-days (as of October 29th, 2018), and 607 per a day at a maximum.
+ Pump vehicles conducted 24-hour drainage operations of 1,200 ha waterlogging over 3 days at Mabi Town in Kurashiuki, Okayama.
+ Road sprinklers and road sweepers supported dust-proofing and water supply to recover primary services for living conditions.
+ Staff members removed sediment, driftwoods and garbage on rivers and roads in Kure City, Hiroshima.

<Search and rescue>

+ The Ministry of Defense operated search and rescue operations with 33,100 self-defense force soldiers, 28 vessels and 38 aircrafts, at its peak.
+ The Fire and Disaster Management Agency rescued 397 victims during searches performed by 15,000 fighters and 271 helicopters in Okayama, Hiroshima, Ehime and Kochi Prefectures.

<Road and rail interruption>

+ Expressways were interrupted by debris flows, bridge collapses and rainfall regulations at 77 sections of 63 routes in many areas from Chubu to Kyushu.
+ Railways were stopped by debris flow, rail submersions and bridge collapses on 115 routes of 32 companies.
+ The JR Freight Company suspended 30% of its operations and provided substitute or alternate transportation.

<Lifeline infrastructure suspension>

+ Lifeline infrastructure of electricity and water-sewage services was damaged in many areas of Western Japan.
+ Many blackouts occurred in Okayama, Hiroshima and Ehime Prefectures, but electricity was quickly restored in urban areas as of July 13th.

+ Water outages occurred due to debris flows into purification plants and pump stations in Okayama, Hiroshima and Ehime Prefectures. Temporary water purifiers were working for a long time in Kure and Uwajima Cities.
+ Sewage treatment plants were damaged in Okayama and Fukuoka Prefectures. Residents were asked to perform voluntary bans.

<Stagnation of medical care>
+ Inundation and water outages hit 95 medical centers in Japan. Some of the damage remained until September 13th.
+ Large-scale inundation hit the Mabi Memorial Hospital after 4:00 am on July 7th, and isolated 300 patients and evacuees.
+ Roof leaks and inundations struck 268 nursing houses for the elderly. 657 occupants from 30 houses had to move to other facilities or hospitals.

<Damage on industries>
+ Agricultural damage was estimated to amount to 167.5 billion yen in agriculture, 160.8 billion yen in forestry, 2 billion yen in aquaculture, and 330.3 billion yen in total.
+ Industrial factories were inundated due to a levee breach in Mihara City, Hiroshima Prefecture and water logging around industrial parks in Okayama City, Okayama Prefecture.

<Disaster garbage>
+ Floods generated a large quantity of disaster garbage. The amount in Okayama, Hiroshima and Ehime Prefectures was 290 tons in total.
+ Waste treatment plants were damaged directly by floodwaters and also from road interruptions and water outages.

<Damage of Typhoon Jebi>
+ Kansai International Airport and Rokko Island were submerged by the storm surge in Osaka Bay. However, Osaka City was protected by tidal gates and pump stations, which were constructed and put into operation following typhoon disasters in 1934 and 1961.

(3) Features of the floods

Based on the rainfall background (1) and the damage outline (2) mentioned above, features of the water-related disaster caused by the July 2018 Heavy Rain were summarized as follows:

< Meteorological factors of recent heavy rains>

+ Heavy rain, which caused water-related disasters in Japan can be sorted into typhoon-type, rainy front-type, rainband-type, and others.
+ The August 2014 Sediment Disaster in Hiroshima and the July 2017 Heavy Rain in Northern Kyushu were caused by linear rainbands settling in relatively narrow areas. The September 2015 Kanto-Tohoku Heavy Rain on Kinu River was induced by linear rainbands boosted by a typhoon and a tropical cyclone. The 2016 Hokkaido-Tohoku Heavy Rain had moving rainbands along a typhoon’s path and intensive rainfall.
+ The July 2018 Heavy Rain was caused by a lingering rainy front enhanced by rich vapor supply from two high-pressure systems that generated long-lasting rainfall over a wide-area.
+ Each water-related disaster had different breakout mechanisms due to natural phenomena, with differing impacts on residents. These factors often worked synergistically.

< Unprecedented hydrological features in 2018>

+ Average precipitation exceeded the flood discharge simulation scenarios in 8 major river basins of Western Japan, including in Takahashi and Hiji Rivers, however, the peak discharges were less than the discharge estimates. This means the July 2018 Heavy Rain had no intensive peaks as in the case of a typhoon, rather, the record-breaking total precipitation occurred over a long-lasting period. Hence, rainy front-type rainfall occurred in Setouchi region where typhoon-type events were heretofore dominant.
+ This explains why many river floods occurred, not only in small and medium scale river basins but also in major river basins, which had relatively wide catchment areas, and that backwater phenomena caused several levee breaches along the Oda River in Takahashi River basin.
+ Large amounts of rainfall exceeding sewerage design capacities and long-lasting high-water levels hindered drainage causing waterlogging.
+ Excessive inflows were stored in dam reservoirs, however 8 dams exhausted the flood control capacity and shifted to emergency discharge operations.
+ Many sediment disasters occurred in the Southern area of Hiroshima Prefecture. With a total 1,242 sediment disasters registered in the prefecture, this is more than their annual occurrences in the whole of Japan.
+ Sediment supply from upstream disasters flowed through the river channel continuously and settled around the slope turning point. The rise in the riverbed downstream caused sediment-water synergistic disasters.
+ Local linear rainbands in long-lasting rainfall episodes created wavy precipitation in each area and produced a couple of water level peak and discharge in each river.

Intensive squalls on fully-moistened soil triggered sediment disasters and quick discharge to rivers and dams.

<Evacuation advisories and residents' evacuation>

+ Municipalities in MLIT-managed river basins, including the severely affected Oda River, issued evacuation advisories citing maximum probable inundation scenarios, a timeline plans of emergency operations, and hotline to MLIT river offices. However, some municipalities in prefecture-managed river basins hesitated to issue evacuation advisories after acknowledging the dangerous water levels. Also sediment disaster warnings did not help in evacuation advisories.
+ In the case of Mabi Town of Kurashiuki City, inundation maps and hazard maps almost corresponded to the actual flooding and evacuation advisories that were issued. Some residents testified that they started evacuation just after hearing the advisories at midnight but that roads were so crowded. However, because the rainfall was not so heavy, a number of residents could not decide to evacuate. In the inundation area, due to levee breaching, 44 among the 51 people who drowned were found in their houses. The fact that most of them were on the ground floor suggests that even vertical evacuation was difficult to perform, especially for elderly people.
+ 90% of human loss due to sediment disasters occurred within sediment disaster warning zones, where early warnings were issued in advance. In the case of Hiroshima City, many people might have decided not to evacuate because they had no experience of past warnings. Long-lasting but weaker rainfall than the 2014 Sediment Disaster might have enhanced their normalcy bias.
+ Huge inundations occurred downstream of the dams that had exhausted flood control capacity. Dam operators delivered operational information to mayors through hotlines and the media, however in many cases, the information without inundation areas did not trigger evacuation of residents.
+ Some victims lost their way to the shelters or got into accidents during the evacuation because evacuation routes were already endangered. In some communities, evacuation routes ran through a sediment disaster-warning zone. In other cases, debris flows hit a housing development from several valleys.

<Socio-economic losses over wide areas>

+ Damage to emergency operation centers and core medical services, to lifeline infrastructure services of electricity and water-sewage, and to transport infrastructure of rail and roads, disrupted emergency response work and quick recovery. The damage even impacted companies that were not in the affected areas.
+ The impact spread widely to areas that were not themselves inundated, through interrupted supply chain networks and employee absences. Automobile factories in Hiroshima and other enterprises had to stop their manufacturing and service operations.
+ Self-defense force soldiers and fire fighters supported search and rescue and the TEC-FOECE members assisted in infrastructure recovery. But widespread damage and interrupted road communications required extended support.

(4) Problems to be solved

+ Limited capacity of existing infrastructure against large-scale flood
- Floods occurred at many sections where channel capacity was limited in both prefecture-managed and MLIT-managed rivers.
- Dams exceeded the flood control capacity and caused flooding downstream. Some dams, which had limited outflow possibilities due to narrow downstream channels, reached their full capacities earlier.
- Much rain caused waterlogging and debris flows simultaneously in wide areas.

+ Complex factors of water-related disasters
- The backwater phenomenon, in which branch river floods synchronized with the major river flood, caused tributary flooding and waterlogging.
- Much sediment flowed through rivers from upstream landslides and settled in the downstream channel. The ensuing riverbed rise caused sediment-water synergistic disasters.

+ Climate change impacts relative to water-related disasters
- This was a confirmed instance of climate change impact. “Increased water vapor due to global warming” contributed to the July 2018 Heavy Rain. Further extreme climate change impacts will make rainfall all the more frequent and violent.
- Rainy front-type rainfall occurred in the Setouchi region where typhoon-types were heretofore dominant. Climate change might alter meteorological factors across regions.

+ Human damage due to overdue evacuation
- Even though hazard maps, local risk information and evacuation advisories were provided, many residents could not understand the risks nor perceive the immediate threats. They did not decide to evacuate and perished from the water-related disaster, especially so in the case of elderly people.
- In instances where evacuation routes were dangerous, victims lost their way to the shelters or got into accidents during the evacuation.

+ Miscommunication on infrastructure operational information
- Dams, sewerage networks, pumping stations, floodgates keep localities safe against heavy rain under a certain threshold. Local residents did not understand the possibility of floods due to heavier rainfall in excess of infrastructure capacity. Lack of information of area-specific risks and of real-time operations made residents unconcerned.

+ Local socio-economic damage
- Damage on local emergency operation centers, core medical centers, lifeline infrastructure networks of electricity and water-sewage services, rail and road transport infrastructure, disrupted the emergency response and quick recovery

processes. Long-term business suspensions and population outflows are an ongoing concern.

+ Wide-spread damage
- TEC-FORCE members were dispatched from all over Japan but it was insufficient to cope with the overwhelming number of requests due the wide-spread of areas affected.
- MLIT Regional Bureaus mobilized staff members and materials. But insufficient information hindered resource allocation.
- Emergency operations faced difficulties in determining the extent of the damage at the initial stage and permits to access private properties for garbage disposal hindered the process.

3. Key concepts of countermeasures

+ Long-lasting rainfall of the July 2018 Heavy Rain caused huge human damage and socio-economic losses in wide areas, not only from river floods exceeding channel capacities but also from complex causes, such as backwater phenomenon and water-debris synergistic disasters.

+ The September 2015 Kanto-Tohoku Heavy Rain reminded the nation that “large-scale floods can inevitably exceed river infrastructure capacity”, which triggered a new policy vision of “Rebuilding Flood-conscious Societies” to prepare for the next flood in coordination with all social sectors.

+ These efforts helped advance emergency information delivery from the public sector and risk communication of water-related disasters. However, lingering problems were clarified, such as the miscommunication in evacuation advisories and local risks, and the misunderstanding of many residents who decided not to evacuate.

+ Lifeline infrastructure suspension of electricity and water-sewer services and transport interruption of road and rail networks over a wide area affected local emergency control operations and socio-economic activities.

+ In recent years, climate change impacts have increased the number of heavy rains. Enormous damage has occurred every year. Many rivers have often risen up above hazardous water levels. We should be aware that climate change has shifted water-related disasters into a new phase, surpassing our flood control efforts. Moreover, climate change will make heavy rain more frequent and violent, exacerbate river floods, waterlogging and debris flow, and cause more severe damage.

+ Therefore, key concepts should stress the importance of structural measures from critical authorities, and urgently strengthen multi-layered countermeasures against complex disasters to prevent and minimize disaster damage through a whole-of society approach. It can be achieved by all social sectors working together in the Mega-flood Management Committees.

+ In practice, the following four key concepts are important to accelerate “Rebuilding Flood-conscious Societies”:

“Life-saving measures against hazards that exceed infrastructure capacity”

- Information sharing of local disaster risks, infrastructure functions and real-time information through communications improvement, simplified indicators, easy access and collaboration with the media.
- Self-decision making of residents for safe evacuation through proactive information acquisition in local communities.
- Life-saving initiatives by constructing disaster preventive infrastructure, durable levees to delay breaching and temporary shelters for stranded victims.

“Preventive measures to minimize socio-economic losses and launch quick recovery and reconstruction”

- Proactive facilitation, such as water-proofing facilities of private companies, reinforcement of lifeline infrastructure and core functions, and capacity building for resilience/recovery through power duplication and material storage.

“Adaptive measures to more frequent and heavier rains over wider areas, exacerbated by climate change”

- Prompt response to climate change impacts confirmed, step-by-step increases of safety levels, advanced monitoring and maintenance, preparation for wide-area disasters and rethinking of our way of living.

“Research and Development”

- Scientific research on disaster breakout mechanisms, focusing on meteorological and social factors, and practical development of effective countermeasures for disaster prevention and mitigation.

4. Recommendations to be implemented promptly

(1) “Life-saving measures against hazards that exceed infrastructure capacity”

1) Seamless information from routine times to emergency

- Emergency warning with local risk information during routine operations

Disclose area-specific risks such as river water levels to guide evacuations and probable inundated areas on hazard maps during routine time. Deliver real-time river information with local risk information through the media and the internet in times of emergency.

- Visualized information to assist emergency risk perception

Deliver water level information with visualized information to assist risk perception through simple and low-cost cameras.

- Timeline plans of disaster operations for evacuation

Enrich timeline plan of disaster operations to clarify time-series disaster operations before and after evacuation advisories to manage locally-specific flash floods, storm surges and sediment disasters, involving dam operators in the Mega-flood Management Committees if necessary.

Develop district-level and personal-level timeline plans of operations.

Involve the media and ICT companies to enhance emergency communication capacity.

- Risk level indicators standardized and shared among various disasters

Develop a user-oriented website to integrate various types of disaster information of river and slope conditions, weather forecasting and hazard maps. Standardize, summarize and simplify disaster information to assist risk understanding.

- Information delivery through active media channels

Improve river information delivery systems in active cooperation with media and ICT companies, and strengthen interdependent partnerships with them.

- Capacity disclosure of disaster management infrastructure

Disclose the capacity of reservoirs, sabo weirs and levees, and damage due to hazards exceeding their capacity, to assist in risk perception for evacuation.

Share dam operation rules with residents in the downstream areas, and deliver operational information during flood control.

2) Risk information sharing without a blind spot

- Probable inundation zoning

Publish probable inundation zones caused by the worst-case rainfall in all legally designated flood-forecasted rivers. Install 3L water level gauges (low-cost, long-life and localized).

Boost probable inundation zoning around sewage networks and coastal areas.

- Probable inundation mapping for downstream dams

Simulate and publish probable inundation areas and depth caused by the worst-case rainfall for downstream dams.

- Probable sediment disaster zoning

Prompt prefectures to complete basic surveys and publish probable sediment disaster zones under the Sediment Disaster Management Act.

- Hazard map revision using maximum flood scenario

Enhance professional support to municipalities for revising hazard maps using maximum inundation scenario with the worst-case rainfall.

Assist public-help for residents with technical and mental challenges for local specific disaster risks.

Publish revised hazard maps, probable inundation zones and probable sediment disaster zones promptly through the hazard map portal site.

- Hazard map portal site of water-related disasters

Enrich and open data on the hazard map portal site for local residents and companies. For instance, publish probable inundation maps, even in small and medium-scale river basins, and maps for storm surges and waterlogging. Disclose topographic classification maps to understand disaster risks without inundation maps.

3) Real-time information to encourage evacuation

- Time-series flood risk-line system

Develop and install a system to assess varying flood risks continuously up-down, right-to-left and hour-by-hour.

Improve forecasting accuracy of the peak water level and arrival times to assist risk-based evacuation and advisories.

- Water level monitoring and flood forecasting

Carry out flood forecasting at more rivers, sewage plants and on the coast. Install 3L water level gauges on small and medium-scale rivers and enrich real-time water level data delivery.

- Flood commentary by river authorities

Explain actual flood management using flood forecasting, water level data and live images from river authorities (MLIT or prefectures) through the local media.

- Dam information delivery for evacuation

Review dam information management, such as releasing discharge and schedule, for local governor’s evacuation orders and evacuee’s actions. Discuss how to use dam and river information with municipalities, and share it among local communities.

- Supplementary sediment disaster warning

Improve sediment disaster warning to support varying risk perception using time-series risk indicators. Assist in the issuance of evacuation orders by automatic indicators of risk level over criteria.

- Warning system ensured during for mega-scale flood

Secure the water-resilience of water level gauges and dam communication systems, even for mega-scale floods, to provide essential data for operation and evacuation.

4) Individual disaster response initiatives

- Multi-help enhancement

Promote neighborhood-level evacuation planning and foster leaders for local disaster management. Enhance local communications among neighboring voluntary groups, social welfare councils and flood fighting teams to ensure evacuation of all residents including the elderly at home and the socially-vulnerable. Promote evacuation planning of nursing homes and keep close ties with the community.

- Personal evacuation planning and risk mapping

Support each community to promote “My Timeline Plans” so individuals can make disaster operation decisions in advance, and “My Evacuation Maps” to reconfirm safe evacuation routes and danger points, keeping adequate relations with the district-level disaster management plan.

- Support tools for evacuation planning

To support individual proactive evacuation planning, develop area-specific and time-series inundation simulations, which indicate inundation areas and arrival times along MLIT-managed rivers and in small and medium-scale river basins, and distribute it through the internet.

- Human resources development for local resilience

Nominate and dispatch experts in water and sediment disaster management to municipalities to support hazard mapping, disaster operation planning, and participatory evacuation drills.

- Disaster education

Promote disaster education using the numerous lessons learned in recent water-related disasters and through locally-specific disaster histories, using the Mega-flood Management Committees. In particular, transfer basic knowledge to students through natural and social science classes at elementary and junior high schools.

- Evacuation drills with public participation

Conduct evacuation drills with public participation using practical evacuation orders and river/dam information. Share various trials in the Mega-flood Management Committees.

5) Structures for flood risk reduction

- Resistant levees to delay breaching

Develop and build durable levees as a crisis management infrastructure in flood-prone areas to gain a little longer time for vulnerable residents' evacuation.

- Sabo works to Protect evacuation routes and shelters

Prevent sediment disasters using sabo structures, like weirs, around the one and only route or shelters, to enable smooth evacuation.

Negotiate to use private buildings as an emergency shelter in high inundation risk areas.

6) Life-saving shelters for stranded victims

- Life-saving shelters as an emergency operation

In areas with no permanent evacuation shelters, reserve life-saving mounds made of disposed soil or private buildings as temporary shelters, under local initiative.

7) Risk management against complex disasters

- Confluence improvement

Strengthen and heighten levees around confluences where backwater phenomenon might breach levees and cause deep inundation.

Reinforce levees of tributaries considering backwater phenomenon.

- Sediment flow management

Build sabo weirs and sediment pools through sound coordinated planning with river improvement to prevent sediment-water synergistic disasters.

- Channel maintenance

Cut trees and dredge riverbeds to secure channel capacity of narrow sections around probable inundation areas of dense housing and critical institutions.

- Cooperative action against complex disasters

Enhance cooperation among various agencies to implement integrated projects to reduce risks of large-scale water-related disasters, which are caused by simultaneous river flood, debris flow, waterlogging, storm surge and others.

8) Countermeasures against unexpected floods

- Dam upgrading for flood control

To enhance flood control capacity, upgrade existing dams through operational improvement, capacity alteration, discharge capacity enlargement and crest heightening. Adjust spillways and remove sediment of retarding basins. Negotiate with dam users to divert reservoir capacity more for flood control purposes.

- Flood control capacity development

Improve downstream channels to enable increased discharge during flood control operations. Prevent sediment inflow to the reservoir and remove sediments hindering full flood control capacity.

Maintain spillways and remove sediment from retarding basins.

- Masonry sabo weirs reinforcement

Reinforce and rehabilitate masonry sabo weirs to secure functions against possible debris flows.

(2) “Preventive measures to minimize socio-economic losses and launch quick recovery and reconstruction”

1) Measures to minimize socio-economic losses

- Resilience of critical infrastructure

Protect lifeline infrastructure of electricity, water-sewer services and transport infrastructure, through sediment control, in cooperation with facility managers.

Promote waterproofing of emergency control centers, core medical centers, water supply and sewage networks in cooperation with facility managers who conduct business continuity planning, evacuation drills and facilitation of storage tanks and barrier walls.

- Protection of the urban center and core functions

In urban and rural flood-prone areas, promote basin-wide flood control integrating river improvement, sewage drainage and existing infrastructure maintenance. In coastal areas, build sea levees and storm surge walls through comprehensive planning.

In areas below sea level, maintain river and sea levees, and strengthen drainage capacity. In dense asset areas of Tokyo or Osaka, develop life-saving levees in collaboration with private developers.

Hasten waterlogging drainage using reserved pumps and pump vehicles from rivers where the water level is not forecasted to rise.

2) Measures to launch quick recovery and reconstruction

- Drainage operation and maintenance

Foster an effective scheme to build and operate drainage facilities against long-lasting waterlogging around river confluences or in areas below sea level.

- Waterproof drainage facilities

Hold the waterproof function of drainage facilities throughout the inundation, and stock materials for quick recovery from interruption.

- Persistent emergency control centers

Hold functions and reliability of the emergency control center through power duplication and other measures.

- Preparation for quick recovery and reconstruction

Share damage simulation scenarios from large-scale water-related disasters with the Mega-flood Management Committees and prepare for quick recovery and permanent reconstruction with all sectors involved.

(3) “Adaptive measures to more frequent and heavier rain over wider areas, exacerbated by climate change”

1) Adaptation to climate change

- Systematic upgrade of safety level

Promote urgently necessary countermeasures against frequent and violent heavy rain due to climate change, and upgrade safety levels systematically in accordance with aggravating climate change impacts.

- Strategic observation and advanced maintenance

Observe river channel capacity periodically, forecast sedimentation and forestation quantitatively using cross-section surveys and 3-D laser imaging. Refine river management and facility operation with more intensive water level monitoring.

2) Preparation for wide-area and long-lasting heavy rain

- TEC-FORCE legalization and activation

Establish the legal basis for TEC-FORCE to prepare for wide-area and long-lasting heavy rain and activate it by involving human resources from the private sector and by installing real-time disaster information management.

- Real-time disaster information collection

Install remote measuring instruments, such as unmanned aerial vehicles and laser imaging sensors, to gather information during simultaneous disasters or successive typhoons. Share the information with local governments.

- Timeline plans of emergency operations involving various agencies

To take integrated actions against wide-area water-related disasters, establish timeline plans of emergency operations to identify time-series countermeasures for each agency involved in the Mega-flood Management Committees. Involve public transportation sectors especially in areas below sea level. Keep mutual communication and information sharing under the timeline plans during disasters.

3) Rethinking the way of living

- On-street disaster risk indicator

Promote on-street hazard signage, such as indication of probable inundation depth, to raise awareness for area-specific risks. Set local risk signboards in sediment disaster risk zones.

- Disaster risk internalization in the societies

Strengthen partnerships between disaster management sections and urban planning sections to reflect disaster risks to consolidated urbanization and house relocation. Cooperate with the real estate industry and the insurance companies to encourage house owners to avoid disaster risks; house renovations can be a good opportunity for this .

In sediment disaster risk zones, encourage owners of existing buildings to implement necessary countermeasures such as safety check, reinforcement and relocation.

(4) Research and Development”

1) Advanced disaster risk assessment

- Changing risk assessment due to climate change

Advance a technical study to reflect on future climate change impacts for infrastructure planning and design, based on past heavy rains and storm surges. For the study, pay close attention on the interactions between flood control, sabo, sewage and coastal management to respond to complex disasters.

In particular, estimate rainfall volume quantitatively and accurately in a trend of frequent and violent heavy rain due to climate change, and analyze rainfall patterns in each region according to meteorological factors.

- Breakout mechanism analysis of various water-related disasters

Develop methods of hazard prediction and risk assessment through analyzing breakout mechanisms of sediment and flood disasters.

Evaluate relative risks in sediment disaster risk zones to save lives.

- Standardized risk assessment method for various disasters

Develop standardized assessment methods of various local disasters in the region for municipalities to promote risk-based town planning, relocation guidance and voluntary disaster preparedness of private companies.

- Socio-economic loss assessment due to heavy rain

Develop quantitative assessment methods of socio-economic losses within and around affected areas to understand total actual damage and prepare for next disasters in coordination with all social sectors.

2) Risk-based disaster prevention and mitigation

- Step-by-step approach to climate change impact

Implement risk management measures one-by-one to respond to confirmed climate change impacts and adapt to uncertainty in the future.

- Flood forecasting accuracy improvement

Improve flood forecasting accuracy by enriching water level observation and applying radar rainfall forecasting to ensure smooth evacuation and adequate dam operation. Enhance flood forecasting even in small and medium-scale rivers using 3L water level gauges and image analysis technology.

For forecasting accuracy improvement, consider required accuracy at the site with a long-term strategy.

- Advanced dam operation using rainfall/inflow forecasting

For further flood control ability, improve accuracy of rainfall/inflow forecasting, and develop forecast-based dam operation methods.

3) Risk information management to support evacuation

- Advanced sediment disaster warning

For accuracy improvement of sediment disaster warnings, develop a higher-resolution soil-rainfall index, and improve website displays and information delivery methods to assist warning and evacuation.

For mayors to issue timely and appropriate evacuation advisories, develop longer-period sediment disaster forecasting and supplementary information such as rainband prediction from radar monitoring data.

- Risk information delivery for evacuation

Develop real-time river information delivery systems to support residents' voluntary risk perception and mayors' timely evacuation advisories, using latest CCTV cameras and artificial intelligence technology.

5. Message to societies

During the July 2018 Heavy Rain, long-lasting rainfall caused substantial human damage and socio-economic losses. Following the September 2015 Kanto-Tohoku Heavy Rain Japan was reminded, “inevitable large-scale flood can exceed river infrastructure capacity” and started a new policy vision of “Rebuilding Flood-conscious Societies” to prepare for the next flood in coordination with all social sectors. However, we should remind ourselves again that structural and non-structural measures have limits. We have to use both in collaboration and exert synergistic effects of disaster prevention and mitigation.

The Sub-panel on Flood Risk Management for Wide-area and Long-lasting Rainfall closely cooperated with other independent panels on each issue, discussed comprehensive solutions from different angles, and in the end generated measures for prompt implementation.

River flooding, waterlogging, debris flow and complex disasters in July 2018 triggered the promotion of conventional treatment and of further cooperative approaches among concerned authorities.

Many people were stranded in water although hazard maps and evacuation advisories were delivered in advance. This fact reveals that governmental services were insufficient. We should promote personal evacuation planning in each district and local communications among neighboring groups to help each other. For this target, we should standardize and deliver disaster information through various channels in cooperation with the media and ICT companies.

Climate change impact undoubtedly contributed to the July 2018 Heavy Rain. Climate change adaptation is not a future problem but an actual challenge today. We should research increasing trends of heavy rain and further study how to assess it quantitatively.

Typhoon, rainy front or local squall have specific mechanisms that lead to water-related disasters. We should understand characteristics of local water-related damage and research climate change impact scientifically to discuss comprehensive solutions for the whole of society.

Basic river data, such as water level and rainfall, are essential to construct infrastructure efficiently and to effectively maintain them. We should advance data collection schemes and develop data management institutions.

All sectors in society should take initiatives. Residents should make decision to evacuate to save own life. These are essential in disaster management. Government should support all sectors and each entity should take self-motivated actions.

It is impossible to build such a society in a couple of days with all sectors involved. We should initiate practical policies and implement them at the local level step-by-step. We should continuously review policies, for policy progress and in response to social changes. We should promote research and development to catch up with the changing climate.

Japan has been improving proactively resilient and reliable land management to cope with frequent heavy rain disasters, however recently, vulnerability to water-related disasters are increasing with regards to hazards magnified by climate change, social transformation of aging population, and other factors. Japan is expected to mobilize all social resources and cutting-edge science and technology to develop a policy system for disaster prevention and mitigation of the world.

Sub-panel on Flood Risk Management for Wide-area and Long-lasting Rainfall
under River Council for Social Infrastructure Development

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