Final Report

Recommendations on disaster risk reduction policies and activities in Vietnam


Mar 21, 2025

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Jull 4, 2022 – Mar 24, 2025 | ikuzuscape@gmail.com

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Recommendations on disaster risk reduction policies and activities in Vietnam

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I. Measures against Flood

1. River improvement in accordance with scientific plan

- Last year, Typhoon No.3 Yagi caused record-breaking water levels in the upper reaches of the Hong River (Lao Cai and Yen Bai etc.), resulting in flood damage. Apart from this typhoon, floods occur frequently in various places in Vietnam every year, and measures should be taken to reduce the flood risk by dredging channels, building dykes, dams and retarding basins, etc. In doing so, the flow capacity of rivers in the entire basin should be investigated, and measures should be considered scientifically based on that. I recently gave lectures to IWRP on such scientific planning methods, and wrote and provided the draft guideline on surveying and planning rivers, so I would like you to provide guidance to IWRP for their use. →Reference (1), (2)
- For example, in the upper reaches of the Hong River, river improvement work such as dyke development would be considered, but if we simply carry out upgrading dyke in the upper reaches, the water that flooded the upper reaches this time will flow downstream, so the risk of flood around Hanoi will increase. In addition, there is a section in the Ba River near the border between Gia Lai and Phu Yen provinces where the river is locally narrow, and this makes it difficult for floodwaters to flow through, but if the river is widened in this narrow section to make it easier for floodwaters to flow through, a lot of floodwaters will flow downstream, increasing the flood risk in Tuy Hoa City. This is not only true of the relationship between upstream and downstream areas, but also of the relationship between tributaries and the main river, and as Director General Mr. Luan pointed out the principle at the workshop on collaborative disaster prevention dialogue with the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) of Japan in November 2024. Therefore, we need a plan based on the flow capacity of the rivers in the entire basin, and measures in line with that plan. Annual budget request and allocation should also be based on such scientific plans.
- At the upstream of the Hong River, there were also cases where the dyke collapsed due to overflowing water washing out the backside of the dyke (confirmed during a visit to Viet Thanh Commune, Tran Yen District, Yen Bai Province) by the Typhoon Yagi. In Japan, technology to reinforce dyke has been introduced so that they do not collapse even if floodwaters overflow, and there is also room to consider such technology.
- Following the flood in last July, there was flood damage due to overflowing water in the Tich and Bui rivers in western Hanoi in Typhoon Yagi of last September as well. Once flooded, the water does not recede for about half a month, as the topography makes it difficult to drain the water, which is hindering the development of western Hanoi. It would be desirable to improve the flow capacity and drainage capacity by widening and straightening the river downstream. The result of risk mapping survey in Day River by the MLIT may also be reference for this matter. →Reference (3)

2. Dissemination of information and improvement etc. on flood control operation by dams

- In Vietnam there are many dam reservoirs, including those for hydropower generation and agricultural purposes, which are also used for flood control. Although the operation of such dams can cause damage if it is not carried out properly, there are also many cases where the operation of the dams has been successful in reducing damage.
- As an example, in the Typhoon Yagi, the four major dams in the Hong River basin (Son La, Hoa Binh, Thac Ba, and Tuyen Quang) lowered their water levels in preparation for flood a few days before the flood arrived, based on the Prime Minister's Decision on the Operation Procedures between Reservoirs (No. 740/2019/QD-TTg) and the instructions of the National Committee for Disaster Management. The lowering of water levels over the past few days has allowed an additional capacity of over 600 million m3 to be secured. These dams were also able to significantly reduce the flow of water during the flood peak. It is thought that the flood control measures taken by these dams have helped to reduce flood damage downstream. →Reference (4)
- As I have previously shared the discussion and recommendation, in the flood of the Huong River in November 2023, the three major dams in the basin (Binh Dien, Ta Trach, Huong Dien) lowered their water levels in preparation for flood about four days before the flood arrived, based on the Prime Minister's Decision on the Operation Procedures between Reservoirs (No. 1606/2019/QD-TTg) and the instructions of the Thua Thien Hue Provincial Disaster Management Committee. As a result, additional capacity of 87 million m3 was secured, and without this, there would have been a possibility that the inundation would have been nearly 30% larger than it actually was. In addition, if the water level lowering were not conducted thanks to the JICA grant aid project, which took place from 4 days to 2 days before the flood arrived, there would have been a possibility that the inundation would have been nearly 10% larger than it actually was. →Reference (5)
- it is important to gain the understanding of the public by clearly communicating information about actual situation on flood control by these dams and the result on the reduction of damage through it.
- On the other hand, we should have the PDCA cycle, by considering whether we could have done better by looking back at the actual situation of flood control, and then applying the lessons learned to future. For example, as has already been pointed out by MARD, it is also important to review the Prime Minister's Decision in light of the flood in the Typhoon Yagi. For example, the current decision states that the first half of September, when the recent floods occurred, is the “Late Flood Period (August 22 - September 15)”, and the water level restrictions are looser than during the “Main Flood Season (July 20 - August 21). Due to the climate change, there is a possibility that typhoons like this one will strike in the future, so it is considerable that the main flood season will be extended to mid-September. There is also room for more precise operation by utilizing rainfall forecasts for up to about three days in advance, as was done in the JICA grant project for the Huong River. VNMHA is already carrying out observations and predictions of rainfall using 10 radars to cover the whole country, and the accuracy of these observations has been

improved thanks to JICA technical cooperation project, which was carried out until 2023. We should continue to work with VNMHA to make use of this observation data in real time for activities such as dam operation and disaster risk reduction, and to be able to predict the amount of water flowing into dams.

- Besides, we are preparing a request for new technical cooperation from JICA and the Japanese government with the aim of establishing the technology on the Huong River and expanding it to the Ba River, and we should continue to promote this request.
- In addition to operational improvements, it is also possible to consider modifying the dams themselves to increase the amount of water they can hold. This is because in all four of the above dams, only approximately the upper third of the dam body height is being utilized for operation, and the rest is dead water capacity (i.e. a section where water or sediment are constantly accumulating). Especially Son La Dam is made by concrete, and if additional discharge gates are installed in low-lying areas, the currently dead water capacity can be used for flood control and power generation. Since construction work to add discharge gates to concrete dams under operation is also being carried out in Japan, there is also room to consider seeking cooperation from the Japanese government and companies. →Reference (6)

3. Risk assessment and land use control etc. using it

- In the Typhoon Yagi, flood of the Hong River also caused inundation in residential areas outside the dyke in Hanoi, too. It seems that the residents' awareness of flood risk has declined due to the fact that there have been no floods in the past 20 years, and there were some residents who did not evacuate despite the calls to do so. It is important to promote evacuation and to control the development of settlements and development outside of the dyke, as MARD has been working hard to do so up until now, and we should also refer to the risk map by MLIT (developed for Hong and Day Rivers last year; planned to be developed from this year to next year), and consider which areas of development should be halted with high priority. →Reference (3) (report)
- As I have shared on our website before, in Japan, as urbanization progresses in the basin of the Tsurumi River, which is close to Tokyo and Yokohama, there is a concern that flood risk will increase if such urban development continues. In order to address this, they have made it a requirement for development projects to include facilities for storing rainwater, and they have prohibited the use of areas with a high risk of flood for housing, etc., in order to conserve green spaces and farmland. The central government, in particular the VDDMA, and local governments should work together to promote such risk-based land use regulations. →Reference (7)

4. Provision of information on river information in an easy-to-understand way

- While some information on river water levels is available on websites, it would be helpful if information on water levels of upstream sections could also be made available, as this would be useful for communities and residents preparing for evacuation, etc. It would therefore be desirable if information on water levels in rivers nationwide could be viewed on a single website. It would also be helpful if the website also provided camera images of the rivers and the river water level forecasts published by the VNMHA. →Reference (8)

- It would be good if the river hazard maps created in various projects to date were also published on the website and could be easily viewed by residents and related organizations.
- It is also important to record the depth of inundation as risk information to future generations. It would be useful to install nameplates on existing poles (e.g. power poles) and house exteriors while the traces of flood are still visible or while residents' memories are still fresh. In Japan, such activities are being carried out commonly, and in Hue and Hoi An, too, there are many signs around the city that show past flood records, which is a good initiative. I hope that consideration will progress in such initiative in the future in various places that were affected in the Typhoon Yagi. →Reference (9)

5. Measures against riverbank erosion

- Riverbank erosion frequently occurs in rivers in Vietnam. For example, in the Quang Hue River, which is part of the Vu Gia-Thu Bon River system, the riverbank was heavily eroded after a flood in October 2022, and this has become a problem.
- There are two main types of work to prevent riverbank erosion: (1) directly protecting the riverbank with "bank protection", and (2) using "river groyne" to avoid strong flow (thalweg) away from the riverbank. In particular, regarding (1), as I have previously explained on our website using an excerpt from a drawing in a MLIT's standard, it is important to ensure to install "foot protection". →Reference (10)
- As for measures against riverbank erosion, technical guidance was provided in the JICA technical cooperation project, the Project for Building a Disaster Resistant Societies in Central Region in Vietnam" from 2009 to 2012, and measures were implemented on the Huong and Thu Bon Rivers in central Vietnam. The riverbanks in both of sites are still stable today after more than 10 years, and the effectiveness of the measures can be confirmed. In addition, in Quang Nam Province, many additional groynes have been constructed in the same way on the Thu Bon River as those constructed at that time, and I think this is a wonderful thing.

II. Measures against flash floods and landslides

1. Construction of sabo dams for flash floods, and early warning systems and countermeasure works for landslides

- In order to prevent flash floods, we are currently working with JICA on a project to construct an sabo (erosion control) dam in Nam Pam Commune, Muong La District, Son La Province. We are also requesting the Japanese government and JICA to support constructing multiple sabo dams in the same river basin. We should hurry up the procedures (document preparation, etc.) within the Vietnamese government for the official request.

- In addition, after investigating the damage and the mechanisms that caused the disaster, if it is thought necessary to proceed with the construction of more sabo dams in other areas, or to promote the early warning system or works for landslides, it would be good to proceed with these measures.

2. Detailed risk assessment and mapping of flash floods and landslides

- With regard to the risk assessment (mapping) of flash floods and landslides, MONRE is to take the lead and MARD is to cooperate in the project stipulated in the Prime Minister's Decision No. 1262 of 2023, but the maps at a scale of 1/50,000 (a rough scale that can be created from aerial photographs) stipulated in the Prime Minister's Decision are not useful for evacuation actions or land use planning in actual fields. On the other hand, maps with a scale of 1/10,000 or more (detailed scale based on topographic maps, etc.) which will be created in high-risk areas would be used for evacuation and land use planning.
- I understand that there was a proposal to develop detailed risk maps at the village level after Typhoon Yagi, but in Japan, such detailed maps based on topographical maps etc. have been published nationwide in Japan, and the technical cooperation project with JICA are experimenting with the creation of such maps, and especially in Yen Bai City, Yen Bai Province, which was affected by Typhoon Yagi, such maps are also going to be created additionally. Therefore, I hope MARD to contribute to and develop these methods. →Reference (11)

3. Advance road closures based on rainfall etc.

- Although many flash floods and landslides occurred along the roads in the Typhoon Yagi, the Minister of MARD had recommended stopping traffic in advance, and if road closures had been carried out actually in advance, it is thought that the damage to vehicles and people could be reduced. In addition, in response to Typhoon No. 4 Soulik, the roads in Son Tra District, Da Nang City, were actually closed in advance, which was a wonderful response.
- Even in cases other than typhoons, which are easy to predict, it is desirable to prevent damage by closing roads before disasters occur based on observed continuous rainfall and hourly rainfall. →Reference (12)

III. Measures against natural disasters in general

1. Securing pre-disaster Investment for disaster risk reduction

- Based on the points I have discussed so far, I believe it is important to promote disaster risk reduction by securing pre-disaster investment in the government budget. I also believe that it is important for the VDDMA to scientifically analyze the effectiveness of such measures and explain it, and to secure the necessary budget within the government budget.
- For reference, in Japan, approximately 1% of the annual expenditure (initial budget) is allocated to flood and sediment disaster risk reduction measures, amounting to 800 to 900 billion yen,

approximately 6 billion US dollars, each year (in addition to this, supplementary budgets are allocated frequently), and most of this is used for pre-disaster works. It can be said that the cornerstone of Japan's economic development is the gradual reduction of disaster risk through the continuation of such investment.

2. Promoting evacuation etc. and making residents feel disaster risk reduction as personal matters

- As mentioned above, there would be a concern that residents' awareness for disaster prevention is declining in areas where disaster risk has decreased, but we should promote reliable evacuation and disaster prevention actions by raising the awareness. To do this, it is of course useful to provide information about risk as mentioned above, but it is also necessary to have initiatives that not only provides information but also encourages residents to think by themselves about the actions they should take based on that information, and it is thought that this is the only way to actually link to evacuation and other actions.
- In Japan, too, initiatives are being taken to give people the opportunity to think for themselves, such as through workshops where people make maps summarizing disaster prevention tips while considering the disaster risks in their own area, or playing card games about disaster prevention actions. In particular, the initiative called “My Timeline”, where each person makes a chronological action plan in advance about what actions to take in the event of a disaster, is being widely implemented in various parts of Japan, partly due to an appeal from MLIT. →Reference (13)
- It is also useful to prepare handbooks on disaster prevention that are created with eye-catching visuals that will encourage people to pick them up, and to raise awareness in schools and other places using teaching materials that encourage people to think by themselves. I think that it may be helpful to refer to the Japanese disaster prevention handbooks, “DISASTER PREPAREDNESS TOKYO (Tokyo Bousai)” and “Aomori Omamori Note”, which I have translated into Vietnamese and shared. →Reference (14)
- In addition, MLIT has been running a campaign to raise disaster prevention awareness, and in recent years it has been considering and compiling measures to “make residents feel that disaster risk reduction as personal matters”. →Reference (15)

3. Improvement in statistics on disasters

- When trying to assess disaster risk, to take measures to reduce risk through pre-disaster activities based on that assessment, or to raise residents' awareness of disaster prevention and to encourage them to take action, it is not possible to make appropriate assessments or take appropriate measures without having data on actual disasters. When referring to the data on the occurrence of disasters in Vietnam, it can be sometimes found that the damage caused by a certain typhoon is simply summarized as “storm”, and in many cases it is not clear whether the actual damage was caused by flood, landslides or flash floods. Rather than simply labeling it as "storm", it is necessary to identify the actual damage caused by what kind of event, and I think that the issue for the future is to improve the ability of local officials to make such identifications.

IV. Disaster recovery and Build-Back-Better

1. Improving post-disaster needs assessments and procurement of relief supplies

- Just after the damage of the Typhoon Yagi, emergency needs assessment surveys were carried out by the Joint Assessment Team (JAT) organized by the VDDMA and DRRP immediately after the disaster. I also participated in the assessment of some areas in Lao Cai and Yen Bai Provinces from September 12th to 14th.
- The officials whom we met seemed to be very busy at that time, and with suspended transportation between regions, it seemed that they had not yet been able to consolidate the support needs of each region. There were also comments about the difficulties they were having in coordinating relief supplies. From this, it seemed to me that it would be quicker and more efficient to gather some information on needs from officials without visiting and use that as a reference to estimate needs first, and then visiting after several days. Also, while local government are busy collecting disaster information, searching for survivors, and carrying out recovery work, I felt that it would be desirable to make the process of receiving and distributing supplies more efficient by having outside personnel stationed there for a while.
- In addition, at that time, I myself made an effort to understand the actual situation of the disaster in various places and share it with the members. Since understanding the actual situation of the disaster is strongly related to selecting survey points and understanding the extent of damage, in the case of conducting similar surveys in future disasters, not only experts in the field of each need but also an expert in disaster itself (civil engineer) who can understand the actual situation of the disaster should definitely participate.

2. Assessment of the damage situation using satellite information and outside personnel

- It is important to assess the damage situation in order to carry out search and rescue and recovery work smoothly.
- In this case, as I provided information on September 18, satellite observation information from Sentinel Asia and other sources can be used as a reference. By using optical satellites to monitor changes in the ground surface, it is possible to identify the locations of flash floods and landslides, and by using SAR satellites to monitor the surface of the water, it is possible to identify the locations of inundation. These observations need to be carried out at the right time (especially to identify inundation areas), and although the accuracy is often insufficient, it is desirable to investigate the disaster situation by utilizing this satellite observation information as well as other information, since in the immediate aftermath of a disaster, road access to the disaster area is often not available and it is not always possible to get a full picture of the damage.

- Also, as local governments (provinces, districts) that have been affected do not have sufficient personnel, it is considerable to support the assessment of damage situation using outside personnel. In Japan, after huge disasters, MLIT gathers highly skilled staff (engineers) from outside the affected areas and dispatches them to support surveys. Such MLIT's survey teams are called "TEC-FORCE". Thanks to the publicity of their activities, they have been increasing their name recognition through their many achievements since their establishment in 2008, and recently, there are many students who apply to work for MLIT as they will to work as a TEC-FORCE member in the future. →Reference (16)

3. Emergency restoration, urgent project

- When carrying out emergency restoration work on damaged facilities, it is important to set not only a long-term goal but also a short-term goal for restoring and reconstructing the facilities within a few years, and to work intensively towards achieving that goal. Setting such goal will also provide a useful basis for explaining the need to secure a budget for construction work.
- In Japan, in order to prevent the same areas from being affected again, intensive countermeasures (such as dyke repairs and dredgings) are often carried out over a period of 3-5 years as 'urgent projects'. In order to do this, MLIT often sets up temporary offices in the affected areas.

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Reference materials

(1) Draft guidelines for river survey and planning methods

(2) Explanation materials for the lecture on river survey and planning methods (Lectures for IWRP, July and August 2024)

(3) Presentation materials on the results of the MLIT's risk map survey of the Hong River system (12th Disaster Prevention Collaborative Dialogue by MLIT and MARD, November 2024)

(4) Considerations regarding the operation of dams in the Hong River system during Typhoon Yagi

(5) Discussion and recommendations on dam operations in the November 2023 Flood of the Huong River and the effectiveness of JICA grant aid project (VDDMA website, June 2024)

(6) Case studies of dam upgrading projects in Japan, particularly the additional construction of discharge gates

(7) Key points of successful flood control measures for the Tsurumi River and recommendations based on them (VDDMA website, March 2023)

(8) On Japanese website showing nationwide water level observation information, camera images, etc.

(9) Examples from Japan and Vietnam showing past flood records in towns

(10) On Countermeasures for riverbank erosion (VDDMA website, March 2023)

(11) Japan's initiatives for detailed risk assessment and mapping of flash floods and landslides

(12) Japan's initiatives for advance road closures (VDDMA website, August 2023)

(13) Examples of initiatives to encourage people to think for themselves about local disaster risks through workshops, etc. (Presentation materials from the APEC EPWG workshop, December 2024)

(14) On the Japanese handbooks for disaster prevention “Tokyo Bousai” and “Aomori Omamori Note”

(15) On the measures to make residents feel that disaster risk reduction as personal matters (MLIT, August 2023)

(16) On the MLIT's disaster situation survey team “TEC-FORCE” (posters by MLIT)

As of 21/1/2025

Guideline for surveying a river and planning flood control (draft)

XX/20XX

XXXX, Ministry of Agriculture and Rural Development, Vietnam

Guideline for surveying a river and planning flood control (draft)

1. Surveying a river

1.1. Significance of survey of river channel characteristics

Individuality (Characteristics) of Rivers

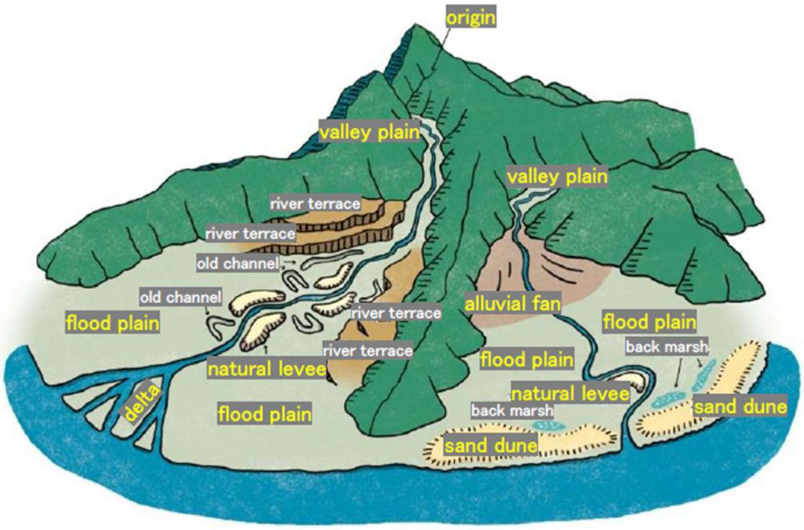
Each river has its own individuality, which is formed by a combination of factors such as topography and geology based on past tectonic movements, volcanic activity, uplift and subsidence, etc., as well as the effects of flow, sediment production and human impact. Even the same river has different channel characteristics longitudinally, in different sections.

Because of this individuality, measures that succeeded in one river may not necessarily be successful in another, and measures that succeeded in one section may not necessarily be successful in another. Conversely, it can be said that it is easier to succeed when applying measures that have succeeded in rivers or sections with similar channel characteristics, so it is extremely important to first understand the channel characteristics of the river and the channel characteristics of the section when considering measures.

Furthermore, it is not uncommon for the river to respond to the measures taken, changing the channel characteristics and resulting in a worse outcome. For this reason, it is important to predict how the river will respond to the measures, and it is desirable to make adjustments and modify the measures while monitoring the response (this approach is known as adaptive management). It is also desirable to design the measures with the river's response in mind.

[Supplementary note] Topography formed by rivers

There is a lot of topography around rivers that has been created by rivers in the past. Rivers that emerge from mountainous areas flow through “valley plain” before emerging onto the plains, and depending on conditions such as the amount of sediment carried by the river, “alluvial fan” is formed, or “river terrace” is formed as the river carves out the landform. In “flood plain”, the river changes the location of its channel as it floods, leaving behind “old channel”, and “natural levee” is formed by sediment deposits during flooding. Near the mouth of the river, the river channel splits into several branches and spreads out to form “delta”, and “sand dune” form along the coastline, with a “back marsh” forming behind them. Figure 1 shows examples of such topography created by rivers, and it is possible to read the characteristics of the river and the section to some extent from these topographic features.

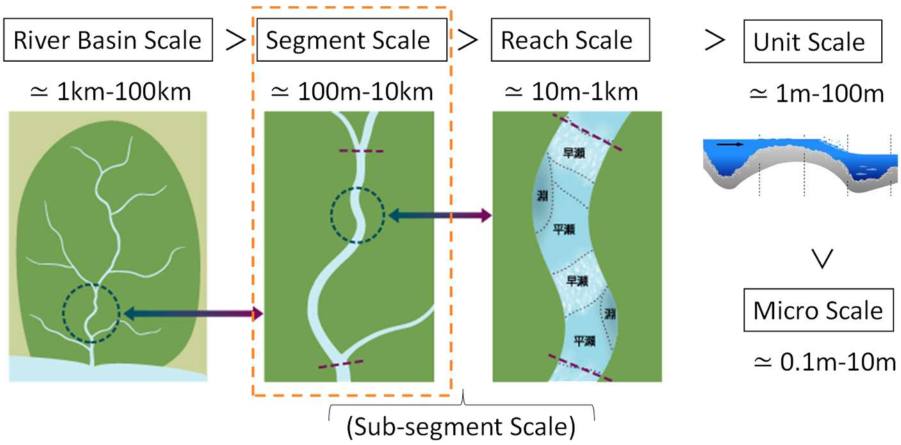


[Figure 1] Topography formed by a river [(a)]

[Supplementary note] Scales, hierarchical structure of river channels

In order to grasp the individuality of rivers and river sections, it is good to look at rivers at various scales. The largest one is the “river basin scale (1km to 100km)”, and it gradually becomes more detailed with the “segment scale (100m to 10km)”, “reach scale (10m to 1km)”, “unit scale (1m to 100m)”, and “micro scale (0.1m to 10m)”. As shown in Figure 2, river channel characteristics are made up of a hierarchical structure of various scales, and the characteristics of larger scales affect those of smaller scales.

While mentioned earlier that it is easier to apply successful measures to rivers or sections with similar channel characteristics, what is extremely important in surveys for planning flood countermeasures is to grasp the characteristics at the “segment scale”, which is a large-scale scale. It is also sometimes desirable to look at the sub-segment scale, which is a segment scale divided into a few.



[Figure 2] Scales, hierarchical structure of rivers [(b)]

1.2. Preliminary preparations and surveys to grasp the characteristics of rivers and sections

Topography and shape of the river (especially the longitudinal and cross-sectional shape of the riverbed) and drawings of the dyke and facilities

In order to understand the characteristics of a river, the first information that should be checked is the topography and shape of the river, in particular the longitudinal and cross-sectional shape of the riverbed. For this reason, survey results are important, and it is desirable to accumulate the results of cross-sectional surveys carried out at intervals of approximately 200m in the longitudinal direction on a regular basis (at least every 5 years). The interval and frequency of the surveys, etc., should be adjusted based on the scale of the river (e.g. river width).

In addition, in order to plan for flood prevention, it is desirable to obtain as much information as possible including drawings of dykes and other river facilities.

Checking longitudinal changes in slope, river width, etc. based on river topography data (upstream/downstream balance)

Once obtaining river topography data, it is good to check longitudinal changes in slope, river width, etc. In places where the river width changes suddenly, the characteristics of the river channel often change too.

Also, although the width of a river generally increases downstream, there are also places where the river becomes narrower downstream, or where there are constrictions (narrow points), and in such places there is a risk of overflow because the floodwaters have difficulty flowing downstream. For this reason, it is important to pay attention to the balance between upstream and downstream like this.

Past disaster history (records of water levels and flood, riverbank erosion, sandbars, etc.)

It is important to collect historical water level data, especially data on past floods, and if available, simulation results. It is also important to understand the history of riverbank erosion, sandbar fluctuations and other changes in river channel conditions. This will help you to identify weaknesses in relation to flooding, riverbank erosion, etc., and will provide important information for flood countermeasure planning. In addition, it is essential to maintain such data, including the topographical data mentioned above, in order to explain the planned countermeasures both internally and externally.

Segment

As mentioned previously, it is important to understand the characteristics of the river channel at the segment scale. When dividing a river into segments, it is best to divide it into sections with similar bed slopes, focusing on points of change in the topography, such as the confluence of tributaries and the divergence of distributaries, as well as changing of longitudinal slope. If the survey data mentioned previously is available, it is possible draw a more accurate longitudinal slope (however, even if you don't have the survey data, you can draw the shape of the topography to a certain extent using Google Earth).

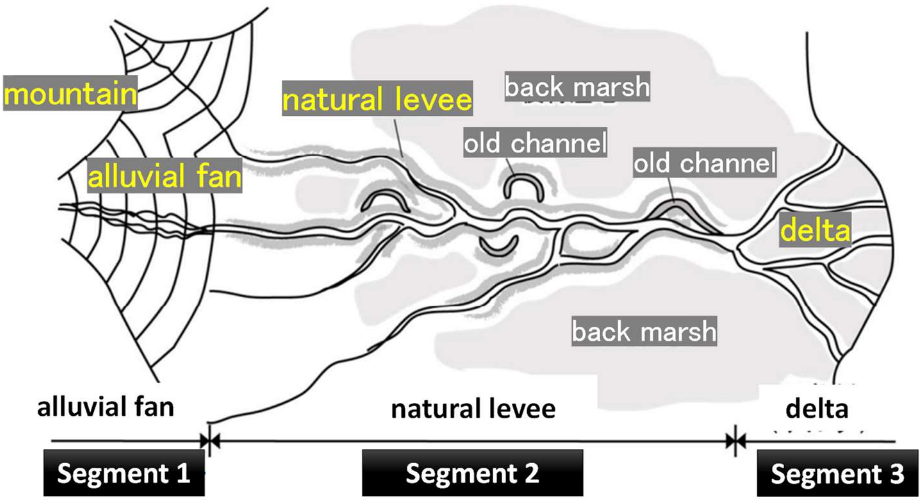
If dividing the river into sections with similar bed slopes, the river channel characteristics within each section will be more or less the same.

For this reason, when surveying a river and planning flood control, it is common in Japan to divide the river into segments 1, 2, and 3 according to the bed slope, as shown in Table 1 (the characteristics of mountain rivers vary greatly, so it is difficult to express them as a single segment, but for convenience they are sometimes referred to as segment M). When understanding these segments, it is easy to imagine the characteristics of those sections to a certain extent. For example, it is known that the size of the sediment on the riverbanks and riverbeds is roughly the same in each segment. As mentioned before, it is easier to succeed if applying measures that have succeeded in rivers or sections with similar channel characteristics, so it is important to check their segment when applying measures from other rivers.

Segments are also roughly consistent with the characteristics of the topography around the river. Specifically, as shown in Figure 3, it is general that segment 1 appears at alluvial fan, segment 2 appears at flood plain with natural levees, and segment 3 appears at delta.

[Table 1] Classification of Segment

Classification	Segment M	Segment 1	Segment 2		Segment 3
			2-1	2-2	
Geography	Mountain	Alluvial Fan	Valley plain	Natural Levee	Delta
Gradient (slope)	Various (Generally steep)	1:60 - 1:400	1:400 - 1:5,000		1:5,000 - flat
Riverbank Material	Various, including rocks	Thin layer of sand/silt (same as riverbed)	Lower layer is mixture of sand/silt/clay (same as riverbed)		Silt and clay
Extent of Meandering	Various	Few meandering	Heavy meandering		Various (Large or small)
Bank Scouring	Heavy	Heavy Scouring	Medium (Big, if riverbed material is large)		Weak
Average depth	Various	0.5m - 3m	2m - 8m		3m - 8m



[Figure 3] Segments and the topography around the river (c)

[Supplementary note] Points to note when checking riverbed materials

Although the size of riverbed materials is roughly the same for each segment, it is important to note that riverbed materials are also affected by characteristics on a smaller scale than segments.

For example, if there is a sandbar in the river channel, fine sand may accumulate locally depending on the position within the sandbar. If the river channel meanders, large riverbed materials tend to accumulate on the outer riverbank, and small riverbed materials tend to accumulate on the inner riverbank. In addition, the local effects of structures cannot be ignored, and for example, the phenomenon named armoring (or armor coating) is well known, where, after a dam has been built, only large gravels remain downstream because sediment from upstream no longer flows downstream.

Field survey with projections based on the segments

Since it is possible to predict the characteristics such as the riverbed materials to a certain extent based on the segment classification, it is advisable to visit the site and check the situation based on such predictions.

When visiting the site, it is also advisable to be aware of the river from a broad perspective, and in particular, to imagine how the water flows during a flood.

1.3. Preliminary preparations and surveys to grasp the characteristics of the surrounding areas of the river

Shape and topography of the river basin, and land use (population, assets)

The shape and topography of the river basin, land use (e.g. housing, offices, factories, rice fields, etc.), including population and asset conditions, should be understood. When planning flood countermeasures, it is important to understand how flood will spread, and how damage will occur (and, by extension, where the weak points will be). As discussed later, this information is also necessary for examining the cost-effectiveness of countermeasures, so it is good to have detailed data that allows for detailed examination. As mentioned before, topographical information can be obtained to some extent from Google Earth, and information on land use can sometimes be obtained from satellite observations.

And as mentioned before, topographical information on river basins in particular can be used as a reference for segment classification, and it is also useful for visualizing how rainwater flows into rivers.

River facilities such as dams

In order to plan flood countermeasures, it is necessary to understand the current state of rivers, and as discussed later from the perspective of flow capacity, it is also important to organize information on the status of river facilities such as dams, as well as the topography of rivers.

Past disaster history (flooding, inundation, riverbank erosion, etc.)

In order to understand the trends in the occurrence of flood and inundation damage, it is necessary to understand the circumstances of past disasters, and flood risk maps are also useful information, if created, for understanding trends.

It is desirable to keep track of as much information as possible, not only about flood, but also about changes in river channels, such as riverbank erosion and sandbar formation, and the history of past plans and countermeasure implementation.

2. Planning flood control

2.1. Deciding the target

Based on surveys of rivers and surrounding areas, imagining the damage and considering possible countermeasures

When drawing up a flood prevention plan, it is important to imagine the damage that could be caused and to consider the countermeasures that could mitigate such damage, based on the characteristics of the river and surrounding areas that we have looked at so far, the history of past disasters, and also with reference to the experiences of other rivers. Specifically, imagine where the river is likely to overflow, where riverbank erosion is likely to progress, and based on this, where particular attention should be paid to in terms of flood prevention.

Deciding the scale of flood (discharge) to be targeted for countermeasures

In flood countermeasure plans, the scale of flood to be targeted for countermeasures is basically based on the largest flood that has occurred in the past, and the goal is often to safely flow its discharge without overflowing. If a river overflowed during a past flood, and countermeasures is planned to take to prevent it from overflowing again, the discharge will be greater downstream than the actual flood because the flood will flow downstream, so it is necessary to make a plan taking this into account. To do this, it is necessary to estimate the discharge that overflowed from the river, or to estimate the discharge in case without overflowing based on the rainfall amount using a simulation.

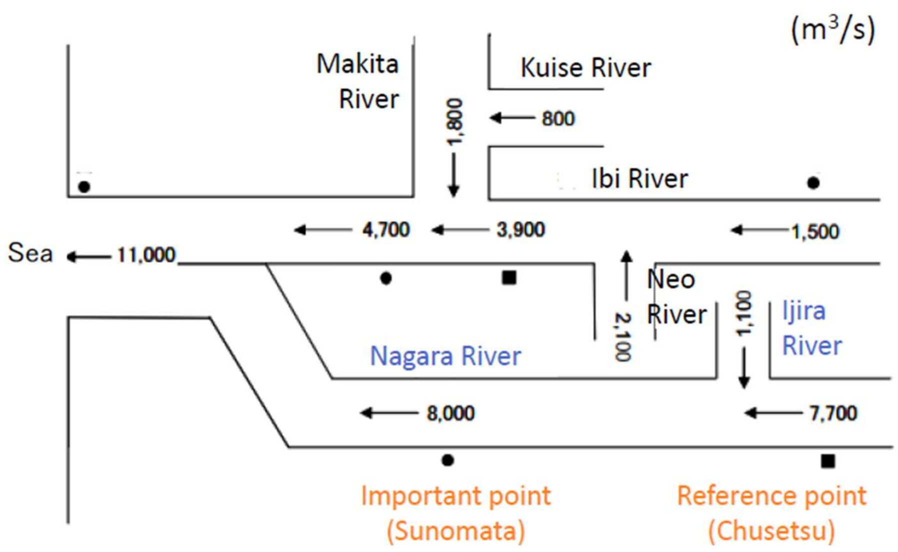
Once the target flood scale (discharge) has been decided, if it is thought that it will take too much time or budget to take measures, it may be possible to set a smaller discharge as an interim target as a step-by-step measure.

Conversely, if it is thought that there is a high possibility of a flood larger than the largest flood that has occurred in the past occurring based on the situations of other nearby rivers, etc., it may be possible to set an even larger discharge as the target. In this case, it may be possible to set a target based on statistics, for example, “once in 100 years”.

When deciding on a target, it is common to use a “reference point” that is an important location for the river (for example, a location close to the city center) and where hydrological observation data can be obtained, and to use the discharge at that point as a guide. However, it is necessary to consider the entire basin, including the upstream and downstream areas and tributaries, rather than just this one point.

Discharge Diagram

Based on the target that has been decided, a “discharge diagram” should be created to show the amount of flow at each point on the river. As shown in the example in Figure 4, the diagram shows the target flow for each point, including the upstream and downstream areas and tributaries, including the “reference point” mentioned above.

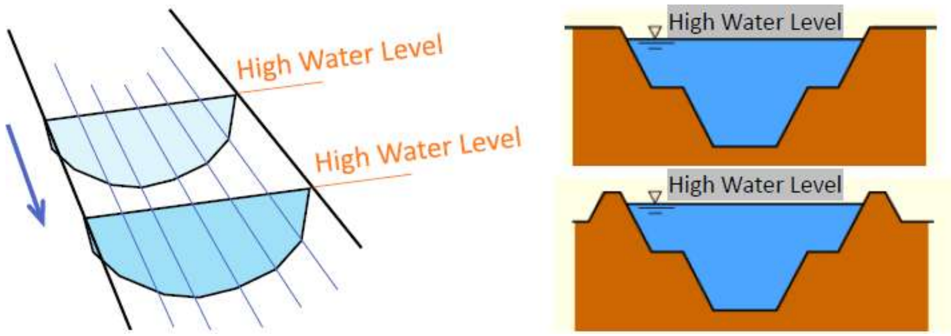


[Figure 4] Example of Discharge Diagram

Deciding what water levels are acceptable (Hight Water Level, HWL)

The water level which the planned flood would safely flow below is called High Water Level (HWL). HWLs are set continuously along the river.

Generally, if the HWL is set higher, it will be possible to flow more floodwater, but this will mean planning for higher dykes, which will make it harder to drain water from the tributaries, and the water level will be more likely to rise even with small- to medium-scale floods, and there is also a risk of the dyke break during a major flood, causing significant damage. For this reason, the basic approach is to set the HWL as low as possible, and specifically, as shown in Figure 5, care should be taken to set the HWL at the height of the ground or within the maximum water level of past floods. When actually designing dykes of rivers, it is standard to add freeboard of 0.6m to 2m depending on the scale of the river (scale of flood flow) to the top height, taking into account the waves and swell during flood.



[Figure 5] Setting High Water Level (HWL)

2.2. Planning measures to prevent flood overflowing

Understanding and calculating the current flow capacity

In order to understand the extent of the gap between the target and the current river channel, the flow discharge that can flow below HWL in the current river is calculated for each point. This flow discharge that can flow in the river channel is called the "flow capacity". As mentioned previously, focusing on the river width alone can give some idea on ease of flow and the balance between upstream and downstream, but it is more accurate to evaluate the situation using this flow capacity, which focuses on the amount of floodwater (m^3) flowing per second (i.e., m^3/s).

In a river like the one shown in Figure 6, if the flow is uniform (the flow does not change from place to place), the discharge can be easily calculated using Manning's formula as follows:

$$v = \frac{1}{n} R^{\frac{2}{3}} I^{\frac{1}{2}}$$

Here, hydraulic mean depth, R = A/S (≈ A/w) [m] (where S is the wetted perimeter, the length of the side of the cross-section that is in contact with the ground. In the case of rivers where the river width is sufficiently large compared to the water depth, this can be approximated to the river width, w.)

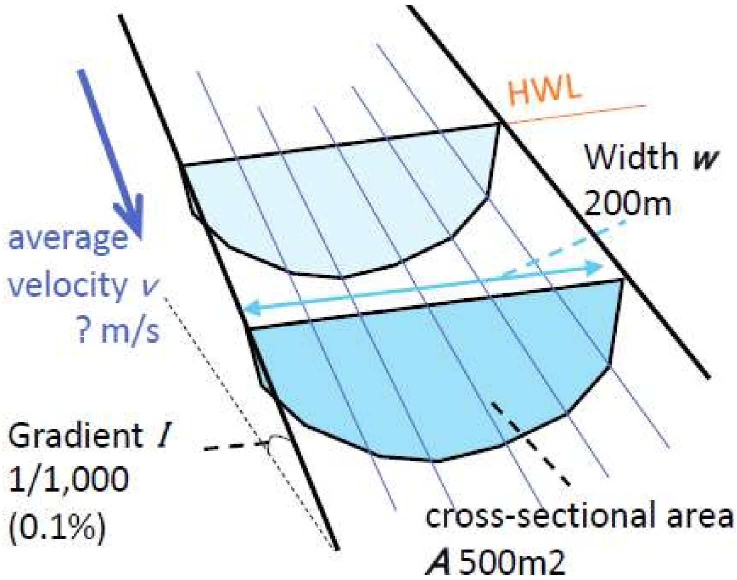
Manning's roughness coefficient, n, differs depending on the riverbed material, etc., but for example 0.025 [$m^{-1/3} \cdot s$].

In this case, the average flow velocity is v = 2.33 [m/s], and multiplying this by the cross-sectional area gives the discharge of Q = 1,165 [m^3/s].

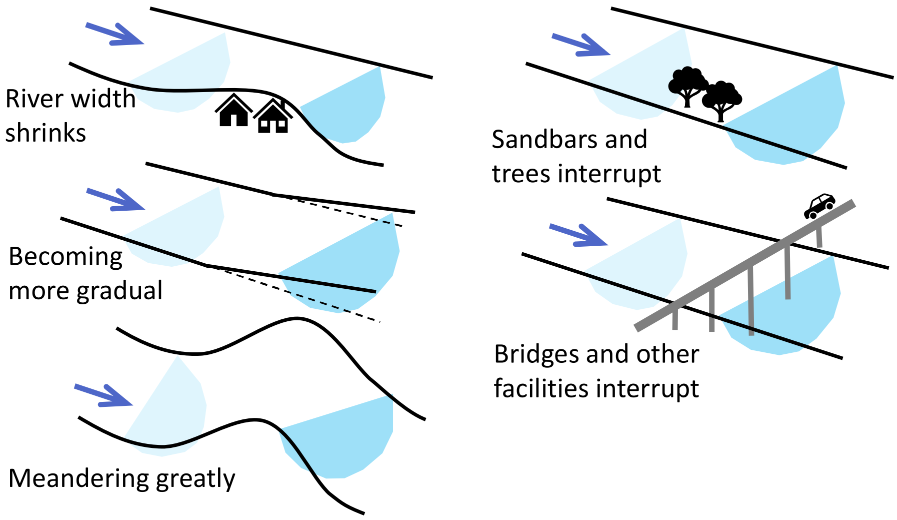
Calculations based on the assumption of uniform flow are often used in calculations for agricultural irrigation channels, etc., but they are not used in calculations for actual river flood. This is because the flow of a flood is not uniform flow, but non-uniform flow (flow that changes depending on the place). Therefore, it is common to calculate the discharge capacity using non-uniform flow calculations that focus on energy conservation.

When calculating the discharge capacity, it is necessary to take into account the factors that make floods difficult to flow through, such as the river width shrinking, becoming more gradual, meandering greatly, and the presence of sandbars, trees, bridge piers and other facilities that obstruct the flow, as shown in Figure 7.

The calculation of flow capacity using non-uniform flow calculations is explained in the Appendix.



[Figure 6] Example of river channel for calculation of discharge

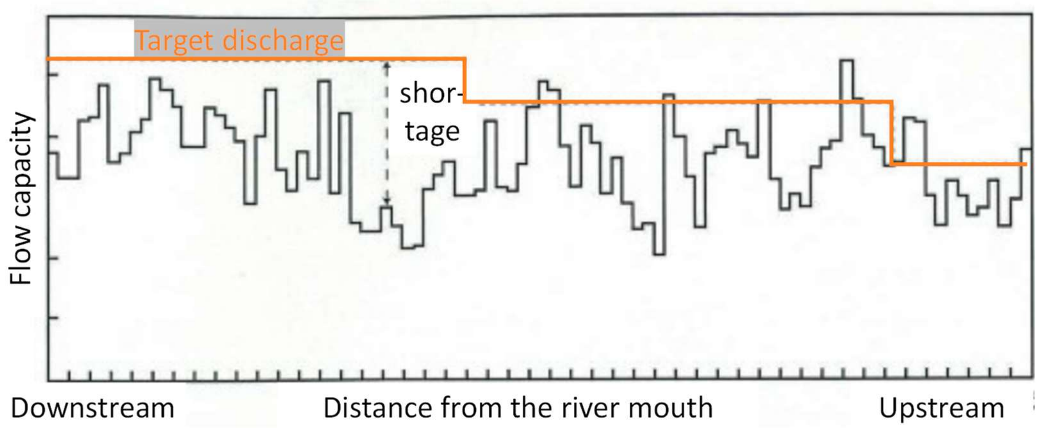


[Figure 7] Some factors that make floods difficult to flow through

Flow capacity Diagram

Once the flow capacity for each point has been calculated, a graph should be created with the river's longitudinal direction as the horizontal axis and the flow capacity at that point as the vertical axis, as shown in the Figure 8. This is called a "flow capacity diagram".

The factors that make floods difficult to flow through, mentioned above, would be expressed as locally small flow capacities in this flow capacity diagram, so it is advisable to refer to this and analyze its background when considering the factors.



[Figure 8] Example of flow capacity diagram

Consider countermeasures based on characteristics of each section and flow capacity diagram

Based on the flow capacity diagram, possible countermeasures would be considered focusing on sections where there is a gap between the current situation and the target.

If the current flow capacity is slightly lower than the target, it is thought that the flow capacity can be secured by taking local countermeasures such as excavation and tree cutting based on the current river channel.

In cases where the current flow capacity is significantly insufficient but it seems likely that the target flow capacity can be secured through river channel improvement alone, then the possibility of carrying out extensive excavation of the riverbed and riverbanks would be considered.

Furthermore, in cases where the current flow capacity is significantly insufficient and it is expected that river channel improvement is not insufficient, then widening of the river and raising of the dykes may be considered, but as raising the dykes means raising the HWL and, as mentioned above, this is basically undesirable. Other possible measures include the flood storage at upstream of the section such as construction or upgrading of dams and development of retarding basins, which can reduce the target flow rate to be discharged through the river channel.

Possible typical countermeasures and side effects (especially the "response" of rivers)

Specific measures would be considered based on the gap between the target and the current situation, but it is important to be aware that there may be disadvantages as a side effect of implementing the measures. In particular, because the function of the river itself (sometimes called the "response of the river") can cause changes in the environment in response to measures taken in the river channel, often resulting in undesirable effects, so it is necessary to refer to the experience of other rivers and sections with similar characteristics, and to monitor environmental changes after the measures have been taken, and to take measures for improvement as necessary.

The following are specific examples of flood control measures that are generally considered and their side effects including responses of the river.

1) River channel excavation and tree cutting

This is a measure to the space within the river channel and thereby secure the flow capacity by removing the sediment and overgrown trees.

Since it is not rare for sediment to accumulate again in the excavated area or for trees to grow back, monitoring after taking measures is essential.

In addition, problems can arise where riverbank erosion is likely to progress due to changes in the way of floods and sediment flowing as a result of river channel excavation, etc.

Furthermore, since tree cutting can result in the loss of valuable natural resources for the local area, it is desirable to consider the positioning and importance of trees in the local area when carrying out tree cutting.

2) River widening

This is a measure to secure the space within the river channel and thereby secure the flow capacity by widening the river by setting back the riverbank and the dyke.

In many cases, compensation is required for the land along the river, and if there are already residential areas, then care is needed because it would be necessary to relocate many houses and infrastructure.

In addition, as with the aforementioned river channel excavation, there is a possibility that problems could arise where the way floods flow and the way sediment flows change due to widening, and riverbank erosion becomes more likely to occur.

3) Flood storage using dams and retarding basins

This is a measure to reduce the target flow capacity that must be secured in the river channel by storing floodwater upstream of the section to be protected.

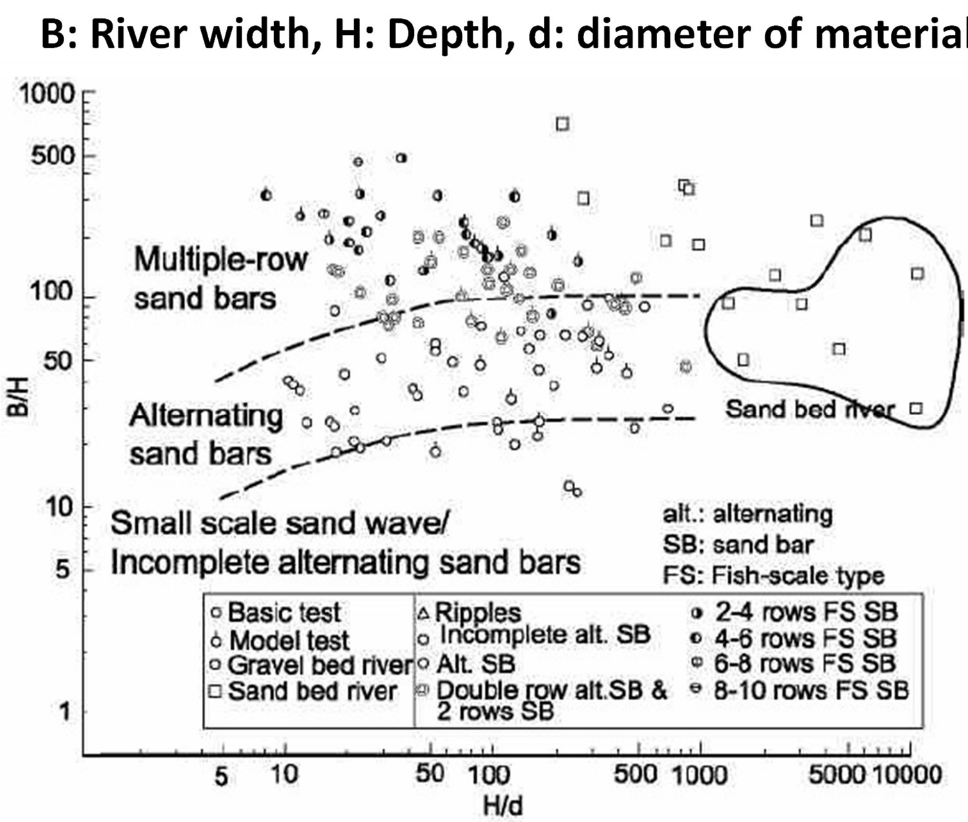
Depending on the scale of the facility, it can store floodwater on a large scale and is very effective, but it requires the acquisition of very large tracts of land, and there might be many houses and infrastructure that need to be compensated for. In the case of dams in particular, the environmental impact on the river channel downstream as well as the surrounding area is also significant.

4) Spillways (Diversion channels)

This is a measure to improve the flow capacity of the river channel by improving drainage on the downstream side (e.g. at the mouth of the river). In particular, if there is a long stretch of flat land or the river channel meandering greatly near the mouth of the river, the effect of improving drainage would be significant, but there may be problems such as the need for a large area of land for the spillway, which will result in more houses and infrastructure requiring compensation, and changes in the way floods and sediment flow may cause coastal erosion to progress more easily.

[Supplementary Note] Impact on sediment dynamics (sandbar formation, changes, etc.)

It is important to be aware that sediment dynamics may change in response to measures taken in the river channel. In particular, if the width of the river changes, the shape of the sandbar in the river channel may change significantly. In Japan, it is known that the morphology of sandbars is roughly determined by the width-depth ratio (B/H), as summarized in Figure 9, so it is important to note that, for example, if a river is widened, sandbars may form in the channel where they have not formed before, and there is a risk that riverbank erosion may progress.



[Figure 9] Appearance of sandbars depends on the river width-depth ratio (B/H) (d)

2.3. Measures to ensure the safety of dyke and riverbank

Identifying weak points

In addition to measures to prevent flood overflowing, it is also important to consider measures to ensure the safety of dyke and riverbank.

It is possible to assume to some extent the areas that are vulnerable to riverbank erosion, i.e. areas that are likely to be eroded, based on the characteristics of each segment, the conditions of sandbars, and the flow during flooding. The tendency of riverbank erosion in each segment is summarized in Table 2 based on Japanese experience. However, in addition to this tendency in each segment, it is also necessary to be aware that erosion is likely to occur due to local conditions such as around bridge piers, weirs, sluice gates, etc.

In order to consider and implement measures to prevent riverbank erosion, it is advisable to do at the same time with considering and implementing measures to ensure the flow capacity.

[Table 2] Tendency of riverbank erosion in each segment

Seg ment	Frequency	Location of Occurrence	Approximate erosion width (case study)
1	Intense (can occur all at once)	Likely on both banks because multiple-row bars are easily formed and the stream meanders over them	About half the width of the bar (about 40 m, up to 100 m)
2-1, 2-2	Moderate (Large if riverbed material is large)	In curved channels, more likely at the outer bank where flood flows, as well as at the flow attacking point. In straight channels, more likely on both banks because the flow meanders over sandbars similarly as in Segment 1.	[2-1] ≒River bank height (h) ×5 (≤ 30 m) [2-2] ≒ h×2～3 (≤ 20m)
3	Weak	Less likely, but possible at the outer side of curve	≒ h×2～3 (≤ 20m)

Measures to prevent riverbank erosion (bank protection, river groyne)

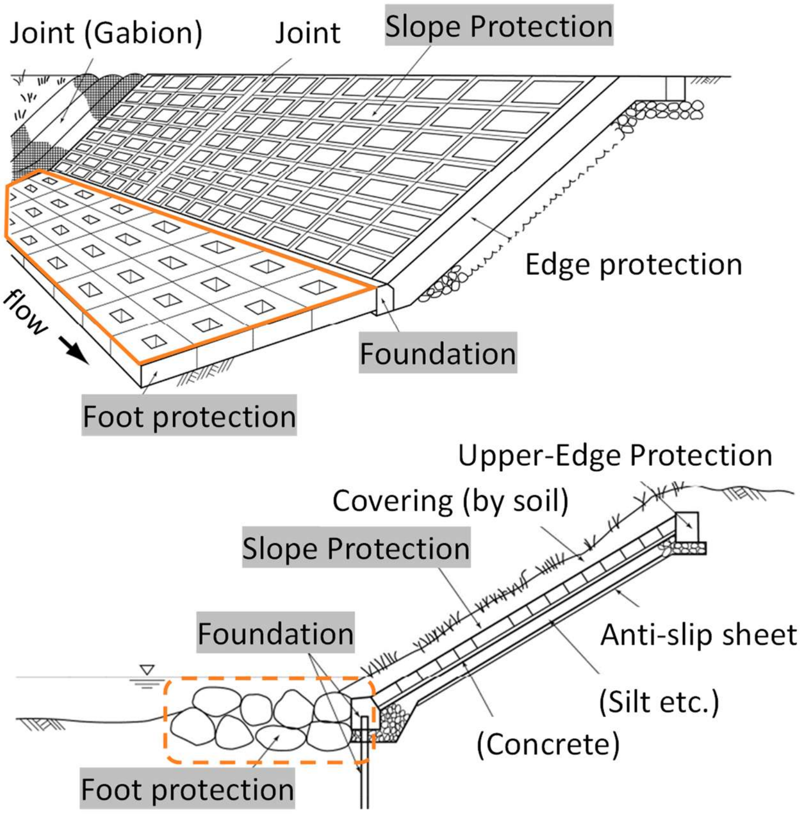
When considering measures to prevent riverbank erosion, it is advisable to set a protective line (a line that will stop erosion at this point) and consider ways to prevent erosion up to this point.

There are two ways of thinking about measures: measures to directly protect the riverbank, and measures to divert the flow. Detailed explanation on each of these are as follows.

1) Measures to directly protect the riverbank

This is to protect the riverbank from erosion by installing bank protection.

As shown in the Figure 10, not only the riverbank but also the riverbed nearby should be covered by a bank protection, otherwise the bank protection would be eroded from the riverbed and slide down. This should be cared because, although this type of riverbed protection (called "foot protection") is important, this is not installed in some cases in Vietnamese rivers.

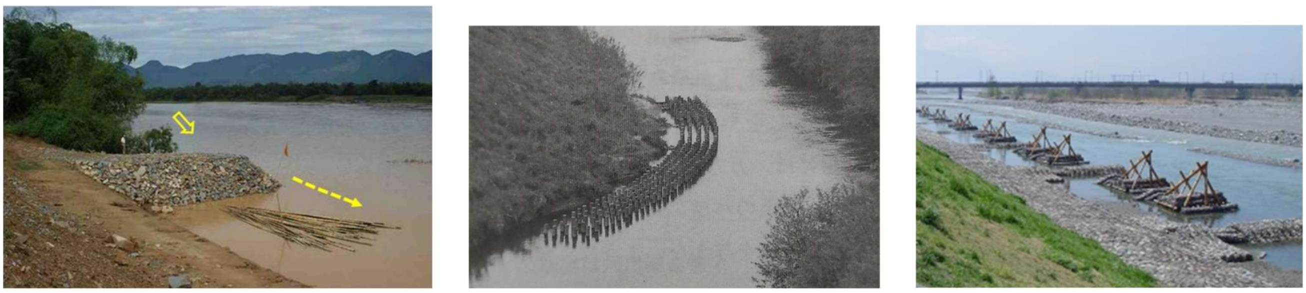


[Figure 10] Bank protection including foot protection [e]

2) Measures to divert the flow

This is to install a river groyne to divert the strong water flow (thalweg) and avoid it flowing near the riverbank.

There are various types of groyne, as shown in Figure 11.



[Figure 11] Various types of groyne

2.4. Summarizing measures

Putting it all together as plans and drawings.

It is important to compile the countermeasures discussed above into a plan and drawings. In the plan, a list should be made of which countermeasures will be implemented in which sections, and the plan should be illustrated in drawings. An example from Japan is shown in Figure 12.

[Figure 12] Example of figure in a flood prevention plan in Japan

Estimation of how much damage is reduced (benefit)

In order to estimate the effectiveness of the measures considered, it is necessary to estimate the extent to which flood damage can be reduced by these measures, and for this purpose, data on the asset value of the areas around the river (flood zone) is required.

Specifically, the amount of damage reduction is calculated for each flood scale (probability of occurrence), and the expected value of the amount of damage reduction is calculated using these results. This yields the benefit of the measures.

For example, if a flood with a 1/100 probability of occurring in a year is expected to cause damage of 10 billion VND without measures taken, but only 1 billion VND with measures taken, the difference of 9 billion VND is the amount of damage reduction for a flood with a 1/100 probability of occurring in a year. This damage amount is calculated by calculating the damage reduction for each actual land use (houses, offices, rice fields, fields, etc.) as much as possible, and then multiplying the total by the unit price according to land use. This is then calculated for several other floods with different scales (probabilities of occurrence), and the expected value of the damage reduction amount is obtained using the results of these calculations.

For more information on calculating of benefits, please refer to the reference shown at the end of this article.

Cost-effectiveness (Cost-benefit)

By comparing the benefits mentioned above with the necessary costs, it is possible to calculate the cost-benefit, and this makes it possible to evaluate the effectiveness and appropriateness of the measures considered. When considering other effects not only what can be expressed in monetary terms (benefit), it can also be expressed as a cost-effectiveness study.

For more information on this, please refer to the references shown at the end of this article.

While structural measures (hard measures) such dykes and dams can be effective in reducing damage, it should be noted that non-structural measures (soft measures) such as promoting evacuation cannot reduce property damage, and in planning, we should be aware of this and to keep in mind on reducing damage through appropriate structural measures in order to satisfy the target.

3. Other points to be noted

Importance of utilization of Data

As having discussed so far, when considering flood countermeasures, the basic data from surveys and other sources on rivers and the surrounding areas is always the basis. It includes data such as the longitudinal gradient of the river channel (and the segment classification based on this), the width of the river and changes in this (upstream/downstream balance), the flow capacity, and the way of flood in the surrounding land (flood zone) and the asset values. It is important to manage this data well, monitor any changes, and reacquire the data as necessary.

Inspection and maintenance

It is important to be aware of changes in the river channel (particularly the response of the river after measures have been taken) through surveying and inspecting the topographical data within the river channel, and to be able to respond quickly. In Japan, cross-sectional surveys are carried out basically every 200m in the longitudinal direction at least every 5 years, and the results are accumulated, though the frequency and interval of surveys depend on the scale of the river (the river width etc.) and other characteristics.

In addition to the topography, it is also necessary to pay attention to the trees in the river channel. This is because trees can grow quickly on sandbars in the river channel and obstruct the flow of floodwater. However, as mentioned previously, in some cases, when cutting down trees, it is also necessary to consider them as valuable natural resources for the local area.

Consideration of the landscape and the environment

This article has looked at rivers from the perspective of flood prevention, but rivers have the function to create natural environments and pleasant landscape, and it is important to avoid artificially modifying rivers simply for flood prevention. The ideal for comprehensive river engineers is to be able to balance with the environment/landscape and flood prevention and to even make them coexist.

Appendix

A.1. On calculation of flow capacity

Basic formula for calculating non-uniform flow

As mentioned before, if the flow is uniform (the appearance does not change depending on the location), the discharge can be easily calculated using Manning's formula. However, this method is not used for calculating floods in actual rivers, because flood flows are not uniform, but rather non-uniform flows where the appearance (river width, slope, water depth, flow velocity, etc.) changes depending on the location.

As you can learn in hydraulics, water depth at each point of non-uniform flow is determined by the law of conservation of energy. Therefore, it is common to calculate the flow capacity by estimating the water depth at each point when a certain discharge rate is flowing, utilizing it, and to compare it with the HWL.

The basic formula for non-uniform flow is obtained from the law of conservation of energy as follows.

$$\frac{dH}{dx} + \frac{1}{2\mathrm{g}}\frac{d}{dx}\left(\frac{Q}{A}\right)^2 + \frac{n^2Q^2}{A^2R^{4/3}} = 0$$

… Equation (1)

In the case of a large river with a wide width compared to the depth, and where the cross-section can be approximated as a wide rectangular, we can set $R \simeq h$ and $A \simeq B \cdot h$, which yields the following.

$$\frac{dH}{dx} + \frac{1}{2\mathrm{g}}\frac{d}{dx}\left(\frac{Q}{Bh}\right)^2 + \frac{n^2Q^2}{B^2h^{10/3}} = 0$$

… Equation (2)

Based on this, the relationship on some values between the two cross-sections can be expressed as follows (here, the discharge Q is constant, and the third term is expressed in the form of the average value for the two cross-sections).

$$\frac{H_2 - H_1}{\Delta x} + \frac{Q^2}{2\mathrm{g}\Delta x}\left\{\left(\frac{1}{B_2h_2}\right)^2 - \left(\frac{1}{B_1h_1}\right)^2\right\} + \frac{n^2Q^2}{2}\left\{\left(\frac{1}{B_2^2h_2^{10/3}}\right) + \left(\frac{1}{B_1^2h_1^{10/3}}\right)\right\} = 0$$

… Equation (3)

By further transforming the equation, the relationship between the two cross-sections can be expressed as follows, and this is widely used in numerical calculations. If you note that only h_1 and h_2 are unknown in this equation, you can see that if you obtain the depth of one of the two cross-sections, you can obtain the depth of the other.

$$\underbrace{z_2 + h_2 + \frac{Q^2}{2gB_2^2h_2^2} + \frac{n^2Q^2\Delta x}{2B_2^2h_2^{10/3}}}_{\text{(downstream side)}} = \underbrace{z_1 + h_1 + \frac{Q^2}{2gB_1^2h_1^2} - \frac{n^2Q^2\Delta x}{2B_1^2h_1^{10/3}}}_{\text{(upstream side)}}$$

… Equation (4)

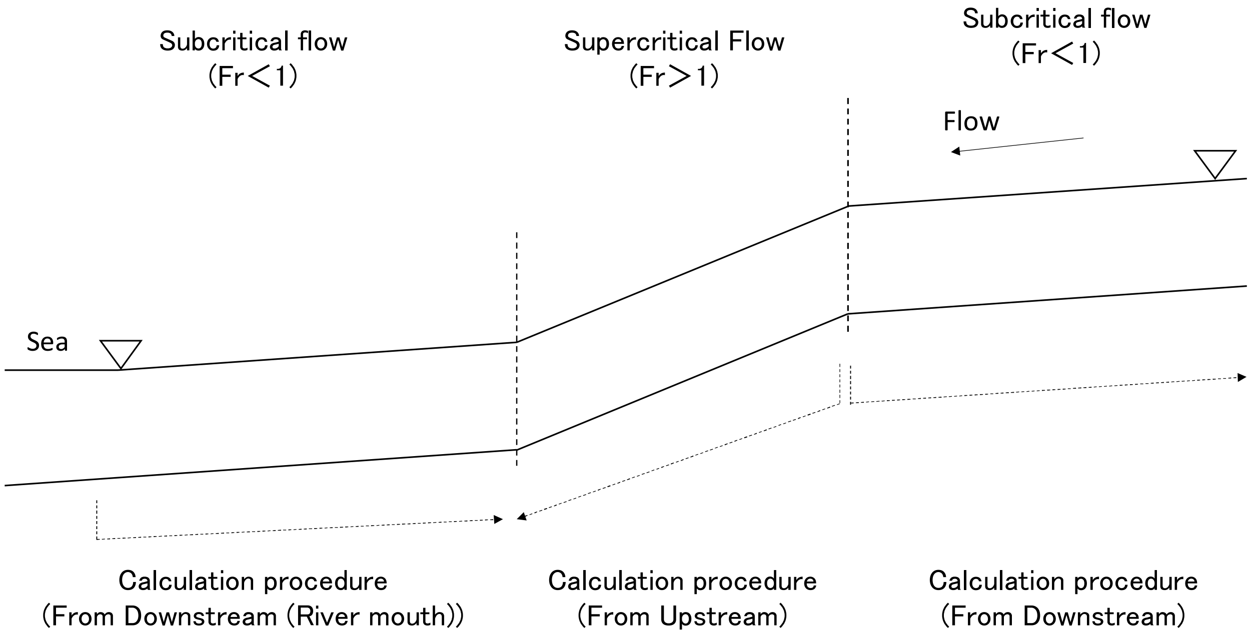
Subcritical flow and supercritical flow

Using the basic formula above, we can calculate the water depth at each point when a certain discharge flows. The specific procedure is to use the relationship between two cross-sections to calculate the water depth at the cross-section adjacent to the cross-section with a known water depth, but it is important to note that the calculation is done sequentially from downstream or upstream depending on whether the flow is subcritical flow or supercritical flow, which we learn in hydraulics. As we learn in hydraulics, we can know whether a flow is subcritical or supercritical by using the Froude Number *Fr*, so we can determine the order of sequential calculation accordingly.

More specifically, in the case of subcritical flow, the flow is not affected by the upstream flow conditions, but is affected by the downstream flow conditions, so it is necessary to calculate from the downstream side. Therefore, we give the depth of the cross-section at the downstream end of the subcritical flow section as a boundary condition, and then sequentially calculate in the upstream direction from there.

In the case of a supercritical flow, on the other hand, it is necessary to calculate from the upstream side, as it is a flow that is not affected by the downstream flow conditions but is affected by the upstream flow conditions. Therefore, the water depth of the cross-section at the upstream end of the supercritical flow section is given as a boundary condition, and calculations are sequentially performed in the downstream direction from there.

If there are both subcritical flow section(s) and supercritical flow section(s) in a river, the calculations are performed separately for each section. For example, the calculation procedure would be as shown in Figure A.1 below.



[Figure A.1] Calculation procedure when both subcritical flow section(s) and supercritical flow section(s) exist

Taking into account the various conditions that affect water levels

Based on the concepts discussed so far, the basic approach is to calculate the flow capacity by determining the water depth at each point when a certain discharge flows, based on the shape of the river channel (cross-sectional profile, slope, etc.).

However, in order to accurately calculate water levels, it is necessary to take into account not only the shape of the river channel, but also the effects of riverbed materials and sandbars, the effects of trees, the effects of sudden constriction, expansion and curve of the river channel, and the effects of structures such as bridge piers, etc. Specifically, the following methods are standard in Japan.

(1) Effect of riverbed materials

This is taken into account as the roughness coefficient. Ideally, if there is sufficient high-precision data such as the water levels of previous floods, it is good to estimate the roughness coefficient by referring to that data. However, if that is not the case, it is also possible to set the roughness coefficient by referring to those shown in Table A.1 as a guide.

[Table A.1] Values of Manning's Roughness Coefficient "n" [f]

Surface/Description	Range Min.	Range Max.
1) Natural stream channels (top flood width less than 30 m)		
(i) Fairly regular section:		
a. Some grass and weeds, little or no brush	0.030	0.035
b. Dense growth of weeds, depth of flow materially greater than weed height	0.035	0.050
c. Some weeds, light brush on banks	0.035	0.050
d. Some weeds, heavy brush on banks	0.050	0.070
e. Some weeds, dense trees	0.060	0.080
f. For trees within channel, with branches submerged at high flood increase all above values by	0.010	0.020
(ii) Irregular sections, with pools, slight channel meander; increase values given above about	0.010	0.020
(iii) Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high flood:		
a. Bottom of gravel, cobbles, and few boulders	0.040	0.050
b. Bottom of cobbles, with large boulders	0.050	0.070
2) Larger stream channels (top flood width greater than 30 m) Reduce smaller stream coefficient by 0.010		
3) Flood Plains (adjacent to stream beds)		
Pasture, short grass, no brush	0.030	0.035
Pasture, tall grass, no brush	0.035	0.050
Cultivated land - no crop	0.030	0.040
Cultivated land – nature field crops	0.045	0.055
Scrub and scattered bush	0.050	0.070
Wooded	0.120	0.160
4) Man-made channels and ditches		
Earth, straight and uniform	0.017	0.025
Grass covered	0.035	0.050
Dredged	0.025	0.033
Stone lined and rock outs, smooth & uniform	0.025	0.035
Stone lined & rock cuts, rough and irregular	0.035	0.045
Lined—metal corrugated	0.021	0.024
Lined—smooth concrete	0.012	0.018
Lined—grouted riprap	0.017	0.030
5) Pipes:		
Cast iron	0.011	0.015
Wrought iron	0.012	0.017
Corrugated steel	0.021	0.035
Concrete	0.010	0.017

(2) Effect of sudden constriction/expansion of the river channel, and effect of trees

The effect of sudden constriction/expansion on water levels (rising water levels) are evaluated by setting up an ineffective flow area (dead water zone). Trees in the river channel are also evaluated as ineffective flow areas, taking into account the density of their growth (for example, if the density is low, the area is treated as 30% smaller, etc.).

(3) Effect of curve of the river channel

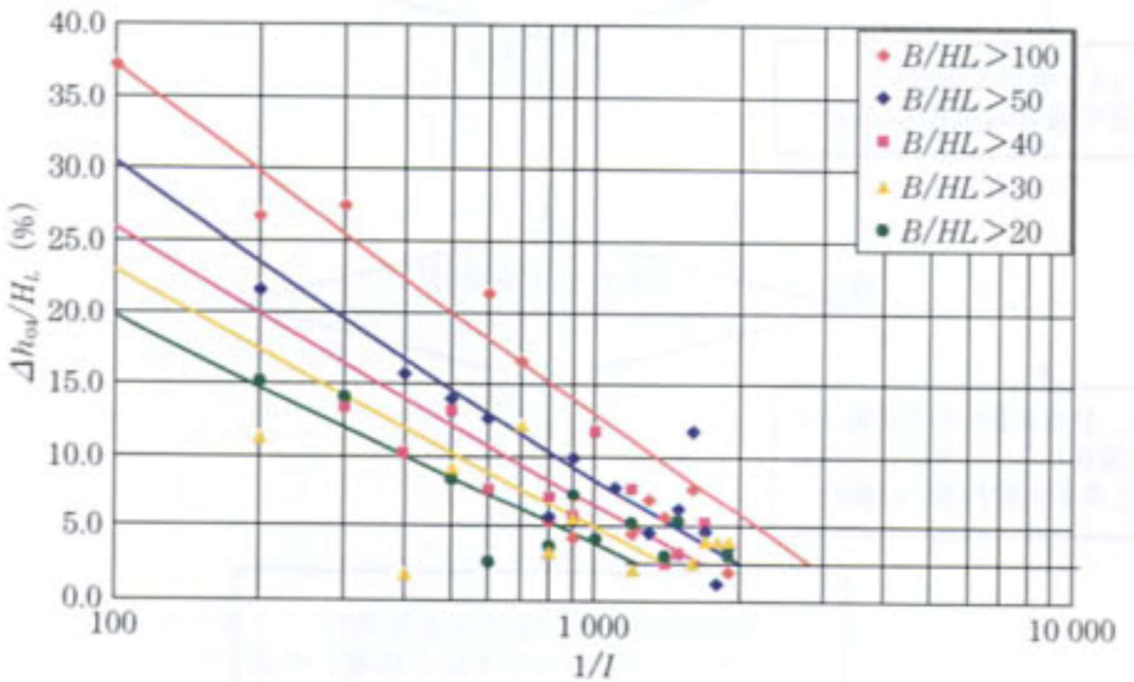
The effect of a sharp curve of the river channel on water levels (rising water levels) is evaluated by adding the amount of water level rise calculated from the radius of curvature, river width and flow velocity. The water level difference between the outer and inner banks caused by the curve, Δh, is calculated using the following formula. In the general calculation of water depth, the average water depth within the cross-section was calculated, and therefore, by adding half of Δh, the amount of water level rise caused by the curve, is added.

$$\Delta h = \frac{BV^2}{grc}$$

Here, *B* is the width of the water surface in the river channel (average value for the curved section), *V* is the average cross-sectional flow velocity (average value for the calculated cross-section of the curved section), *g* is the acceleration of gravity, and *rc* is the radius of curvature of the river channel (measured at the center of the river channel). In addition, when the angle is 60 degrees or more and rc/B<10, it is evaluated that a sharp bend has occurred, and only in this case the amount of water level rise due to the curve shall be added.

(4) Effect of sandbars formation

The effect of sandbar formation on water levels (water level rise) is evaluated by adding the amount of water level rise calculated from past records of water levels. However, in cases where there are few records, the amount of water level rise can be estimated based on the trends shown in Figure A.2 based on past experience.



[Figure A.2] Water level rise due to sandbar formation (reference based on past experience)

(H_L, *B* are the water depth and river width at the time of the average annual maximum discharge, respectively, and *I* is the riverbed slope)

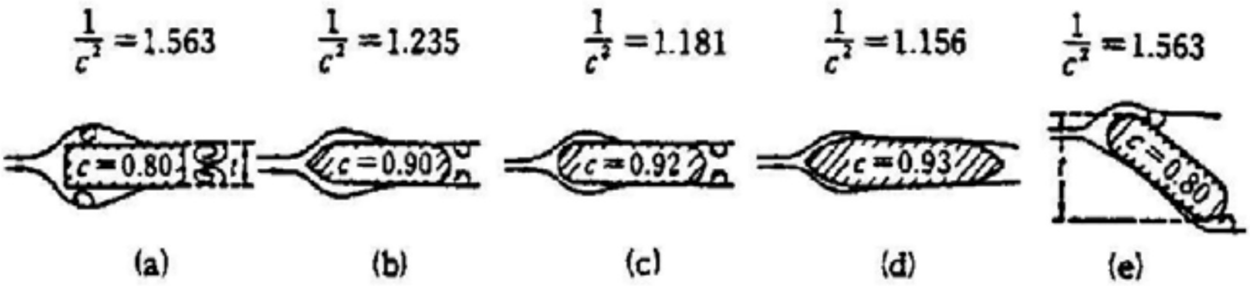
(4) Effect of structures such as bridge piers

The amount of water level rise due to piers is calculated based on the D'Aubuisson Formula and added to the calculation. However, in sections where the Froude Number Fr is larger than 0.6, the water level rise due to weir raising is local and its impact does not spread upstream, so it is not taken into account.

$$\Delta h = \frac{Q^2}{2g}\left\{\frac{1}{C^2 b_2^2 (H_1 - \Delta h)^2} - \frac{1}{b_1^2 H_1^2}\right\}$$

Here, Δh is the water level rising due to the bridge piers, Q is the discharge, b_1 is the width of the channel upstream of the piers, b_2 is the value obtained by subtracting the total width of the bridge piers from the total width of the channel, and H_1 is the water depth upstream of the piers.

The constant C is determined by the plan shape of the bridge pier, and a guide is shown in Figure A.3 below, while C = 1.0 in case of building a new bridge.



[Figure A.3] Constant C, determined by the plan shape of the pier for D'Aubuisson Formula.

In Japan, it is also standard to take into account the effects of energy loss due to interference between flows in the lower and higher water channels when there is a clear distinction between them in the river channel, and energy loss due to the confluence with tributaries.

Outline of the method for calculating water levels

Based on discussion so far, as mentioned at the beginning, we calculate the flow capacity by estimating the water depth at each point when a certain discharge flows, and compare it with the HWL.

The water depth at each point when a certain discharge flow is actually calculated in the following way.

(1) Gather information of the topography of the river channel (slope, river width, etc.), the water level at the river mouth (called the starting water level because it is the water level at the downstream end, which is the starting point for the calculation for subcritical flow), and the conditions of the riverbed materials, trees, vegetation, etc. listed in the previous section.

(2) Next, it is necessary to distinguish between subcritical flow and supercritical flow, but since it is not possible to tell it without calculating it, the calculation is carried out assuming that the entire section is subcritical flow (i.e., the water level is calculated sequentially from the mouth of the river, at the downstream end).

(3) If there is supercritical flow section(s), the water level is calculated sequentially for that section based on the water level at the upstream end of that section. At this time, (a) if there is a section of subcritical flow upstream of this section, the critical depth is given at the upstream end of this supercritical flow section. On the other hand, (b) if there is no subcritical flow section upstream of this section (i.e. if the upstream end of this section is the upstream end of the entire section being calculated), it is necessary to set the upstream end water level.

(4) In the case of (a) in (3), i.e., if there is a supercritical flow section where there is a subcritical flow section upstream of that, the subcritical flow section is recalculated. In this case, as in (3), the upstream end of the immediately downstream supercritical flow section is given as the critical

In calculations above, the various conditions that affect the water level listed in the previous section are taken into account.

Notes on calculations for rivers

If the river channel can be assumed to be a wide rectangular section, it is possible to calculate the flow without considering the differences in flow due to the cross-sectional direction, by expressing the river channel topography in terms of gradient and river width alone (this is called one-dimensional analysis because it only takes into account the direction of the flow). However, in the case of a river with a cross-sectional profile that varies in terms of factors such as topography and tree growth, it is standard practice to divide the cross-sectional profile into sub sections and perform calculations that take into account the differences in flow velocity in each of the divided sections (this is called a quasi-two-dimensional analysis, as it takes into account the differences in flow along the cross-sectional direction, although it mainly takes into account the direction of flow). In addition, when there is a confluence of tributaries, etc., calculations that take this into account are required.

With this in mind, it is common practice to calculate water levels using numerical simulation.

For more details, please refer to the reference at the end of this article.

A.2. Reference

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2) On Cost-effectiveness analysis, Cost-benefit analysis:
MLIT Japan (2005) Manual for Economic Evaluation of Flood Control Investment - Draft
https://www.mlit.go.jp/river/kokusai/pdf/pdf06.pdf

3) On river bank protection, Groyne
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(VIET)
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4) On Upstream-Downstream balance, Comprehensive measures at the river basin:
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(ENG)
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A.3 Sources of figures, etc.

(a) Website of Geographical Survey Institute of Japan (Japanese)
https://www.gsi.go.jp/CHIRIKYOUIKU/kawa_1-1.html

(b) Website of Riverfront Research Center (Japanese)
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(c) Dr. Harada (2021)
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(d) DPWH Philippines, JICA (2003) Manual on Flood Control Planning
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(e) Chubu Regional Development Bureau, MLIT (2022) (Japanese)
https://www.cbr.mlit.go.jp/kawatomizu/kouzou/pdf/11_03gogan.pdf

(f) DPWH Philippines, JICA (2003) Manual on Flood Control Planning
(same as (d))

(g) Japan Institute of Country-ology and Engineering (ed.) (2002)
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12/July/2024

Points for surveying a river and planning flood control

SUZUKI Takashi,
JICA Expert (Advisor for Disaster Risk Management), VDDMA, MARD

1

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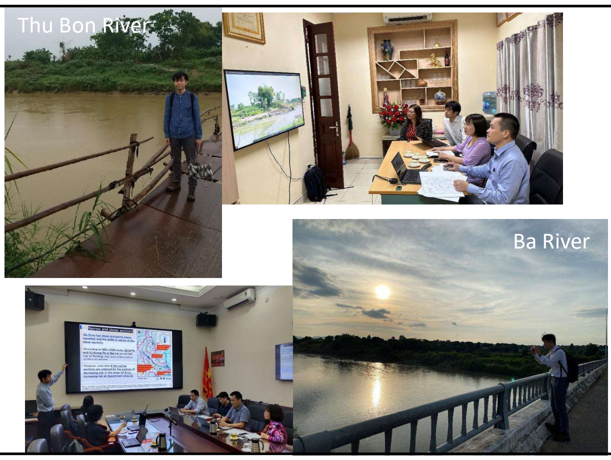
2008 - 2022 (14 years)
MLIT (Ministry of Land, Infrastructure etc...)
*Civil Engineer @Headquarters & Local offices

2022 - now
MARD
*Advisor for Disaster Risk Management

2



3

Aim

- ✓ In Japan, before planning flood control measures, we survey the river and analyze based on the results.
- ✓ In this program, I will introduce the key points of such survey and planning methods, which I hope will be useful for survey and planning in Vietnam.
- ✓ In addition, in the surveys and planning, we sometimes conduct very technical studies that involve advanced calculations. However, in this program, I will only introduce basic points and viewpoints. If you are interested in such technical studies, please refer to some documents for more advanced information.

4

Contents

[Session 1] 12/July (Friday)

◆Suzuki explains:
- Preliminary preparations and surveys to grasp the characteristics of:
  + rivers and each section
  + the surrounding areas of the river (flood zone, river basin)
- Deciding the premise for considering countermeasures

(break)

◆Discussion, Q & A

◆Explanation of homework

[Session 2] 2 or 9/August (Friday) (TBD)
- Planning of flood control measures
- Other points to keep in mind

5

6

Individuality (Characteristics) of Rivers

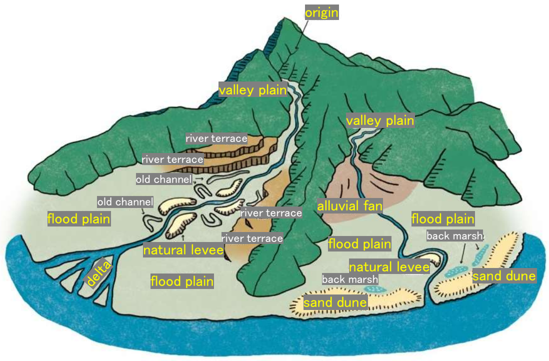
- ✓ River channel characteristics are formed by topography, geology, and other conditions based on past tectonic movements, volcanic activity, uplift and subsidence, etc., as well as the effects of flow, sediment production, and human impact.
- ✓ Furthermore, the same river has different channel characteristics longitudinally (section by section).

- ✓ Measures that succeeded in one river may fail in another river.
- ✓ Measures that succeeded in one section may fail in another section.
- ✓ It is easy to succeed by adapting measures that have succeeded in rivers [segments] with similar river channel characteristics.

➔ Understanding river channel characteristics and segment is important.

- Measures frequently may change the channel characteristics worse.
- It is desirable not only to predict the response, but also to modify the river monitoring its response (adaptive management). More specifically, it is desirable to take measures that anticipate the river's response.

Topography formed by a river



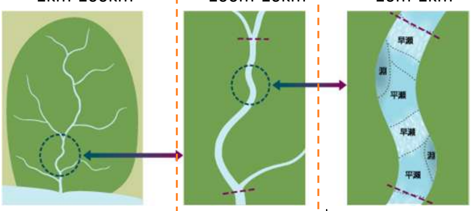
Website of Geographical Survey Institute of Japan
https://www.gsi.go.jp/CHIRIKYOUIKU/kawa_1-1.html

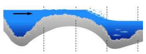
Observing rivers

- ✓ Scales, hierarchical structure of rivers (river channels)

River Basin Scale > Segment Scale > Reach Scale > Unit Scale

≃ 1km-100km | ≃ 100m-10km | ≃ 10m-1km | ≃ 1m-100m





∨

Micro Scale

≃ 0.1m-10m

(Sub-segment Scale)

◆ The viewpoint of large scale (Segment) is especially important.

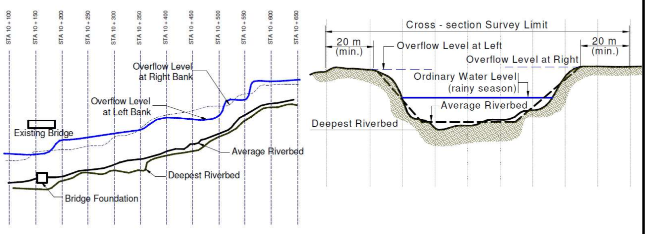
* In some cases, necessary to focus on smaller scales to capture characteristics.

1. Preliminary preparations and surveys to grasp the characteristics of rivers and each section

(1) Preparation based on maps and aerial photographs

- Maps showing the topography and shape of the river (especially the longitudinal and cross sectional shape of the riverbed)
- Survey results, and drawings of the dyke and facilities if available

Accumulate results of periodic surveys
(at least every 5 years, approximately every 200m in longitudinal direction(*))



(*) Required scale of the survey intervals and drawings depend on the river size (width etc.).

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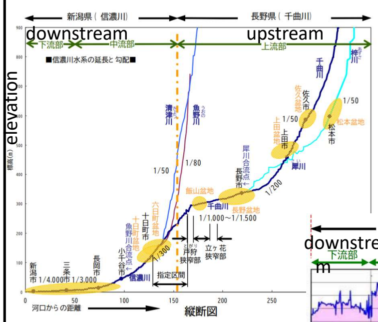
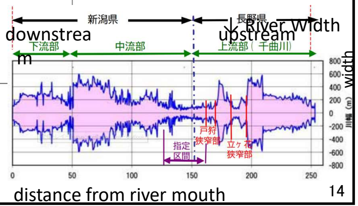
Check longitudinal changes by river topography data



Shinano River
(The longest river in Japan)

← Longitudinal profile of the river



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Ba River

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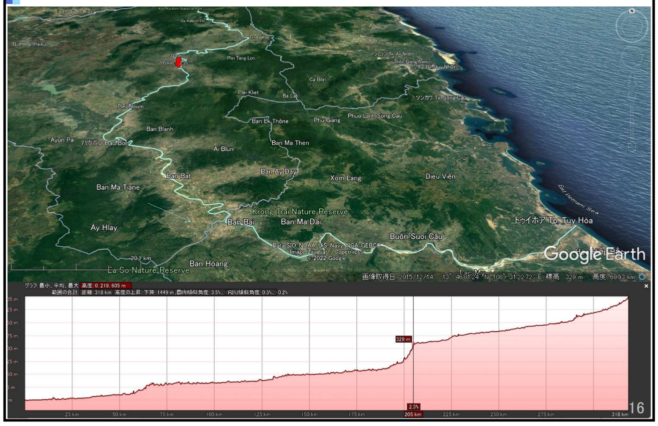
Ba River



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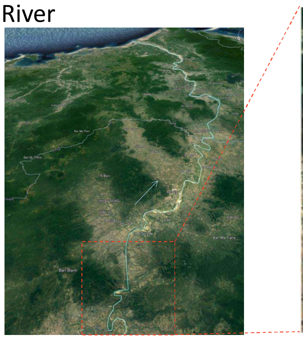
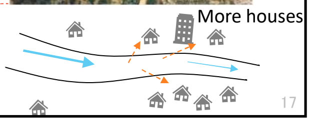
Ba River



Upstream-downstream balance

If more floodwater flows upstream than downstream, the river would likely **overflow at the change point.**



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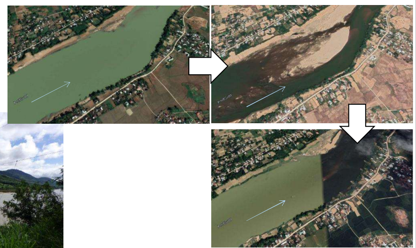
(2) Preparation based on the history of past disasters

- Water level data, actual floods (and simulations if available)
- History of riverbank erosion (imagine flood flows) and other changes in river channel conditions (e.g., sandbar fluctuations)

→This can also help to understand weak points

Data accumulation (water level, topography) is essential for planning and explaining the measures.



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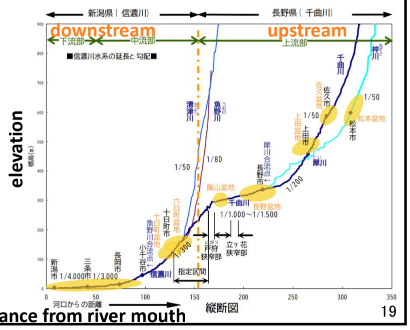
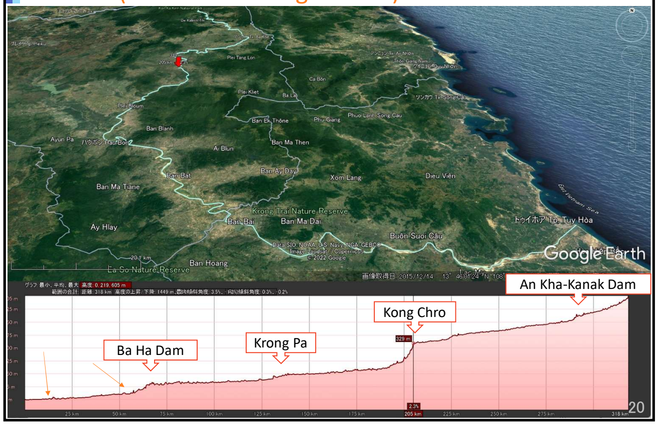
(3) Find "change points" in the appearance of the river

- Confluence and diversion of tributaries
- Points of change in longitudinal gradient and river channel geometry
  → Divide a river into sections = Concept of "segment"

With periodic survey data, more accurate longitudinal gradients can be drawn.



Ba River (Let's touch Google Earth)



Segment

- Divide into sections with approx. same gradient →similar characteristics.
- If the gradient is same, the size of the sediments is also roughly same.

Classification	Segment M	Segment 1	Segment 2		Segment 3
			2-1	2-2	
Geography	Mountain	Alluvial Fan	Valley plain	Natural Levee	Delta
Gradient (slope)	Various (Generally steep)	1:60 - 1:400	1:400 - 1:5,000		1:5,000 - flat
Riverbank Material	Various, including rocks	Thin layer of sand/silt (same as riverbed)	Lower layer is mixture of sand/silt/clay (same as riverbed)		Silt and clay

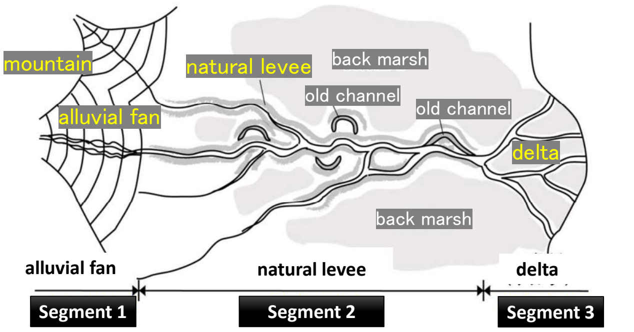
By "Segments", the characteristics can be imagined

- Common in Japan as a way to understand river characteristics
- When utilizing experience from other rivers, check which segment it is

Classification	Segment M	Segment 1	Segment 2		Segment 3
			2-1	2-2	
Extent of Meandering	Various	Few meandering	Heavy meandering		Various (Large or small)
Bank Scouring	Heavy	Heavy Scouring	Medium (Big, if riverbed material is large)		Weak
Average depth	Various	0.5m - 3m	2m - 8m		3m - 8m

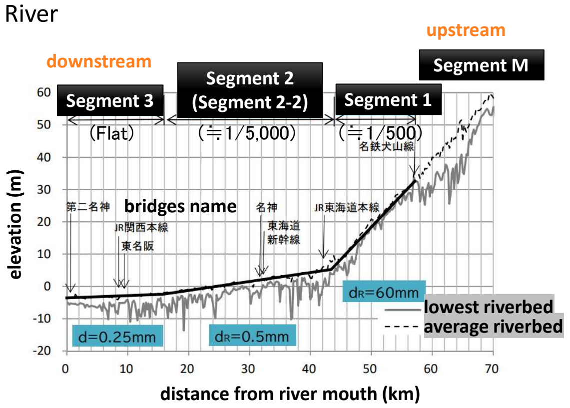
✓ It is easy to succeed by adapting measures that have been successful in rivers [segments] with similar river channel characteristics.
→Understanding river channel characteristics and segment is important.

Segments are roughly consistent with surrounding topographic features



Dr. Harada, Gifu University
https://www.green.gifu-u.ac.jp/~bhdlab/wp-content/uploads/2021/06/f03650d30d5cc0a416559de67708de80.pdf

Kiso River



Dr. Harada, Gifu University
https://www.green.gifu-u.ac.jp/~bhdlab/wp-content/uploads/2021/06/f03650d30d5cc0a416559de67708de80.pdf

Kiso River

downstream

upstream

Segment 3 (Flat)

Segment 2 (≒1/5,000)

Segment 1 (≒1/400)

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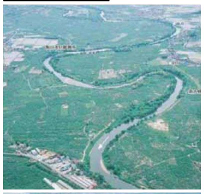
Iwaki River

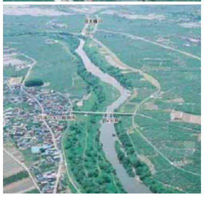
downstream

upstream

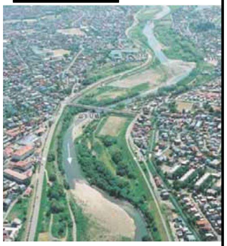
Segment 3 (≒1/29,500)

Segment 2 (≒1/2,500)





Segment 1 (≒1/300)



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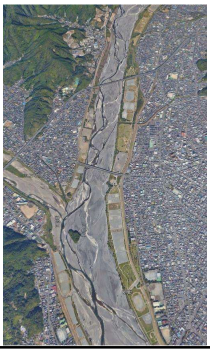
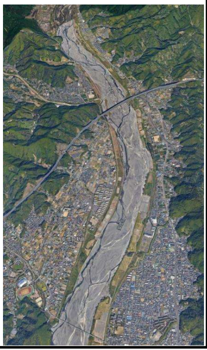
Abe River

downstream

Segment 1 (≒1/200)

upstream



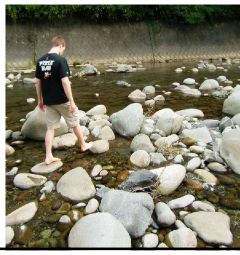


Notes for when looking at riverbed materials

- Smaller scales (meanders, sandbars, facilities, etc.) may also affect

Influence of meanders, sandbars

Influence of facilities in small scale
[e.g.] Armoring (Armor coat)
No sands downstream of dam, only large gravel
(common in segments 1 and 2-1)



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(4) **Field survey** with projections based on the segments

- ✓ Predict features based on segments and see the conditions in the field.
- ✓ Especially those that are difficult to confirm on maps and aerial photos (riverbed morphology, riverbed materials, etc.)
- ✓ It is effective to be aware of the large scale in the field and to **imagine how flood flows**.

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2. Preliminary preparations and surveys to grasp the characteristics of the surrounding areas of the river

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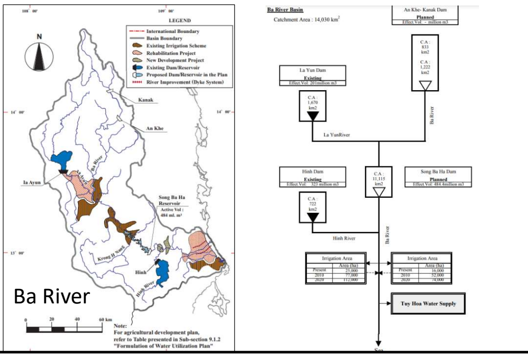
(1) Preparation based on maps and aerial photographs

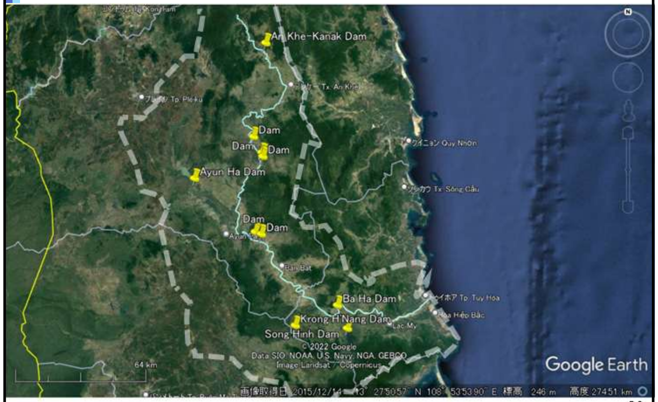
- Shape and topography of the watershed, facilities such as dams
- Land use such as residences, offices, factories, fields, etc.



Japan International Cooperation Agency : Nippon Koei Co., Ltd. : NIKKEN Consultants, Inc. (2003.9)

31

Ba River



White dash line: River basin area, based on WB et al (2020)

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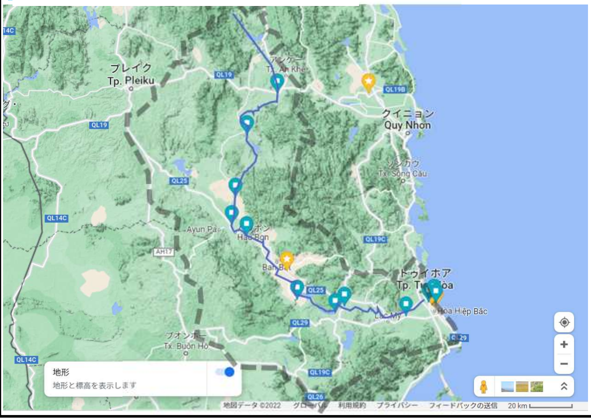
Ba River



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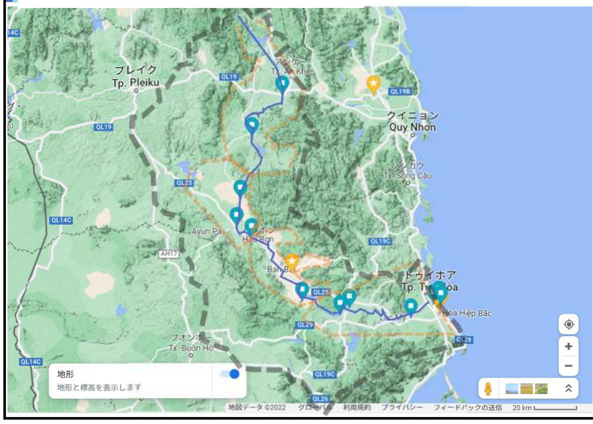
Ba River



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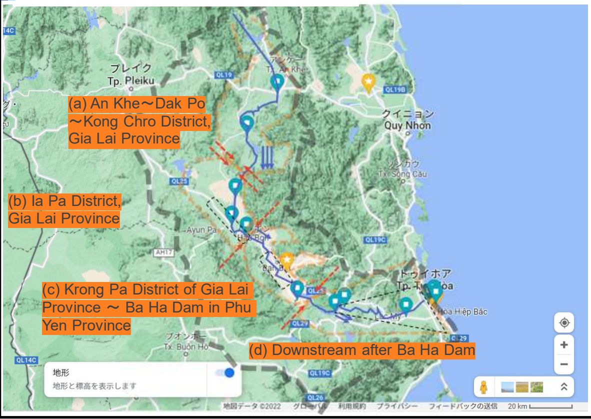
Ba River



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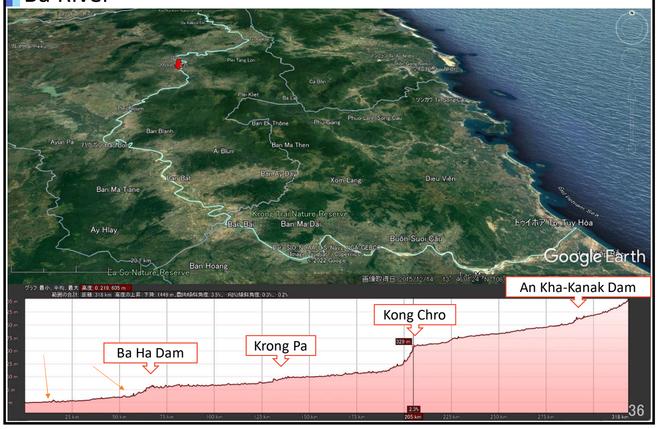
Ba River



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(2) Preparation based on the history of disasters, etc.

- Past floods record (Inundation depths and durations), existing risk maps
- River change (bank erosion etc.), history of river planning and works

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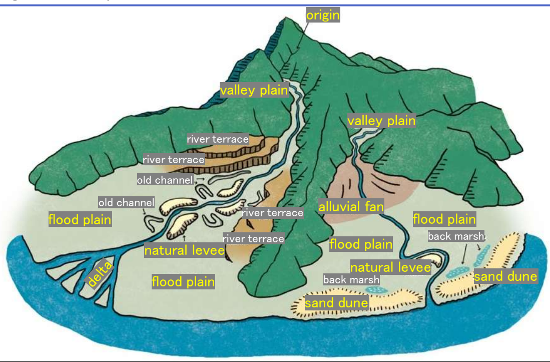
(3) Identify topographic features

- Understand the topography in combination with river segments.
- Imagine the way rainwater collects and the form of flood inundation.



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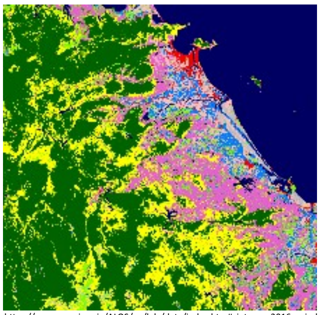
(4) Grasp the distribution of population/assets (if possible)

- Data on population distribution
- Data on assets (housing, offices/factories, land use such as fields, etc.)

Such data in detail would be useful for detailed study.



https://www.eorc.jaxa.jp/ALOS/en/lulc/data/index.htm#vietnum_2016period

39

3. Deciding the premise for considering countermeasures for disasters (especially flood)

40

(1) What kind of disaster should be prevented?

- flood
- storm surge
- riverbank erosion
- drought

Based on the characteristics of the river and the surrounding area that we have seen so far, we will visualize the possible damage and countermeasures, referring to the experience of other rivers.
(Where is the area likely to overflow, where is the area likely to experience riverbank erosion, and where are the areas that should be protected?)

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(2) Decide the target discharge of countermeasures

- Basically, <u>the discharge of the largest flood in the past</u> is often used as a guide. (overflows from the river must also be taken into account)
- If the measures take too much time and budget, a smaller discharge may be used as an short-time target (a step-by-step response).
- On the other hand, if it is considered highly likely that a greater flood will occur based on conditions in other nearby rivers, an even higher target may be set.
  (Based on statistics, a setting such as "once in 100 years" may be used.)
- It is common to set a <u>reference point</u> at an important location for the river (e.g., near an urban area) where hydrological observation data can be obtained, and use the discharge at that point as a guide.
  (However, it is necessary to consider not only this point, but also the entire upstream and downstream areas.)

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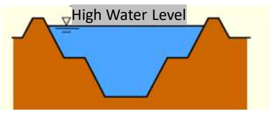
(3) Decide what water levels are acceptable (HWL)

- **High Water Level (HWL)** is set as:
  "the water level which the planned flood would safely flow below".

*Generally, setting higher HWL allows more floods to flow below the HWL, but it means planning higher dikes, which may result in poor drainage from the riverside area and tributaries and higher water levels even in small and medium-sized floods, as well as the risk of breaching the levees and causing huge damage in the event of a major flood, resulting in serious damage. Therefore commonly set HWL as low as possible. If possible, set the HWL at ground level to avoid building dykes newly, or set it so that it does not exceed the highest water level of past floods.
*When planning dykes, its height is determined by adding some margin to the HWL.



https://www.pref.ishikawa.lg.jp/kasen/saigawa/qa/q03.html

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That's all for today

[Today's Key Points].
- Segment (focusing on longitudinal gradient, etc.)
- Upstream-downstream balance (especially, focus on river width)
- Understanding weak points
- Imagin how flood flows

- Accumulation of surveying and other data to understand the situation and changes in detail

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Discussion

45

Homework

- Choose one of your favorite rivers from the Ba, Kone, or Tra Khuc Rivers and summarize the following in an about 2-page report (Word file).

1. Using a GIS such as Google Earth, find the points of change in longitudinal gradient and divide the river into some sections. Please also indicate the approximate longitudinal gradient of each section.
2. Using a GIS such as Google Earth or other existing data, plot a graph showing the approximate change in the river channel's width or cross-sectional area.
3. Summarize what kind of damage has been caused by disasters in each section so far, as far as it is known from existing data, etc.
4. Based on the above information, list specific measures and locations (one to three) that you believe are necessary to reduce the damage from flood.

- Deadline : 26/July (Friday), File name: (YourFullName).docx
- How to Submit: Send the Word File to Ms. Nga (Zalo, 0932295343)

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Today's presentation material

https://drive.google.com/drive/folders/1xphKUVfuDSd31PzETpGXBOesIbbUXvlc?usp=sharing

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13/August/2024

Points for surveying a river and planning flood control

Session 2

SUZUKI Takashi,
JICA Expert (Advisor for Disaster Risk Management), VDDMA, MARD

Contents

[Session 1] 12/July (Friday)
- Preliminary preparations and surveys to grasp the characteristics of:
  + rivers and each section
  + the surrounding areas of the river (flood zone, river basin)
- Deciding the premise for considering countermeasures

[Session 2] 9/August (Friday)

◆**Suzuki explains:**
- Review of Session 1 and homework
- Planning of flood control measures

◆**Discussion, Q & A**
◆**Explanation of homework**

What we learned in Session 1

✓ Individuality (Characteristics) of Rivers / River Sections
✓ It is easy to succeed **by adapting measures that have succeeded in rivers [segments] with similar river channel characteristics**.
➔ **Understanding river channel characteristics and segment** is important.

✓ Check longitudinal changes in gradient, and divide into "segment".
✓ Check longitudinal changes in river width. **Upstream-downstream balance**.

✓ **Same "segment" have similar characteristics** (e.g. size of sediments)
*By understanding segment, can imagine the characteristics there.
*Also roughly consistent with the surrounding topographic features.

✓ Even in the field, and **imagine flood flow** from the large scale.
✓ Understand the characteristics of the basin (maps/aerial photos, past disasters, topography, population and assets)
✓ *What types of disasters should be prevented?*
Set goals, Decide what water levels are acceptable (HWL)

Review of homework

Homework of Session 1

- Choose one of your favorite rivers from the Ba, Kone, or Tra Khuc Rivers and summarize the following in an about 2-page report (Word file).

1. Using a GIS such as Google Earth, find the points of change in longitudinal gradient and divide the river into some sections. Please also indicate the approximate longitudinal gradient of each section.
2. Using a GIS such as Google Earth or other existing data, plot a graph showing the approximate change in the river channel's width or cross-sectional area.
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- Deadline: 26/July (Friday), File name: (YourFullName).docx
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Homework

No.	Name
1.	Trịnh Đức Anh _ Tô Xuân Kha
2.	Trần Quốc Uy _ Trương Quỳnh Chi
3.	Vũ Thanh Nghĩa
4.	Vũ Văn Sơn
5.	Đặng Văn Việt Hùng
6.	Đào Tuấn Anh
7.	Lê Phương Hồng
8.	Nguyễn Bá Cường _ Nguyễn Thị Thu Hương
9.	Phạm Huy Thông
10.	Phạm Xuân Thành
11.	Trần Thị Mến
12.	Lê Thị Tươi

Segment

- Divide into sections with approx. same gradient →similar characteristics.
- If the gradient is same, the size of the sediments is also roughly same.

Classification	Segment M	Segment 1	Segment 2		Segment 3
			2-1	2-2	
Geography	Mountain	Alluvial Fan	Valley plain	Natural Levee	Delta
Gradient (slope)	Various (Generally steep)	1:60 - 1:400	1:400 - 1:5,000		1:5,000 - flat
Riverbank Material	Various, including rocks	Thin layer of sand/silt (same as riverbed)	Lower layer is mixture of sand/silt/clay (same as riverbed)		Silt and clay

By "Segments", the characteristics can be imagined

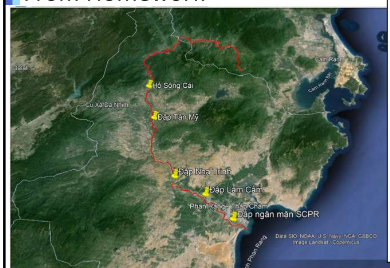
- Common in Japan as a way to understand river characteristics
- When utilizing experience from other rivers, check which segment it is

Classification	Segment M	Segment 1	Segment 2		Segment 3
			2-1	2-2	
Extent of Meandering	Various	Few meandering	Heavy meandering		Various (Large or small)
Bank Scouring	Heavy	Heavy Scouring	Medium (Big, if riverbed material is large)		Weak
Average depth	Various	0.5m - 3m	2m - 8m		3m - 8m

✓ It is easy to succeed **by adapting measures that have been successful in rivers [segments] with similar river channel characteristics**.

➔ **Understanding river channel characteristics and segment** is important.

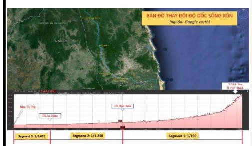
From Homework

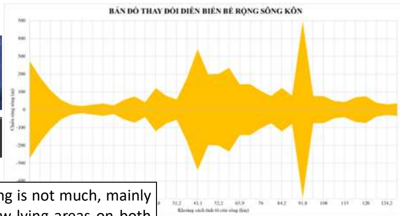


- **For segment M, segment 1:** Mainly the problem of river bank erosion, local flooding in some riverside areas
- **For segment 2:** In addition to the problem of river bank erosion, inundation and inundation often occur in low-lying areas, with a total affected area of about 2,000-3,000 hectares in the lower reaches of the Cai Phan Rang river.

Cái Phan Rang River / Đặng Văn Việt Hùng

From Homework



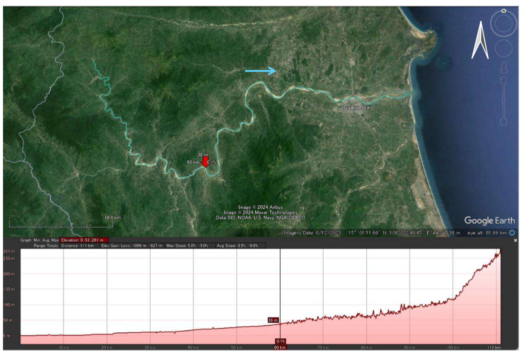


- **Segment 1:** The level of flooding is not much, mainly flooding agricultural land in low-lying areas on both sides of the river.
- **Segment 2:** The level of damage is higher than Segment 1, including **damage** mainly to agricultural land, in addition to damage to traffic infrastructure, irrigation works, and houses. …
- **Segment 3:** The level of damage is the most serious and much higher than Segment 1 and Segment 2, including **damage** to people, agricultural land (rice), traffic and medical facilities , administrative headquarters, irrigation system...

Own solution :
For Segment 2 and Segment 3 implement solutions to clear and dredge flood drainage channels, and build dikes in sections where banks often overflow, causing serious damage...

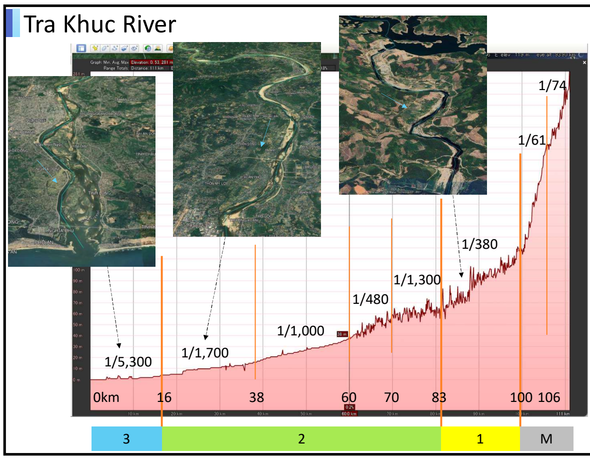
Kone River / Đào Tuấn Anh

Tra Khuc River

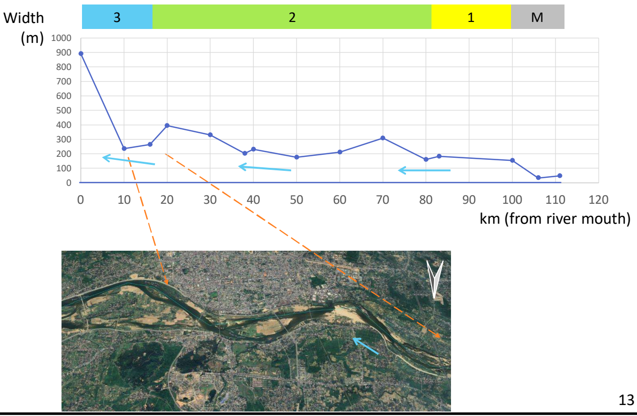


The following pages were prepared using only limited information from Google Earth, and may not necessarily correspond exactly to the actual conditions. Therefore, there may be inaccuracies in the analysis, too.

Tra Khuc River



Tra Khuc River



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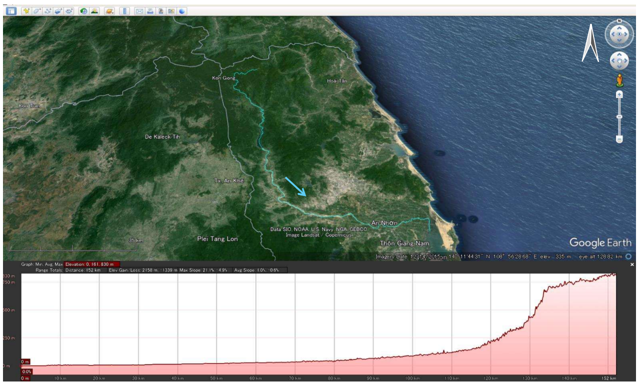
Kone River



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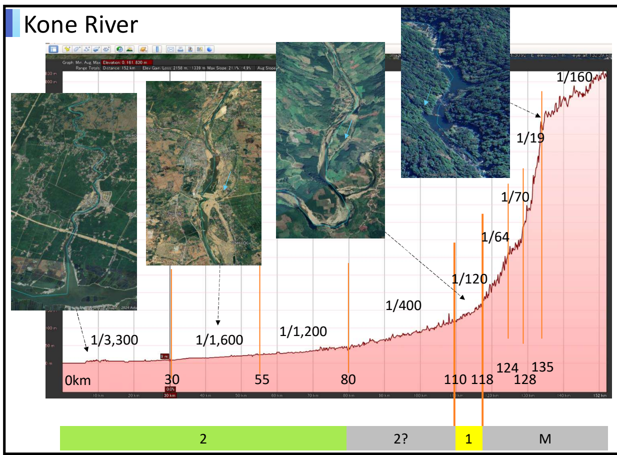
Kone River



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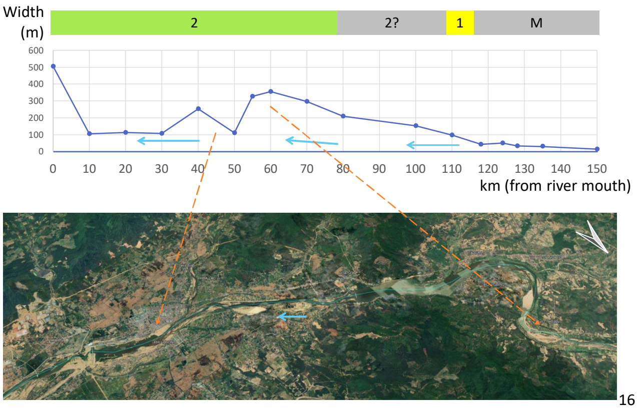
Kone River



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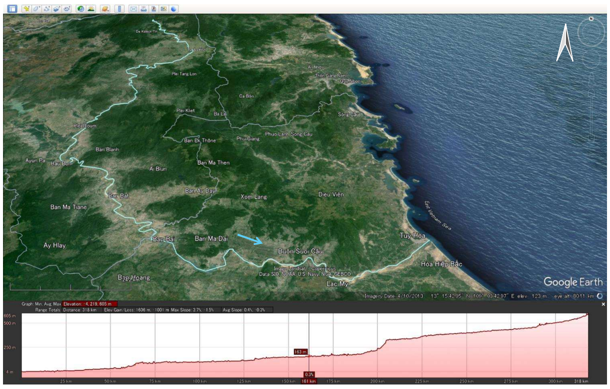
Ba River



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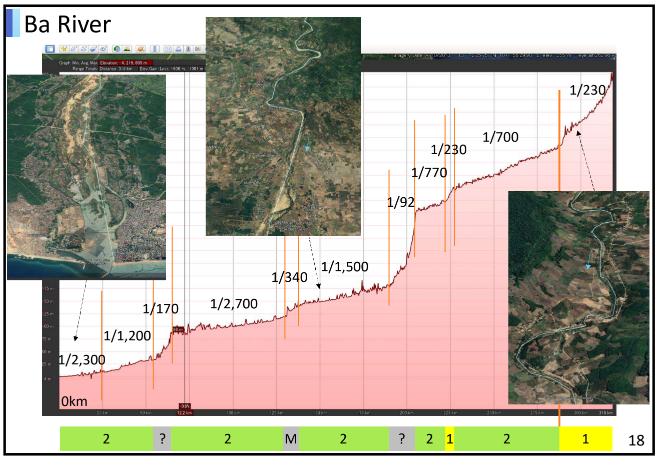
Ba River



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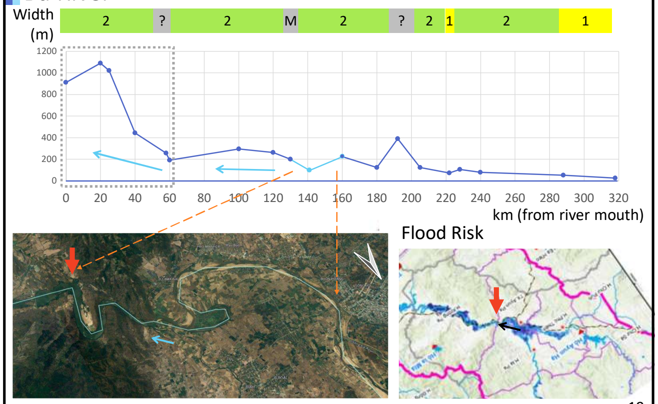
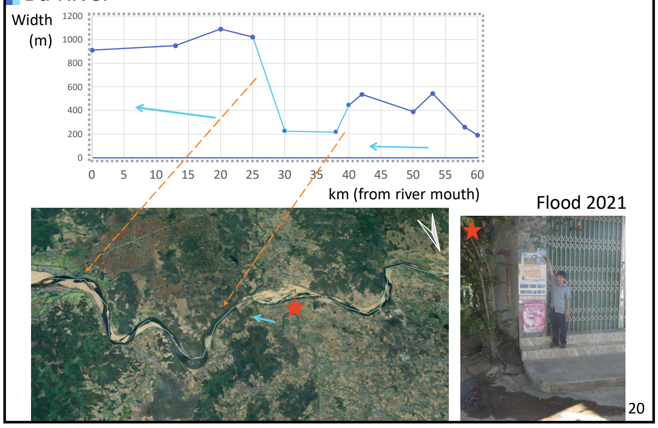
Ba River



Ba River



What did you find?

- ✓ Characteristics on a large scale <u>can be imagined to some extent</u> by analyzing maps, aerial photos, and Google Earth, without going to the site. (Yet, <u>field surveys are necessary</u> to confirm this imagination and to obtain information on smaller scales.)

- ✓ Gradient varies longitudinally.
  Each <u>section (segment)</u> has different characteristics and damage.
  <u>*Topographic data from Google Earth (especially the river bottom) is really accurate?</u>
  <u>*With survey results, more accurate and easier to analyze.</u>

- ✓ River width varies longitudinally.
  <u>Weak spots that may be overflowing could also be predicted.</u>
  <u>*Only the river width is enough to see upstream-downstream balance?</u>
  <u>*It would be better if there were survey results or if "flow capacity" could be expressed.</u>

3. Deciding the premise for considering countermeasures for disasters (especially flood)

(1) What kind of disaster should be prevented?

- flood
- storm surge
- riverbank erosion
- drought

Based on the characteristics of the river and the surrounding area that we have seen so far, we will visualize the possible damage and countermeasures, referring to the experience of other rivers.
(Where is the area likely to overflow, where is the area likely to experience riverbank erosion, and where are the areas that should be protected?)

(2) Decide the target discharge of countermeasures

- Basically, <u>the discharge of the largest flood in the past</u> is often used as a guide. (overflows from the river must also be taken into account)

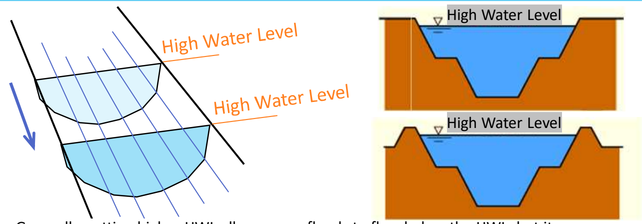
- If the measures take too much time and budget, a smaller discharge may be used <u>as an short-time target (a step-by-step response)</u>.

- On the other hand, if it is considered highly likely that a greater flood will occur based on conditions in other nearby rivers, an even higher target may be set.
  (Based on statistics, a setting such as "once in 100 years" may be used.)

- It is common to set a <u>reference point</u> at an important location for the river (e.g., near an urban area) where hydrological observation data can be obtained, and use the discharge at that point as a guide.
  (However, it is necessary to consider not only this point, but also the entire upstream and downstream areas.)

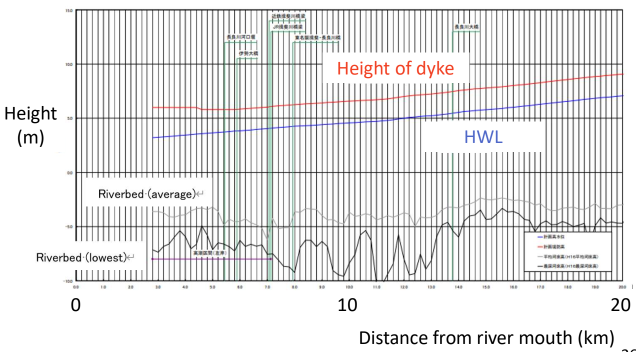
(3) Decide what water levels are acceptable (HWL)

- **High Water Level (HWL)**:
  "the water level which the planned flood would safely flow below".



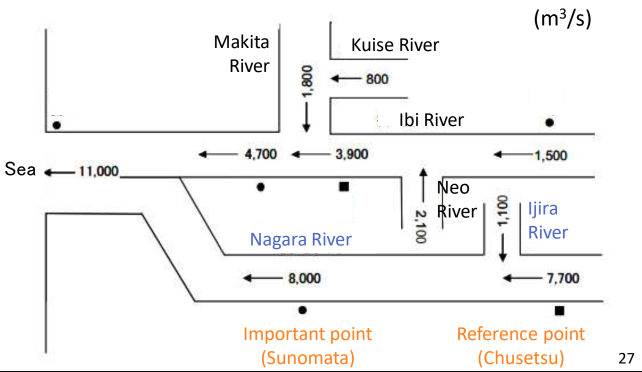
- Generally, setting higher HWL allows more floods to flow below the HWL, but it means planning higher dykes, which may result in poor drainage from the riverside area and tributaries and higher water levels even in small and medium-sized floods, as well as the risk of breaching the dykes and causing huge damage in the event of a major flood, resulting in serious damage.
- Therefore commonly set HWL as low as possible. (If possible, set the HWL at ground level, or set it so that it does not exceed the highest water level of past floods.)

High Water Level (HWL)



(4) Discharge Diagram

- Figure out how much flow is required at each point.



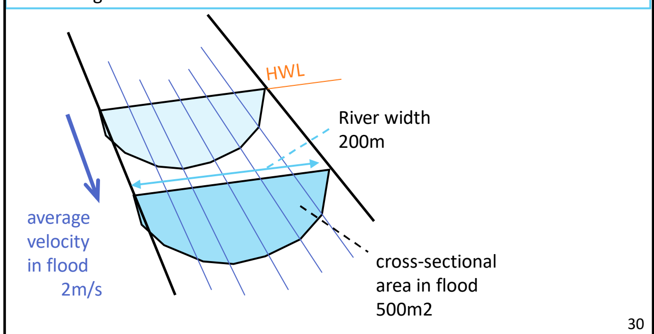
4. Planning countermeasures

4. Planning countermeasures

a) Measures to prevent flood overflows	b) Measures to ensure the safety of dyke and riverbank

(1) Flow capacity

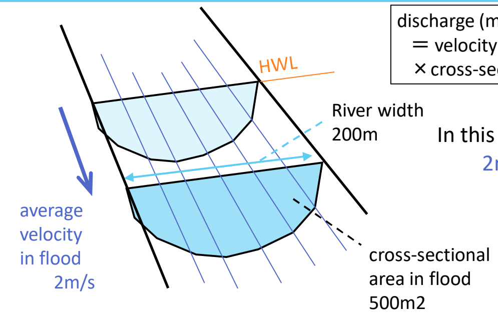
- How much flood water can be handled in one second = "flow capacity".
- River width can be also a reference, but more accurately expressed in discharge



(1) Flow capacity

- How much flood water can be handled in one second = "flow capacity".
- River width can be also a reference, but more accurately expressed in discharge

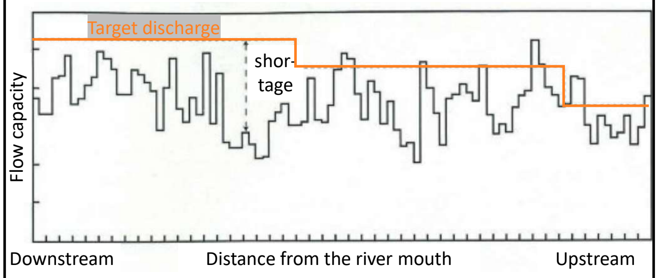
discharge (m^3/s)
＝velocity (m/s)
×cross-sectional area (m^2)



In this figure's case:
2m/s × 500m^2
＝1,000m^3/s

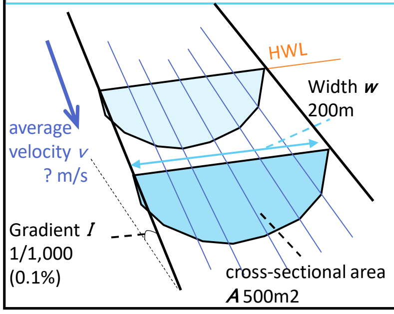
(2) "Flow capacity diagram" to identify weak points, etc.

- Graph the "flow capacity" at each location.
- Overlap the target discharge and check for shortages



Calculating "Flow capacity"

- Flow capacity is determined to some extent by the river width, cross-sectional area, gradient, riverbed material, etc.
- Here, **Manning's equation** for reference (often used in the calculation of waterways, etc., but not really used in the analysis of river floods)



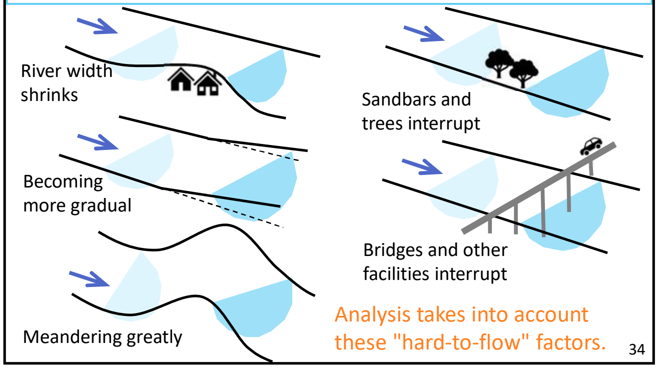
$$v = \frac{1}{n} R^{\frac{2}{3}} I^{\frac{1}{2}}$$

$R = A/S$ (≒ A/w) [m]
(S : grounded length ≒w)
n = Manning's roughness coefficient. For example, 0.025 [m $^{-1/3}$ s] (varies with riverbed material, etc.)

➔Velocity v =2.33 [m/s]
Discharge Q =1,165 [m^3/s]

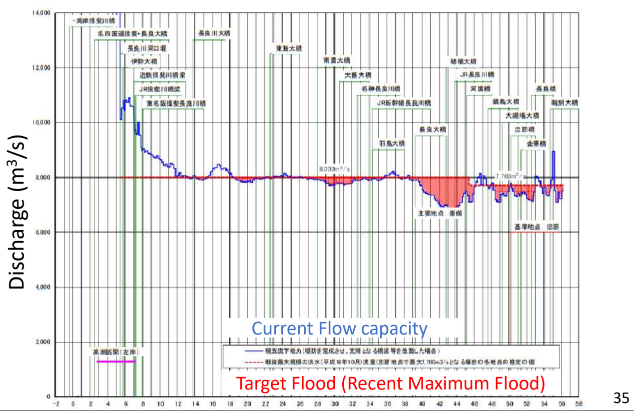
Calculating "Flow capacity"

- Hydraulic analysis taking into account: sandbars, trees, meandering, etc.; tributary confluence; and water level at the mouth of the river.

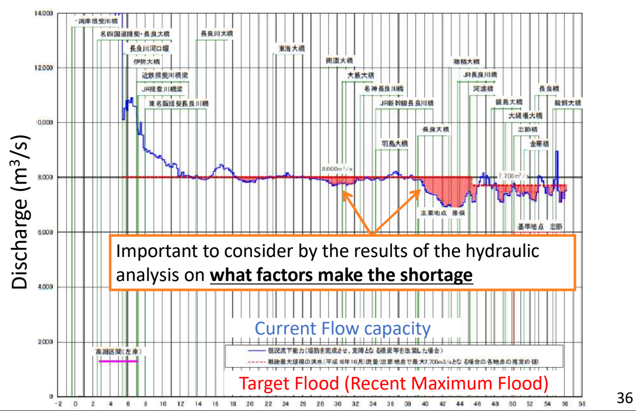


Analysis takes into account these "hard-to-flow" factors.

Flow capacity Diagram



Flow capacity Diagram



(3) Consider countermeasures based on characteristics of each section and flow capacity diagram, etc.

- Consider measures to ensure flow capacity below the planned HWL

- If flow capacity shortage is slight:
  →Localized measures (excavation, tree cutting, etc.) on current channel

- If big shortage but just improve of river channel might be enough:
  →Excavation of river bed or riverbank

- If big shortage, and improvement of the channel is not enough:
  →Widening, Dyke heightening(*),
  Storing flood water at upstream (dam, retarding reservoir),etc.
  (*)Note that Dyke heightening results in increasing HWL

※**However, these measures may cause side effects (Ideally, we should consider countermeasures imagining possible side effects.)**

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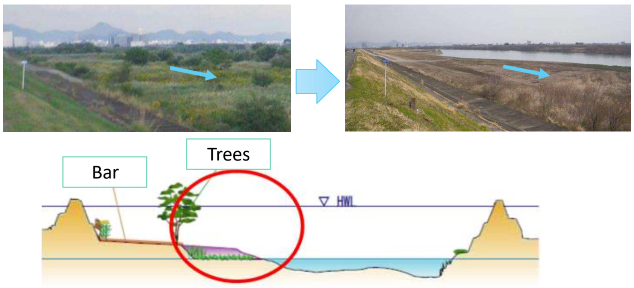
Excavation, tree cutting (to have more space in channel)



***Examples of possible side effects:**
1) Some may say that precious greenery will be lost, which they feel very sad.
2) Sediment may accumulate or trees may grow back in the area that has been excavated.
3) Changes in water and sediment flow (e.g., riverbank erosion)

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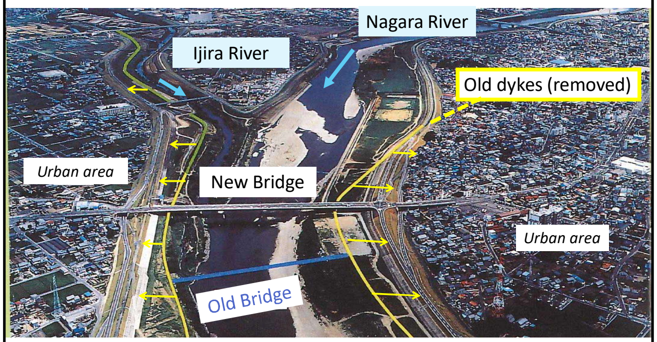
Widening (to have more river space)



***Examples of possible side effects:**
1) Affecting many homes and infrastructure (may requires relocation)
2) Changes in water and sediment flow (e.g., sandbars)

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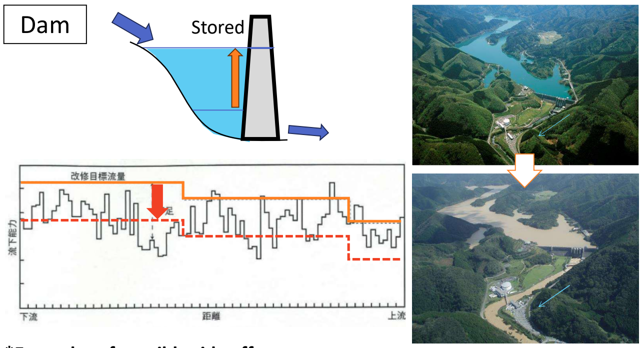
If difficult to catch in the river channel, store in upstream



Hiyoshi Dam, Katsura River
Flood in 2023

***Examples of possible side effects:**
1) Need very huge land, affecting many homes and infrastructure
2) Changes in downstream

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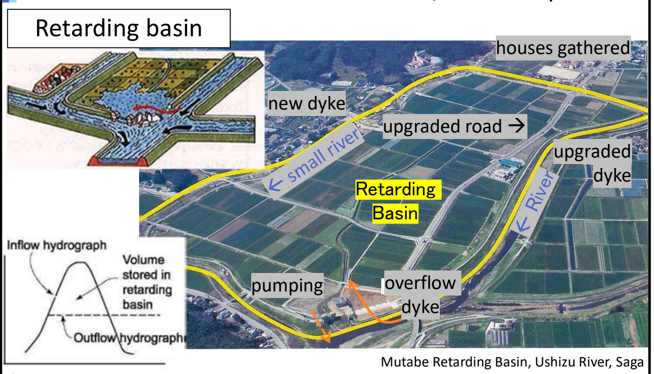
If difficult to catch in the river channel, store in upstream



Mutabe Retarding Basin, Ushizu River, Saga

***Examples of possible side effects:**
1) Need huge land, affecting many homes and infrastructure (compensation)

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Improve drainage around river mouth (spillway)

Many lagoons, Rivers Meandering: due to coastal dunes. (400 years ago)
→ Up to now, many spillways to improve drainage.

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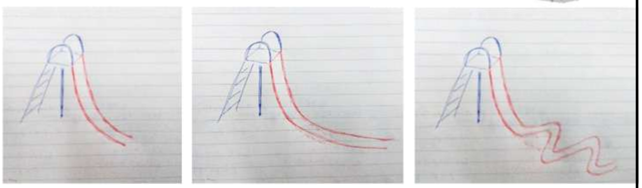
Slide (at playground)



Downstream is too long

Meandering too much

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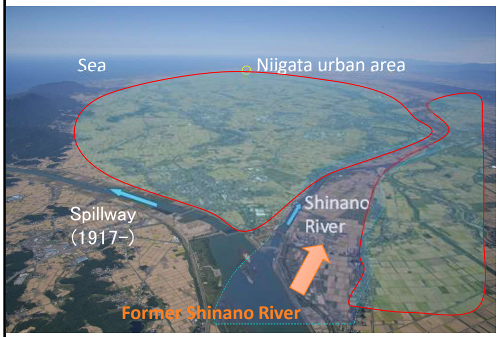
Improve drainage around river mouth (spillway)



- Flood mitigation
- Better Rice paddy
- Better Land use (Urban area, transport)

***Examples of possible side effects:**
1) Need huge land, affecting many homes and infrastructure
2) Changes in water and sediment flow (e.g., coastal erosion)

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(4) Be careful for river's response

Shinano River Mouth (Niigata City) Photo: 1985

https://www.pref.niigata.lg.jp/sec/kasenkanri/1195056559246.html

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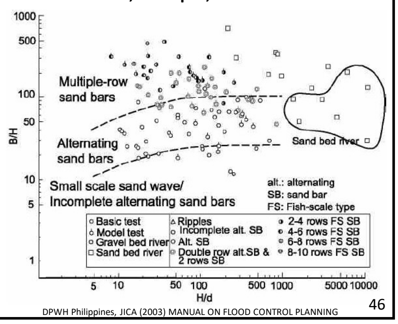
Be careful for river's response

Tokachi River (Watanabe, 2019)

Appearance of sandbars depends on the river width-depth ratio (B/H).
*For details, refer to specialized materials.

B: River width, H: Depth, d: diameter of material



DPWH Philippines, JICA (2003) MANUAL ON FLOOD CONTROL PLANNING

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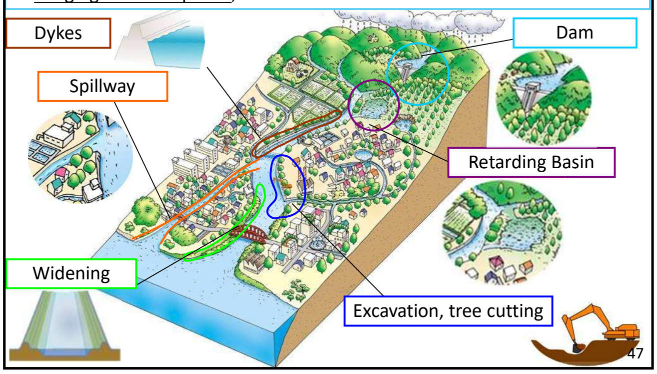
Various measures to prevent flood overflows

- Consider based on flow capacity, segments, and other characteristics. Imaging river's response, too.



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4. Planning countermeasures

a) Measures to prevent flood overflows | b) Measures to ensure the safety of dyke and riverbank

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(1) Identify weak points and decide areas to be addressed

- Roughly from the characteristics of each section, sandbars, flood flow, etc.
- Better to consider in combination with the measures for the flow capacity.

Seg ment	Frequency	Location of Occurrence	Approximate erosion width (case study)
1	Intense (can occur all at once)	Likely on both banks because multiple-row bars are easily formed and the stream meanders over them	About half the width of the bar (about 40 m, up to 100 m)
2-1, 2-2	Moderate (Large if riverbed material is large)	In curved channels, more likely at the outer bank where flood flows, as well as at the flow attacking point. In straight channels, more likely on both banks because the flow meanders over sandbars similarly as in Segment 1.	[2-1] ≒River bank height (h) ×5 (≤ 30 m) [2-2] ≒ h×2～3 (≤ 20m)
3	Weak	Less likely, but possible at the outer side of curve	≒ h×2～3 (≤ 20m)

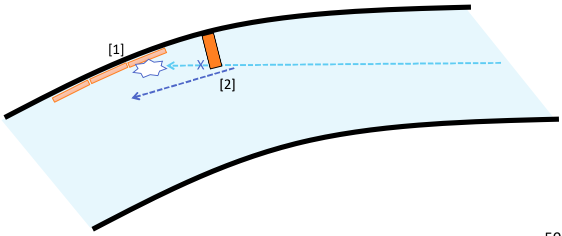
Note that scouring by local flows is likely to occur near piers, weirs, sluice gates, etc.

(2) Consider countermeasures for bank erosion

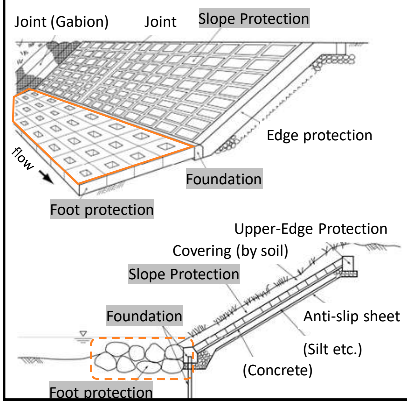
- Set up a "protection line " and limit erosion to that point.
- Two ways: [1] use revetments, etc., and [2] keep the flow away.

[1] Bank protection

[2] River Groyne (to keep strong flow (thalweg) away)

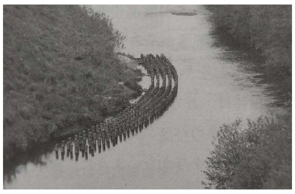


[1] Bank protection



Foot protection is important.

[2] River Groyne



5. Summarizing measures

(1) Put it all together as plans and drawings.

(Example)

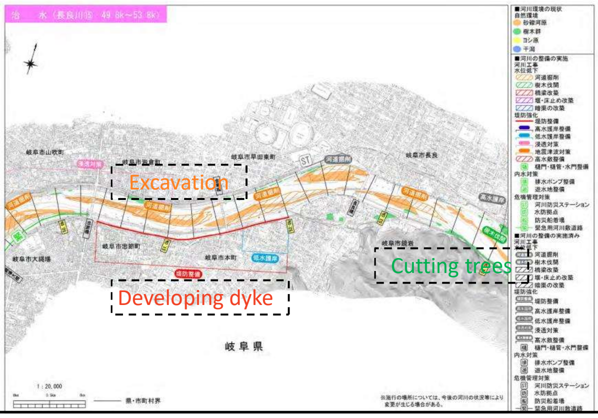
Excavation

River	Side	Place	
Nagara	Left side	AAA～BBB, Gifu City	51.4～52.4 km
Nagara	Right side	CCC～DDD, Gifu City	50.1～51.4 km
Ijira	Right side	EEE～FFF, ○○ City	4.6～5.0 km
・・・	・・・	・・・	・・・

Cutting Trees

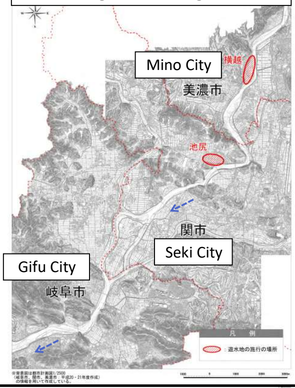
River	Side	Place	
Nagara	Right side	GGG, Gifu City	54.0～54.5 km
・・・	・・・	・・・	・・・

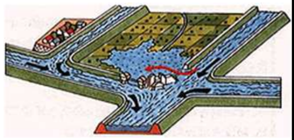
(1) Put it all together as plans and drawings.



(1) Put it all together as plans and drawings.

Retarding basins, Nagara River





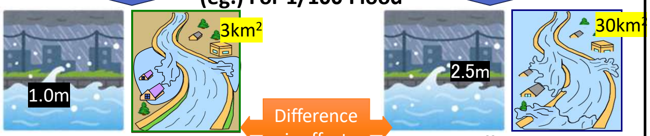
areas for retarding basins

(2) Assumption of how much damage is reduced

- Assume damage reduced by the measures (property values' data needed)
- Calculate reduction amount for each flood extent (probability) and obtain the expected value = benefit of the measures

With the project | Without the project

(eg.) For 1/100 Flood



Damage: 10 Billion VND | **100 Billion VND**

Damage reduction is calculated for each kind of land use (houses, offices, rice paddies, fields, etc.) based on inundation simulations with and without measures, and then multiplied by the unit cost for each kind of land use to evaluate the amount of reduction.

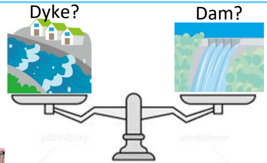
*For more details, refer to the specialized materials.

(3) "Cost-effectiveness."

- Effectiveness of measures = damage reduced by measures (benefit in terms of monetary value)
- Cost-effectiveness (cost-benefit) = compared to the cost required

Structural measure A

(example) B/C=3.0



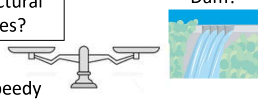
Structural measure B

(example) B/C=4.0

Non-Structural measures?

Structural measure

Dam?



○ Quick, low cost ➔ Can be implemented speedy

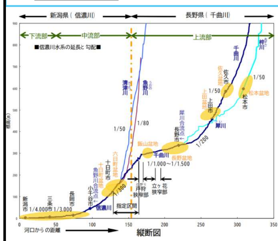
× No mitigating the external forces ➔ **Not so big impact**

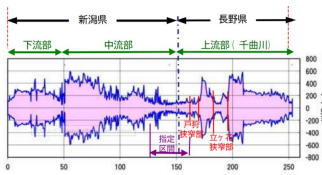
(∵ **No reduction of inundation damage**)

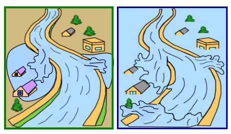
6. Other points to be noted

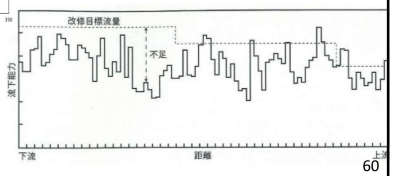
Importance of utilization of Data

- **Basic data** such as river and basin surveys are **the basis for all**





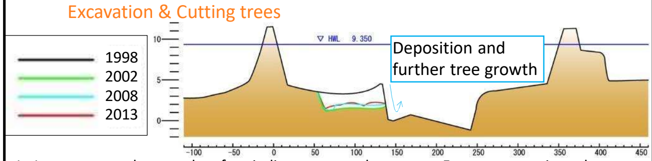




Inspection and maintenance are important.

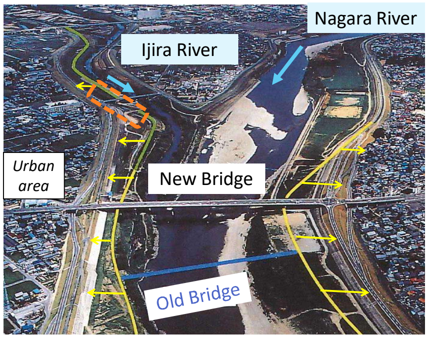
- Recognize changes in the river channel (especially response after work) and respond as soon as possible

Excavation & Cutting trees

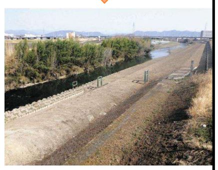


In Japan, accumulate results of periodic surveys: at least every 5 years, approximately every 200m in longitudinal direction. Required scale of the survey intervals and drawings depend on the river size (width etc.).

Be careful of trees, and of cutting down trees.



2022.10



2023.3

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Learning journey is endless

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For those who want to learn more -1

- DPWH Philippines, JICA (2003) Manual on Flood Control Planning
  [Segment, Flow capacity, River survey and planning]
  https://www.jica.go.jp/project/philippines/0600933/04/pdf/Manual_on_FC_Planning.pdf

- MLIT Japan (2005) Manual for Economic Evaluation of Flood Control Investment - Draft
  [Cost-benefit analysis]
  https://www.mlit.go.jp/river/kokusai/pdf/pdf06.pdf

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For those who want to learn more -2

- Suzuki (2023) On Countermeasure for Riverbank Erosion
  [Revetment, Groyne]
  (VIET) https://phongchongthientai.mard.gov.vn/Pages/bai-trinh-bay-cua-chuyen-gia-jica-ve-bien-phap-chong-xoi-lo-bo-song.aspx
  (ENG) https://phongchongthientai.mard.gov.vn/en/Pages/presentation-of-jica-expert-on-countermeasure-for-riverbank-erosion.aspx

- Suzuki (2023) Key points of successful flood control measures for the Tsurumi River and recommendations based on them
  [Upstream-Downstream balance, Comprehensive measures at the river basin]
  (VIET) https://phongchongthientai.mard.gov.vn/Pages/chuyen-gia-jica-diem-mau-chot-trong-cac-bien-phap-kiem-soat-lu-thanh-cong-cho-song-tsurumi-tai-nhat--.aspx
  (ENG) https://phongchongthientai.mard.gov.vn/en/Pages/jica-expert-key-points-of-successful-flood-control-measures-for-the-tsurumi-river-and-recommendations-based-on-them.aspx

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What we learned

Session 1 (River Survey)

- ✓ Individuality (Characteristics) of Rivers / River Sections
- ✓ It is easy to succeed **by adapting measures that have succeeded in rivers [segments] with similar river channel characteristics**.

➔ **Understanding river channel characteristics and segment** is important.

- ✓ Check longitudinal changes in gradient, and divide into "segment".
- ✓ Check longitudinal changes in river width. **Upstream-downstream balance**.

- ✓ **Same "segment" have similar characteristics** (e.g. size of sediments)
  *By understanding segment, can imagine the characteristics there.
  *Also roughly consistent with the surrounding topographic features.

- ✓ Even in the field, and **imagine flood flow** from the large scale.
- ✓ Understand the characteristics of the basin (maps/aerial photos, past disasters, topography, population and assets)

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What we learned

Session 2 (Flood Control Planning)

- ✓ Decide the target discharge of countermeasures, high water level
- ✓ Considering countermeasures based on Flow Capacity
  - * Various measures
  - * Be careful for Side effect (especially river's response: sandbar, coast)
- ✓ **Ensure the safety of dyke and riverbank from the characteristics of each section, sandbars, flood flow, etc.**
- ✓ Two ways: [1] use revetments, etc., and [2] keep the flow away.
- ✓ Put it all together as plans and drawings.
- ✓ Cost-effectiveness, based on damage reduction
- ✓ Importance of utilization of Data
- ✓ **Inspection and maintenance** (especially **response after work**)

Suggestion by Suzuki

- **"Segment", "Discharge Diagram" and "Flow Capacity Diagram"** shall be the standard for surveying and planning in Vietnamese rivers, and shall be attached to the Flood Control Master Plan.
- From segment characteristics, sandbars, and flood flows, mark sections where riverbank erosion countermeasures are particularly needed.
- Conduct periodic surveys as much as possible and update the Flow Capacity Diagrams accordingly.
- Institutionalize a system and budget for periodic inspections and maintenance.

⇩

If you agree with these, I would be happy to continue discussing them with you sometimes, and also to assist in the development of "Guidelines for River Surveying and Planning".

Homework

1. For the river you chose at the previous homework,

a. Imagine the longitudinal changes in the flow capacity based on the width and gradient of the river, etc., and draw a rough graph as a flow capacity diagram.

b. Based on the flow capacity diagram you drew in a., list specific measures and locations (one to three) that you believe are necessary to reduce the damage from flood.

c. For each of the measures listed in b., list possible "side effects" and suggest what can be done to reduce its negative factor.

2. Tell us what was new and impressed you during these two sessions. Also, tell us how you would like to apply them to your future work.

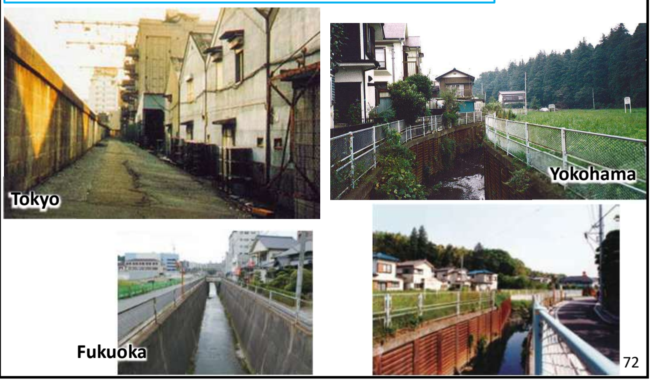
- Deadline: 10/September (Tuesday), File name: (YourFullName).docx
- How to Submit: Send the Word File to Ms. Nga (Zalo, 0932295343)

Today's presentation material

https://drive.google.com/drive/folders/1FNbYly1Qm1X0sUqaDiubJV1nD5HOC9qG?usp=drive_link

If you **only** think about flood control...

✓ Ugly landscape, Unpleasant daily life



With **city design** & **environment design**,

✓ Pleasant daily life

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Hội Thảo Đối Thoại Hợp Tác Quản Lý Thiên Tai Việt Nam-Nhật Bản Lần Thứ 12

Tiến độ Dự án Xây dựng bản đồ rủi ro lũ lụt tại Sông Hồng và Sông Mã

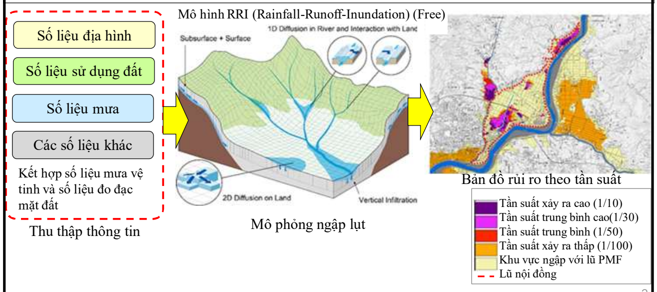
MARUYAMA Kazuki
Giám đốc điều phối quốc tế về kỹ thuật sông
Cục quản lý nước và thiên tai
Bộ Đất đai, Cơ sở hạ tầng, Giao thông và Du lịch, Nhật Bản

Hà Nội, 28/11/2024

Nội dung

1. Giới thiệu Dự án Xây dựng bản đồ rủi ro lũ lụt

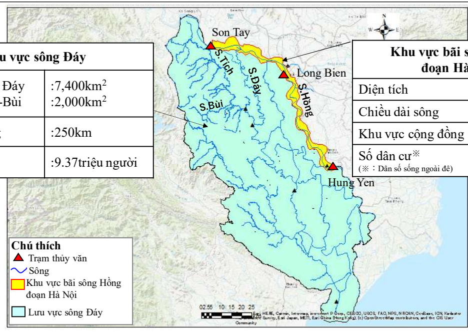
- Nhật Bản đã trình bày "Sáng kiến Kumamoto về Nước" tại Hội nghị thượng đỉnh về Nước Châu Á - Thái Bình Dương lần thứ 4 vào năm 2022.
- Dựa trên sáng kiến này, Nhật Bản đang hợp tác với một số quốc gia Châu Á về "Lập bản đồ rủi ro lũ lụt".
- Trong Dự án này, các khu vực có nguy cơ ngập lụt sẽ được tính toán chính xác bằng cách kết hợp dữ liệu vệ tinh với dữ liệu quan sát mặt đất và trực quan hóa tần suất lũ lụt trên bản đồ.
- Bản đồ rủi ro dựa trên tần suất có thể được sử dụng trong việc đánh giá và phát triển các chiến lược giảm thiểu lũ lụt.



Dự án Xây dựng bản đồ rủi ro lũ lụt tại Việt Nam

- Dự án lập bản đồ rủi ro lũ lụt tại Việt Nam được thực hiện tại 2 lưu vực sông gồm lưu vực sông Hồng-Thái Bình và lưu vực sông Mã với sự thống nhất giữa MLIT và MARD.
- Năm nay, Dự án sẽ tiến hành đánh giá rủi ro lũ lụt tập trung vào lưu vực sông Hồng - Thái Bình trong đó tập trung vào khu vực dân cư ở bãi sông ngoài đê sông Hồng đoạn Hà Nội và lưu vực sông Đáy.

Lưu vực sông Đáy	
Diện tích sông Đáy Diện tích Tích-Bùi	:7,400km^2 :2,000km^2
Chiều dài sông	:250km
Dân số	:9.37triệu người



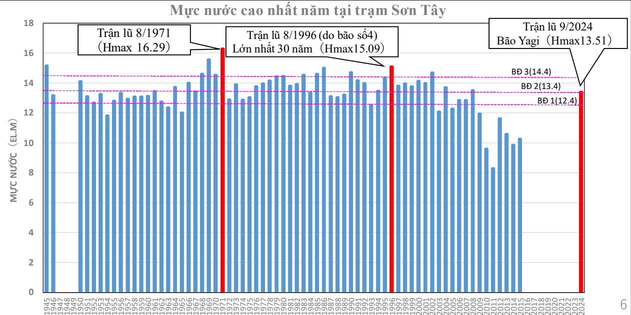
Khu vực bãi sông Hồng đoạn Hà Nội	
Diện tích	:346.1km^2
Chiều dài sông	:163.0km
Khu vực cộng đồng	:89điểm
Số dân cư※ (※：Dân số sống ngoài đê)	:365 ngàn

2. Nghiên cứu khu vực bãi sông Hồng đoạn Hà Nội

Tình hình lũ tại khu vực dân cư ngoài bãi sông Hồng

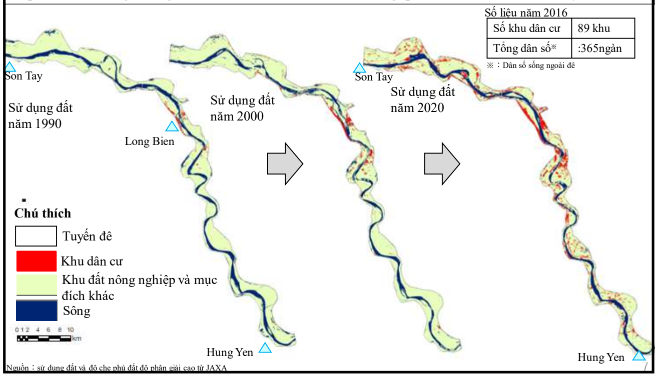
- Kể từ năm 1945, theo kết quả đo đạc tại trạm Sơn Tây có ít nhất 13 trận lũ vượt báo động lũ cấp III (14.4EL.m), trận lũ 8/1971 là trận lũ lớn nhất được ghi nhận. Trận lũ 8/1996 là trận lũ lớn nhất kể từ năm 1971, Hmax= EL.15.09m và Qmax = 20.000 m^3/s.
- Trong trận lũ tháng 9/2024 (bão Yagi), mực nước cao nhất ghi nhận tại Sơn Tây là EL.13.51m, vượt mức cảnh báo lũ II (EL.13.4m).

Mực nước cao nhất năm tại trạm Sơn Tây



Đặc điểm sử dụng đất khu vực bãi sông (thay đổi sử dụng đất)

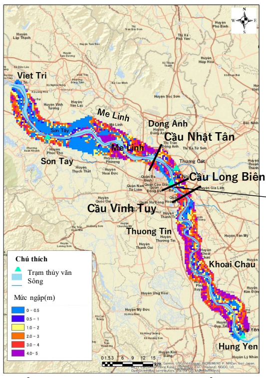
- Các khu dân cư đã được hình thành và mở rộng tại khu vực này, đồng thời có quy hoạch phát triển trong tương lai nên cần xem xét đến rủi ro ngập lụt của các địa điểm này.



Tổng quan về mô hình cho khu vực bãi sông sông Hồng

	Tổng quan về xây dựng mô hình khu vực bãi sông
Mô hình	Rainfall-Runoff-Inundation (RRI) Model（Miễn phí）
Độ phân giải	15 sec (khoảng 500x500m)
Khu vực nghiên cứu	Khu vực dân cư ngoài đê sông Hồng đoạn Hà Nội
Địa hình	Hiệu chỉnh HydroSHEDS(Miễn phí) và dữ liệu mặt cắt khảo sát
Điều kiện biên tính toán	Số liệu đo đạc lưu lượng tại trạm Sơn Tây (biên thượng lưu) Số liệu đo đạc mực nước tại trạm Hưng Yên (biên hạ lưu) (Trang web của vp phòng chống thiên tai thành phố Hà Nội, Đài khí tượng)
Sử dụng đất	GLCNMO（Miễn phí）
Mặt cắt	Mặt cắt đo đạc năm 2000, 2023（MARD cung cấp）
Trận lũ kiểm định	Trận lũ 8/1996 Trận lũ 9/2024
Thời gian tính	8/8 – 31/8/1996 3/9 – 25/9/2024
Thời gian ổn định mô hình	1/7 – 7/8/1996 25/8 – 2/9/2024

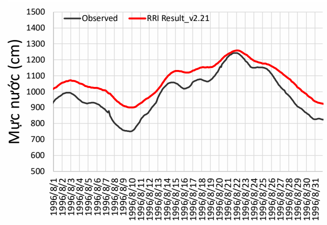
Kiểm định mô hình cho khu vực bãi sông Hồng（Trận lũ 8/1996）



Bản đồ vùng ngập độ sâu ngập lớn nhất trận lũ 8/1996

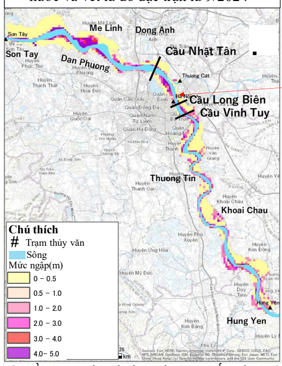
- Mặc dù vẫn còn có một số sai số trong mực nước tính toán do thiếu dữ liệu cắt ngang, nhưng nhìn chung mô phỏng được mực nước đỉnh lũ.

So sánh với mực nước đo tại điểm Long Biên (Hà Nội)



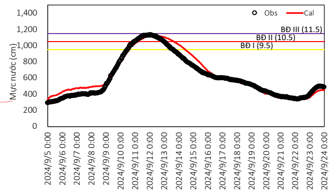
Kiểm định mô hình cho khu vực bãi sông Hồng（Trận lũ 9/2024）

- Kết quả mô phỏng tương đối tốt mực nước và vết lũ đo đạc trận lũ 9/2024

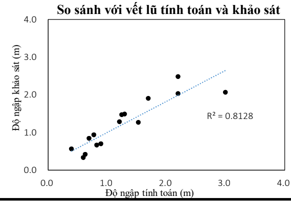


Bản đồ vùng ngập độ sâu ngập lớn nhất trận lũ 9/2024

So sánh với mực nước đo tại điểm Long Biên (Hà Nội)

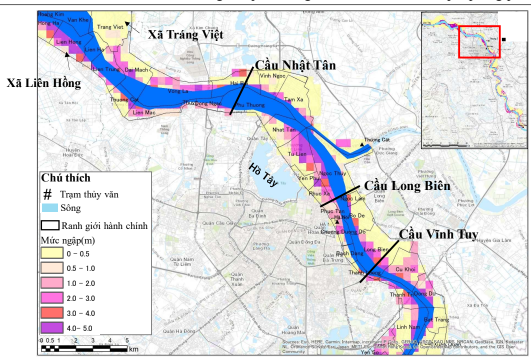


So sánh với vết lũ tính toán và khảo sát



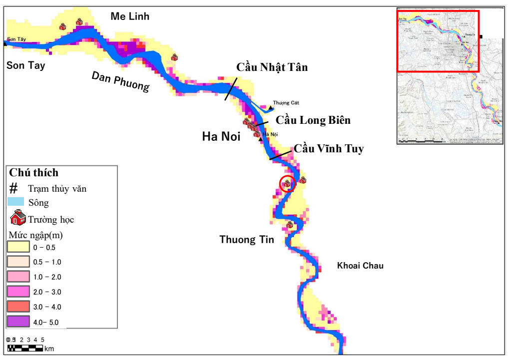
Ví dụ về sử dụng bản đồ ngập lụt (hiểu rủi ro lũ lụt theo từng khu vực hành chính)

- Thể hiện nguy cơ ngập lụt theo từng ranh giới hành chính lên bản đồ, có thể hình dung được sự phân bổ rủi ro lũ lụt khu vực đó như một thông tin quan trọng để thực hiện các biện pháp ứng phó thích hợp.



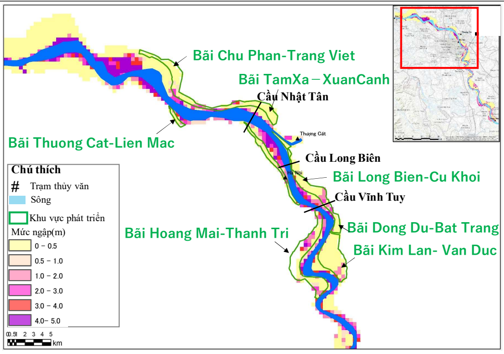
Ví dụ về sử dụng bản đồ ngập lụt (hiểu rủi ro lũ lụt các cơ sở quan trọng như trường học)

- Thể hiện các vị trí của trường học và các cơ sở quan trọng khác lên bản đồ khu vực ngập lụt, có thể hiểu được nguy cơ thiệt hại do lũ lụt đối với các cơ sở này và có biện pháp đối phó thích hợp.



Ví dụ về sử dụng bản đồ ngập lụt (hiểu rủi ro lũ lụt với khu vực sẽ phát triển)

- Thể hiện các khu vực phát triển trong tương lai lên bản đồ vùng ngập lụt, có thể đánh giá đúng rủi ro lũ lụt, đưa ra các biện pháp thích hợp để giảm thiểu rủi ro và thúc đẩy phát triển bền vững và an toàn



3. Nghiên cứu tại lưu vực sông Đáy

Tổng quan về sông Đáy

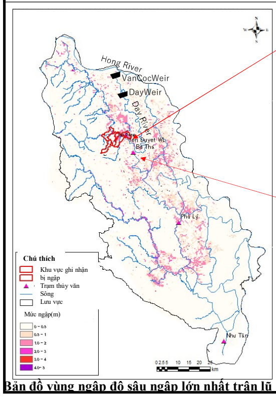
Tại lưu vực sông Đáy, xây dựng mô hình phân tích dành riêng cho sông Đáy và kiểm định các trận lũ lớn đã xảy ra trong quá khứ nhằm có được cái nhìn tổng quan về tình hình ngập lụt.

Tổng quan về xây dựng mô hình sông Đáy

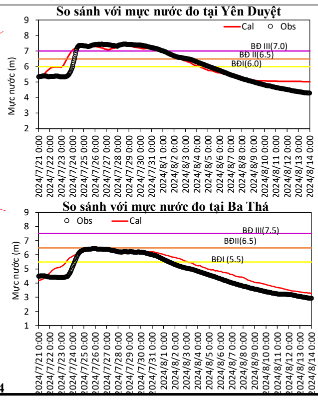
	Mô hình sông Đáy
Mô hình	Rainfall-Runoff-Inundation (RRI) Model（Miễn phí）
Độ phân giải	15 sec (khoảng 500x500m)
Khu vực nghiên cứu	Lưu vực sông Đáy
Địa hình	HydroSHEDS(Miễn phí)
Điều kiện biên tính toán	Số liệu mưa đo đạc Số liệu đo đạc mực nước tại trạm Như Tân (biên hạ lưu) (Trang web của vp phòng chống thiên tai thành phố Hà Nội, Đài khí tượng)
Sử dụng đất	GLCNMO（Miễn phí）
Mặt cắt	Mặt cắt đo đạc năm 2023（MARD cung cấp）
Trận lũ kiểm định	Trận lũ 7/2024 Trận lũ 9/2024
Thời gian tính	16/7 – 21/8/2024 3/9 – 5/10/2024
Thời gian ổn định mô hình	1/7 - 15/7/2024 20/8 - 2/9/2024

Kiểm định mô hình cho lưu vực sông Đáy（Trận lũ 7/2024）

- Kết quả mô phỏng tương đối tốt so với mực nước đo đạc trận lũ 7/2024

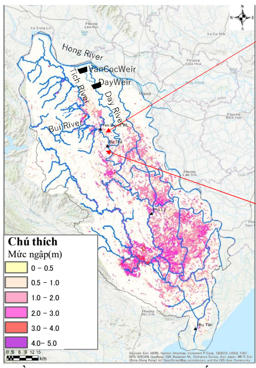


Bản đồ vùng ngập độ sâu ngập lớn nhất trận lũ 7/2024

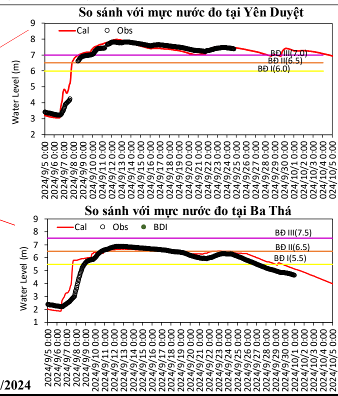


Kiểm định mô hình cho lưu vực sông Đáy（Trận lũ 9/2024）

- Kết quả mô phỏng tương đối tốt so với mực nước đo đạc trận lũ 9/2024

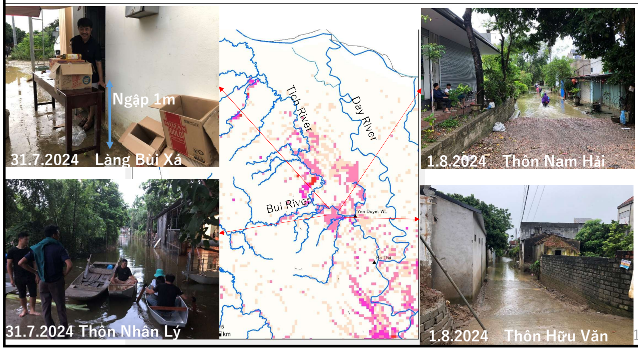


Bản đồ vùng ngập độ sâu ngập lớn nhất trận lũ 9/2024



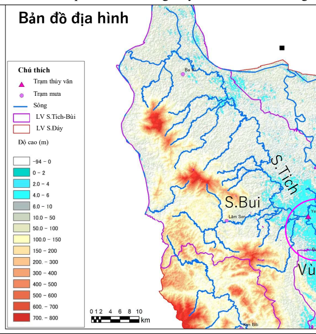
Thiệt hại do lũ tại lưu vực sông Tích Bùi của sông Đáy (Trận lũ 7/2024)

- Theo báo cáo UBND TP Hà Nội ngày 2/8/2024, khu vực Hà Nội xảy ra mưa lớn từ ngày 22/7- 25/7 do bão số 2, tổng lượng mưa tại Chương Mỹ là 324 mm. Tại Yên Duyệt trên sông Tích, mực nước cao nhất đạt 7,43 m (cao hơn cấp III 0,43 m) vào lúc 5 giờ ngày 29/7/2024, gây thiệt hại do lũ lụt trên diện rộng. Về thiệt hại do lũ lụt, có 3 người chết, 1.252 hộ gia đình bị ảnh hưởng do lũ lụt, 3.529 người phải sơ tán.



Điểm cần lưu ý ở sông Đáy: Đặc điểm địa hình dễ bị lũ lụt ở sông Tích-Bùi

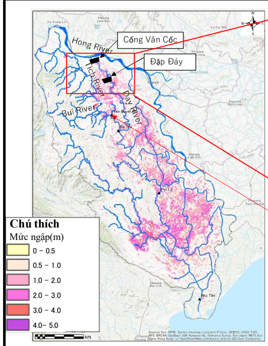
- Địa hình sông Tích-Bùi có núi cao ở phía tây và vùng đất trũng ở phía đông. Nhiều con sông có thượng nguồn xuất phát từ sườn núi cao phía tây, khi mưa lớn sẽ sinh lũ rừng ngang chảy nhanh tập trung về hạ lưu. Ngoài ra, do hợp lưu với sông Đáy tại hạ lưu nên thoát nước kém, dễ xảy ra lũ lụt. Đồng bằng là vùng trũng rộng lớn, có nhiều người dân sinh sống dưới mực nước thiết kế nên một khi lũ lụt xảy ra sẽ có nguy cơ gây thiệt hại lớn.
- Vì vậy, khi xem xét phân lũ vào sông Đáy cần xét đến tác động đến lưu vực sông Tích-Bùi.



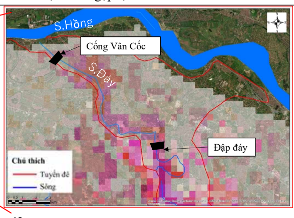
Hộ đê khẩn cấp sông Bùi 10/9/2024

Tình hình ngập lụt lưu vực sông Đáy (mô phỏng khi phân lũ 2.500m3/s từ sông Hồng)

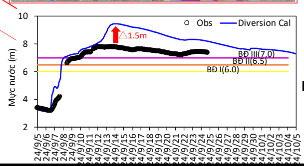
- Để kiểm tra ảnh hưởng của việc phân lũ từ sông Hồng vào sông Đáy, dự án tiến hành mô phỏng việc phân lũ 2.500m3/s trong trận lũ năm 9/2024. Nhận thấy, phân lũ không chỉ gây ra ngập lớn ở thượng nguồn sông Đáy mà mực nước sông Tích-Bùi cũng bị dâng cao, tăng độ sâu và diện tích ngập lụt.



Bản đồ vùng ngập độ sâu ngập lớn nhất



Khu vực phân chậm lũ



Mực nước trạm Yên Duyệt

4. Kế hoạch dự kiến

Lộ trình tổng thể dự án

Trong tương lai, Dự án Xây dựng bản đồ rủi ro lũ lụt dự kiến sẽ tiếp tục thực hiện các đánh giá rủi ro lũ lụt nhằm góp phần thúc đẩy các biện pháp đối phó lũ lụt ở các lưu vực sông mục tiêu cho đến tháng 3 năm 2026.

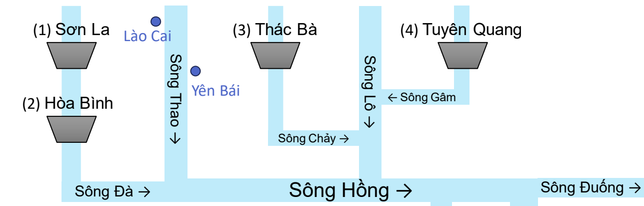
Giai đoạn dự án		2024(Q2-Q4)			2025				2026			
		Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Dự án Xây dựng bản đồ rủi ro lũ lụt (Dự án)	Phân tích và đánh giá rủi ro ngập lụt thí điểm tại khu dân cư ngoài đê khu vực Hà Nội và lưu vực sông Đáy của sông Hồng											
	Phân tích ngập lụt và lập bản đồ rủi ro cho lưu vực sông Mã dựa trên kinh nghiệm sông Hồng											
	Các nghiên cứu bổ sung (đánh giá hiệu quả công trình, ảnh hưởng biến đổi khí hậu v.v.)											
	Xây dựng sổ tay hướng dẫn											
	Hội thảo chia sẻ về hướng dẫn và quy trình											

Scale up

Kết thúc dự án

Flood mitigation in dams in Hong River Basin

✓ Major hydropower dams had been lowering water level and securing capacity in a few days before the flood. (＞600 mil. m^3 for these days)

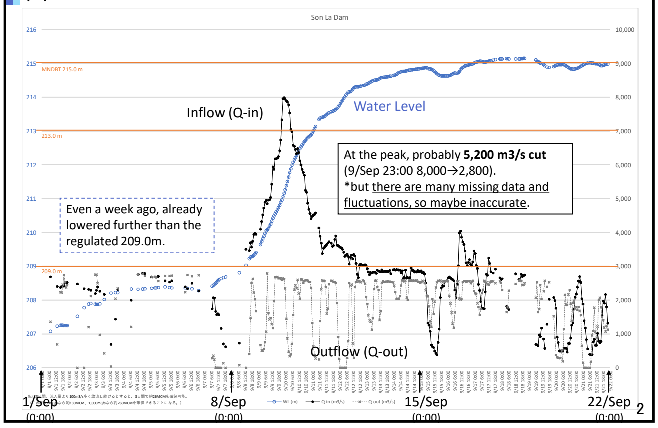


Flood mitigation result:

Dam name	Peak cut (m^3/s)	Prior lowering (m^3)
(1) Sơn La	5,200 (8,000→2,800)	-
(2) Hòa Bình	2,700 (8,300→5,600)	235 million
(3) Thác Bà	2,400 (5,600→3,200)	152 million
(4) Tuyên Quang	1,300 (7,000→5,700)	227 million

1

(1) Sơn La



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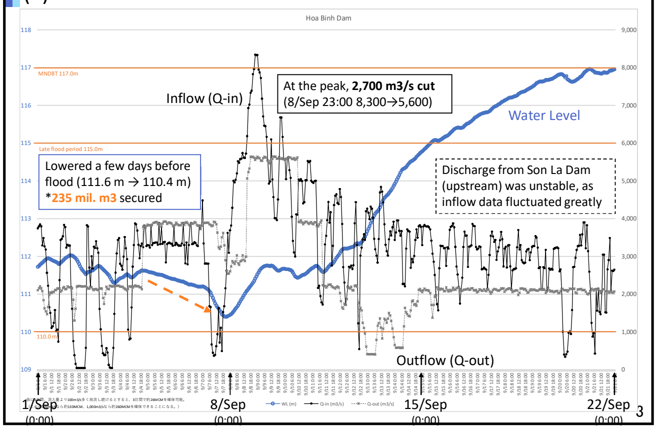
(2) Hòa Bình



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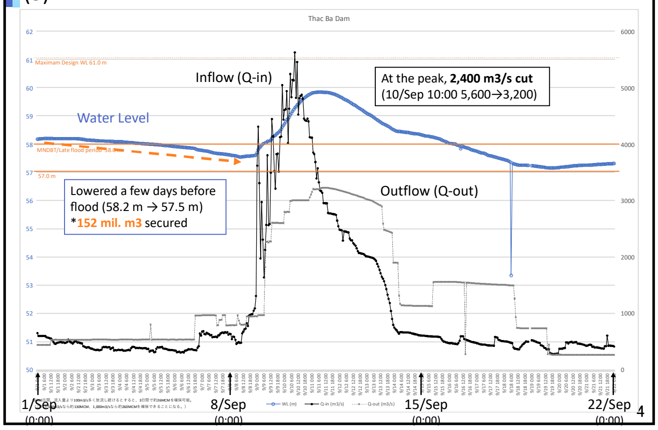
(3) Thác Bà



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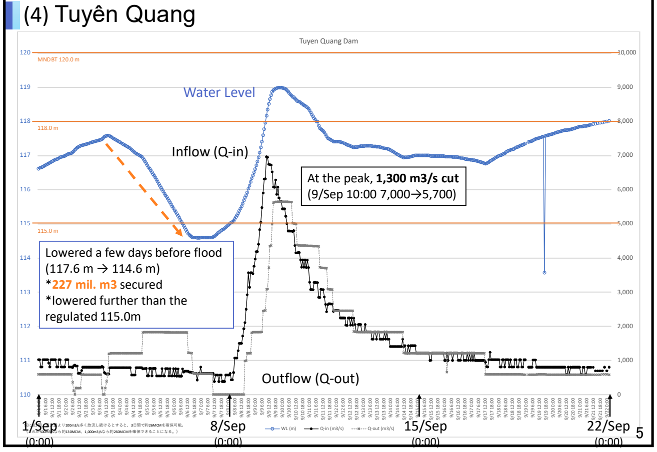
(4) Tuyên Quang



5

As of 27/Mar/2024

SUZUKI Takashi (Advisor for Disaster Risk Management, MARD, Vietnam)

Dam Operations in the November 2023 Flood of the Huong River (Discussion and Recommendations)

Executive summary

With regard to flood control operations at the three major dams on the Huong River basin, in the November 2023 flood a considerable flood reduction was achieved, and if there had been no dam flood control, the extent of inundation would have been twice as great as it actually was. The reservoir water levels of all the three dams were lowered approximately 4 days prior to the arrival of the flood, and the capacity secured by this lowering was equivalent to 18-40% for each dam (27% in total) of the capacity used for flood control this time, which means that without this prior lowering, the inundation could have been nearly 30% larger.

In addition, the on-site office revealed that "the damage was minimized thanks to the grant aid project" and "the lowering reservoir water level started four days in advance this time, whereas such lowering starts two days before the flooding in the past". If the water level had not been lowered for the first two days, the inundation could have been nearly 10% larger, which might mean to be the effect by the project.

While these effects were achieved, there was also room for improvement, and the PDCA cycle (Plan-Do-Check-Act) should be established to conduct post-event verification and to repeatedly learn lessons from each flood response and apply them to the next. The dam operation support system introduced in the project should be familiarized as well. Furthermore, the actual conditions and effects of flood control by dams should be communicated to the public in an easy-to-understand manner based on data in order to deepen public understanding. It is also important to consider revising the rules if it is found necessary after verification.

In addition, the experience and know-how gained from the Huong River should be shared with other river basins, and at that time, cooperation between offices in charge of disaster management and VNMHA should be promoted to ensure that they can utilize radar and other observation data owned by the VNMHA in real time, and to share knowledge on mechanism of radar and data handling.

1. Introduction

(1) Overview of the Huong River and its basin

The Huong River flows through Thua Thien Hue Province in central Vietnam, with a length of about 100 km and a basin area of about 2,800 km2. The Huong River is named after the confluence of the Ta Trach and Huu Trach Rivers, which originate in the mountains along the border with Laos, southwest of Hue City, and then flow through the center of Hue City before the confluence with the Bo River downstream and flowing through the largest lagoon in Southeast Asia to the Pacific Ocean.

The Huong River basin is prone to heavy rainfall due to typhoons and mountainous terrain, and there are basically no levees along the river, making it prone to flood damage, including in the city center. On the other hand, there are three major dams upstream as follows, and although some of them are managed by hydropower companies, they are operated contributing to flood control under the direction of Thua Thien Hue Province in accordance with the dam operation regulations described below:

- Binh Dien Dam (hereinafter "BD") located on the Huu Trach River, upstream of the Huong River * Managed by the hydropower generation company
- Ta Trach Dam (hereinafter "TT") located on the Ta Trach River, upstream of the Huong River *Managed by the Ministry of Agriculture and Rural Development (MARD)
- Huong Dien Dam (hereinafter "HD") on the Bo River, a tributary of the Huong River *Managed by the hydropower generation company

The specifications and their basic water levels of these dams are shown in Figure 1.

(2) Dam operation rules for the Huong River

Summary of regulations on flood control operation of the three major Dams

In the Prime Minister's Decision (No. 1606/2019/QD-TTg)[1)] on dam operations in the Huong River system, the outline of flood control operations for the above three major dams (BD, TT and HD) are stipulated as follows:

(i) If the water level in the downstream river (for BD and TT, Kim Long, Huong River; for HD, referring to both Kim Long, Huong River and Phu Oc, Bo River) is lower than the alert level 2 by 30 cm or more, the flood control operation is based on "water level before flood" (if higher than this, it should be gradually lowered, and if lower, it should not exceed). In the absence of flood control, it should not exceed the "flood season level".

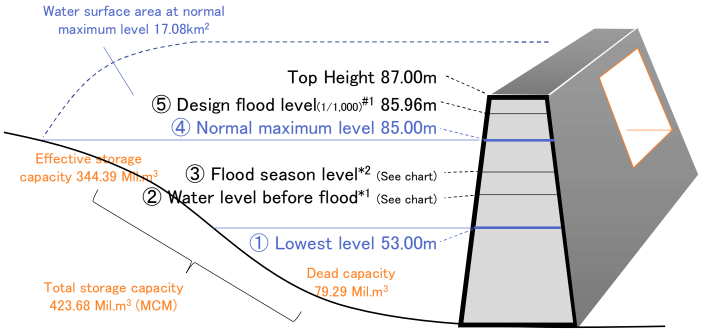
(ii) When the downstream river level comes within 30 cm of the alert level 2, or when the inflow exceeds 400 m3/s for BD and 500 m3/s for TT or HD, release the same amount as the inflow (i.e., the reservoir level is maintained).

(iii) If the downstream river water level exceeds alert level 2, or if the inflow exceeds 800 m3/s for BD, or 1,000 m3/s for TT or HD, release less than the inflow (i.e., implement flood control), but do not exceed the "normal maximum level (but 50.0 m for TT)". If the reservoir water level exceeds the level, release the same amount as the inflow (i.e., the reservoir level is maintained).

(iv) The above stages (i) to (iii) are operated under the authority of the Chairman of the Disaster Management Committee of Thua Thien Hue Province, but in "emergency situations" such as when the downstream river water level exceeds the alert level 3 even though rainfall is still expected, or when the reservoir water level exceeds "normal maximum level (but 50.0m in the case of TT)", operate under the authority of the Chairman of the People's Committee of Thua Thien Hue Province.

(v) Flood control is terminated when the reservoir water level is below the "flood season level" and the rainfall and flooding are over.

The outline of these regulations is illustrated in Figure 2.

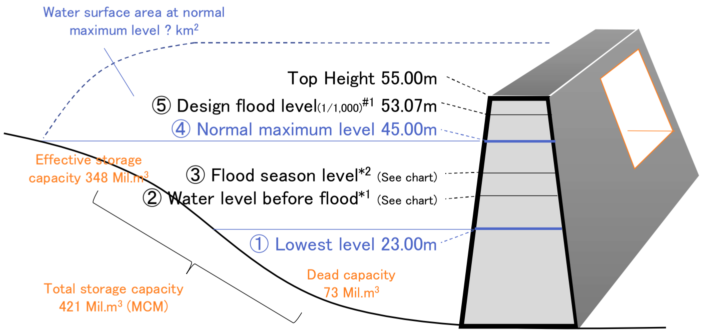


	9/1–30	10/1–31	11/1–15	11/16–12/15
③ Flood season level*2	80.6m	80.6m	80.6m	81.6–85.0m
② Water level before flood*1	74.5m	74.5m	74.5m	81.6m

(No.1606/2019/QD-TTg)

(Note.) *: However, in the literal translation of the Prime Minister's decision, *1) minimum water level for flood mitigation, *2) maximum water level before flooding during the flood season
.#1: The scale of probability of setting (return period) varies depending on the reservoir.

(a) Binh Dien Dam Reservoir (Catchment area 515.0 km2, Huu Trach River)

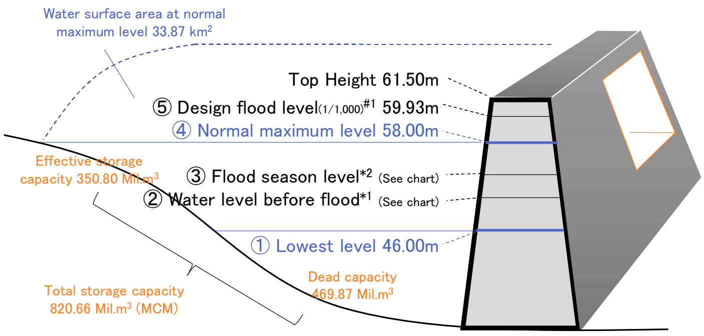


	9/1–30	10/1–31	11/1–15	11/16–12/15
③ Flood season level*2	25.0m	28.0m	35.0m	38.0–45.0m
② Water level before flood*1	23.0m	25.0m	30.5m	38.0m

(No.1606/2019/QD-TTg)
Capacity volume is according to FRICS's material

(Note.) *: However, in the literal translation of the Prime Minister's decision, *1) minimum water level for flood mitigation, *2) maximum water level before flooding during the flood season
.#1: The scale of probability of setting (return period) varies depending on the reservoir.

(b) Ta Trach Dam Reservoir (Catchment area 717.0 km2, Ta Trach River)



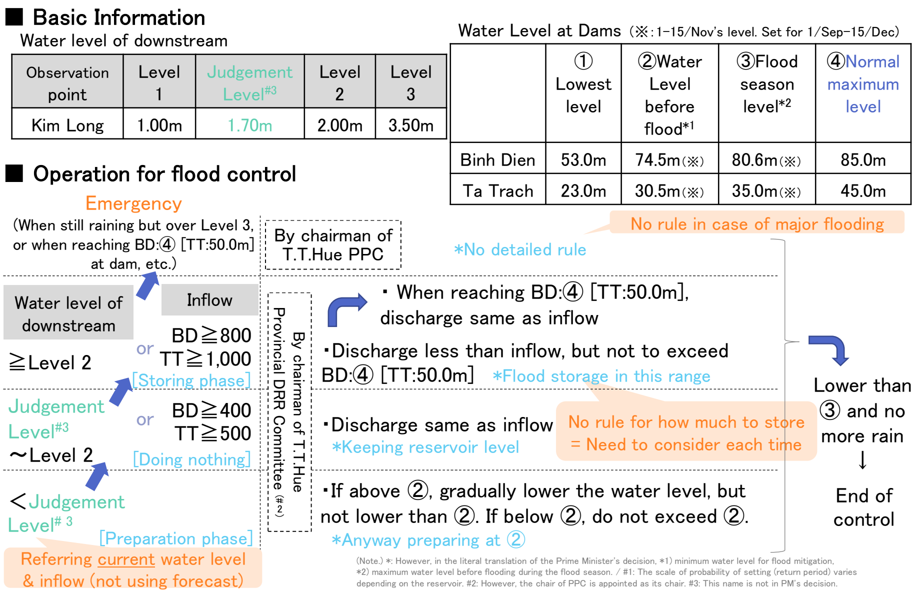
	9/1–30	10/1–31	11/1–15	11/16–12/15
③ Flood season level*2	56.0m	56.0m	56.0m	56.5–58.0m
② Water level before flood*1	53.5m	53.5m	53.5m	56.5m

(No.1606/2019/QD-TTg)

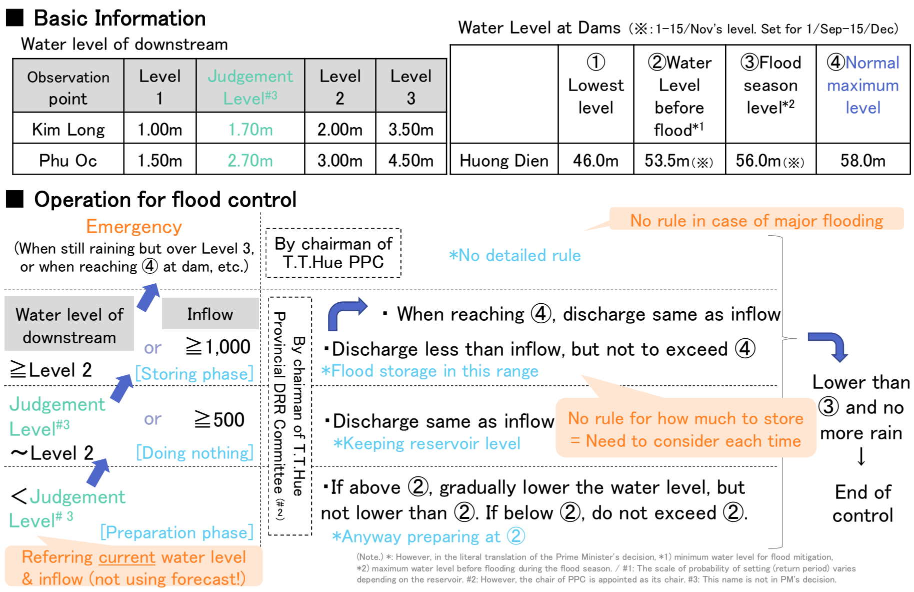
(Note.) *: However, in the literal translation of the Prime Minister's decision, *1) minimum water level for flood mitigation, *2) maximum water level before flooding during the flood season
.#1: The scale of probability of setting (return period) varies depending on the reservoir.

(c) Huong Dien Dam Reservoir (Catchment area 707.0 km2, Bo River)

[Figure 1] The specifications and their basic water levels of these dams (Source: No. 1606/2019/QD-TTg[1]; however, for TT, since the capacity data described are doubtful, referring to the data confirmed in the grant aid project described below).



(a) Flood control operation at Binh Dien Dam (Huu Trach River) and Ta Trach Dam (Ta Trach River)



(b) Flood control operation at Huong Dien Dam (Bo River)

[Figure 2] Regulations on flood control operation of the three major dams in the Huong River basin

(Based on: No. 1606/2019/QD-TTg[1])

Characteristics of operation rules

The following characteristics can be pointed out to this operation regulation, as noted in Figure 2:

- Under the regulation, the observed (real time) values of downstream river levels and inflow at the dam are mainly used to determine which of the steps (i) to (v) to be applicable, and "forecast information" on rainfall and river levels is not used. (Note: According to the Thua Thien Hue Provincial Disaster Prevention Office, such forecast information is used as on-site reference.)
- In general, the amount of water discharge is not specifically defined and is left largely to the on-site judgment. In

particular, there are no specific provisions on the amount and rate of storage compared to inflow at the flood control stage, or the degree of raising or lowering of the reservoir water level.

- In addition, there is no provision for operation in the event of a particularly large flood, "emergency situation". In this respect, too, a considerable portion is left to the judgment of the field.

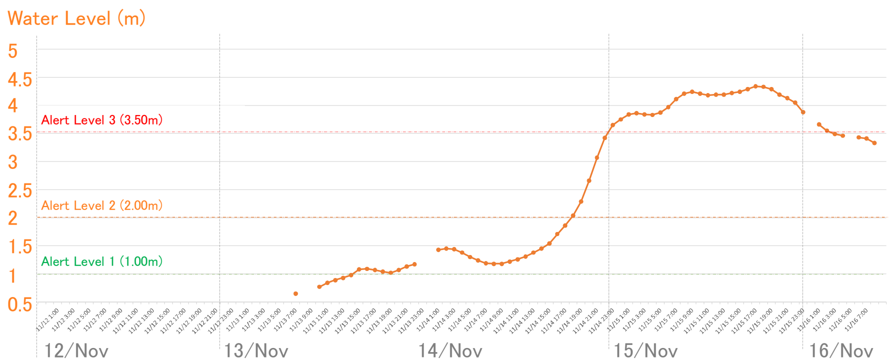
Thus, on-site judgement and action is important, as mentioned later too. From this perspective, now the response to the November 2023 flood, which was the most-severe recent flood, will be reviewed.

2. Dam operation in the November 2023 flood

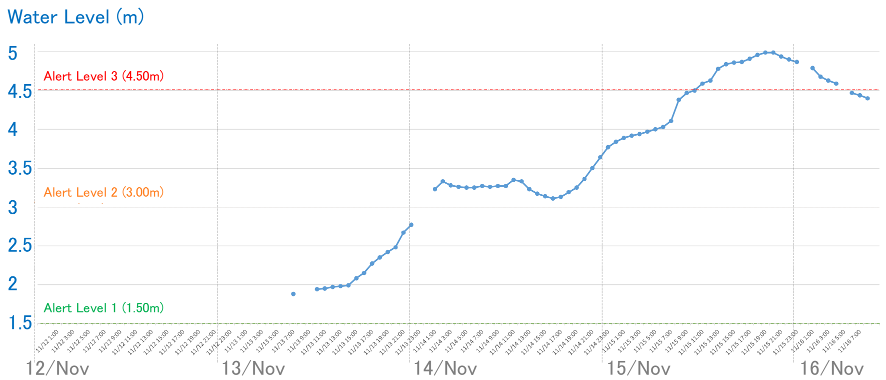
(1) Flood control by dam operation and its effects

Summary of November 2023 flood

In the Huong River basin, rainfall was heavy from around November 13, resulting in peak levels of over 4.3 m at Kim Long on the Huong River (around 17:00 on November 15) and over 4.9 m at Phu Oc on the Bo River (around 19:00 on November 15), both exceeding alert level 3, flooding a wide area of Hue City. Water levels at each point are shown in Figure 3.

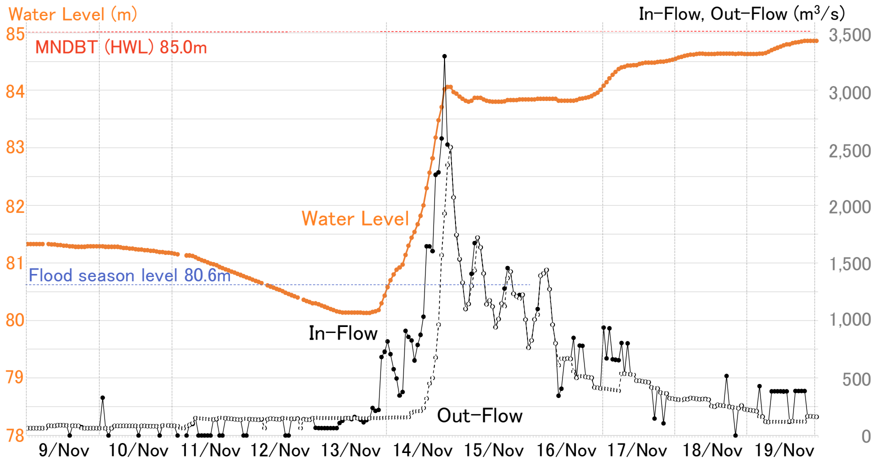


(a) Huong River (Kim Long) Water Level

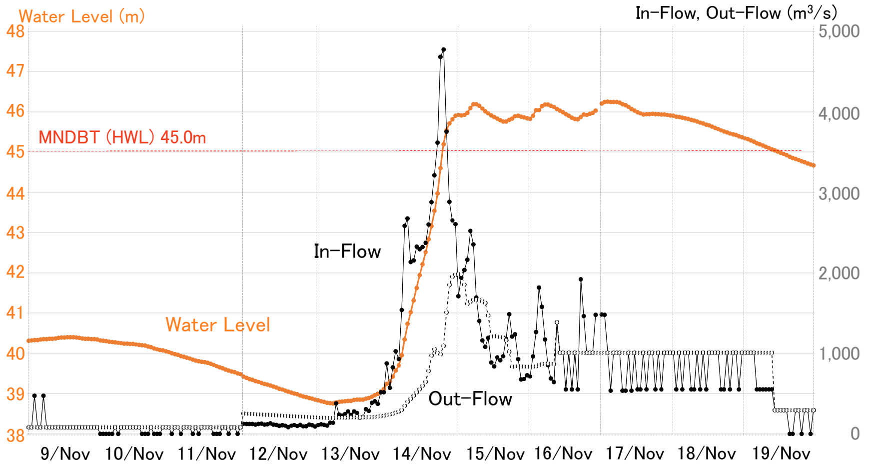


(b) Bo River (Phu Oc) Water Level

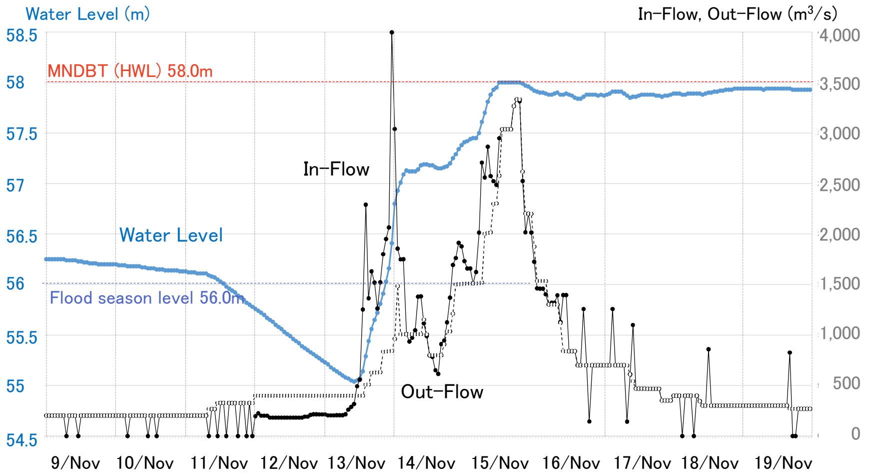
[Figure 3] River water level in the November 2023 Flood (Source: Thua Thien Hue Province Website[2)])



(a) Binh Dien Dam Reservoir



(b) Ta Trach Dam Reservoir



(c) Huong Dien Dam Reservoir

[Figure 4] Operation data in the November 2023 flood at the three major dams in the Huong River Basin

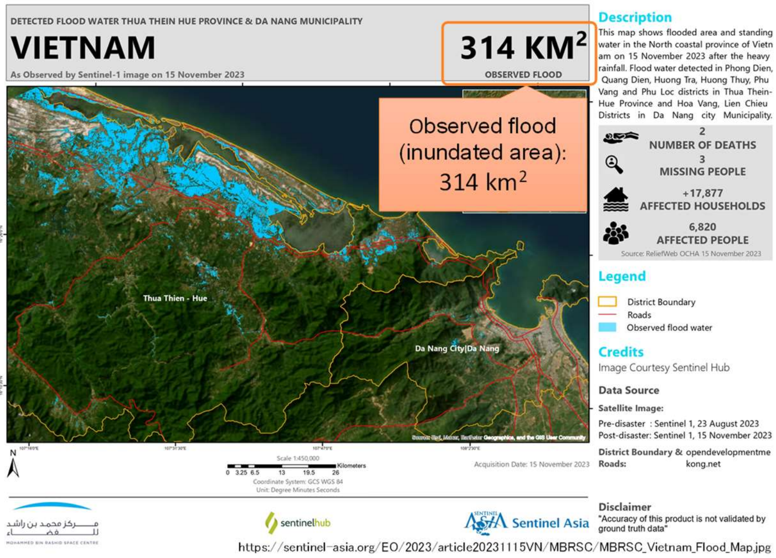
(Data source: MOIT website[3]) for BD and HD, and MARD website[4]) for TT. However, some periods for which data were not available on the web were supplemented with data confirmed in the grant aid project described below)

Flood control at the three major dams

At this time, flood control was being conducted at BD, TT, and HD dams, all of which achieved a considerable extent of flood reduction, including during peak inflow periods. As related data are shown in Figure 4, the peak flood at BD had a maximum inflow of approximately 3,300 m3/s (around 19:00 on March 14), but the maximum discharge was approximately 2,500 m3/s (approximately 2 hours after the peak inflow). In TT, the maximum inflow was approximately 4,800 m3/s (around 19:00 on March 14), but the maximum discharge was approximately 2,000 m3/s (approximately 5 hours after the peak inflow). Furthermore, in HD, the maximum inflow was approximately 4,000 m3/s (around 23:00 on the 13th), but the maximum discharge was approximately 1,500 m3/s (approximately 2 hours after the peak inflow). (However, in HD, as described later, the second peak occurred about 43 hours after this peak, and the inflow was about 3,300 m3/s. At that time, the dam capacity was exhausted and no flood control was conducted.) It can be pointed out that the flood control operation mitigated the rise of water levels in downstream rivers and reduced the damage caused by inundation, and also delayed the rise of water levels downstream, thereby allowing more time for evacuation and other activities.

In addition, the total amount of water stored through the whole floods is estimated to be about 62 million m3 for BD, 159 million m3 for TT, and 99 million m3 for HD, for a total of about 320 million m3. It is also clear that these flood control measures have had the effect of reducing the extent of inundation compared to what would have occurred in the absence of dam flood control.

In fact, the area inundated in this flood is estimated to be 314 km2 by Sentinel Asia (based on satellite imagery from November 15, 2023, see Figure 5), and assuming the average depth of inundation at that time was 1 m, the inundation volume would be estimated to be about 314 million m3, which suggests that if there had been no dam flood control, the extent of inundation would have been about twice as severe as it actually was, with the additional amount of water mentioned above (about 320 million m^3). (Note that the inundated area estimated by Sentinel Asia may include inundation due to internal flooding and storm surge in addition to one due to flood from the Huong River basin. See also (Note 1)).



[Figure 5] Inundated area estimated from satellite image (Source: Sentinel Asia, satellite image on November 15[5)])

(2) Preliminary reservoir level lowering and its effects

In the flood response, the reservoir level was lowered gradually before the peak of the flood in order to increase the available capacity. Specifically, the lowering reservoir level started approximately four days prior to the arrival of the flood. The four-day lowering of the reservoir water level secured an additional capacity of approximately 18 million m^3 for BD, 29 million m^3 for TT, and 40 million m^3 for HD, for a total of approximately 87 million m^3, which corresponds to approximately 18 to 40% of the total stored water mentioned above, respectively for each dam (27% in total) (see [Figure 6] and also (Note 2)). This shows the significance of the prior lowering of reservoir levels.

When the inundation volume is estimated to be approximately 314 million m^3 as mentioned above, it is assumed that if the reservoir water levels had not been lowered in advance, the extent of the inundation would have been nearly 30% larger than the actual volume, with additional 87 million m^3 mentioned above.

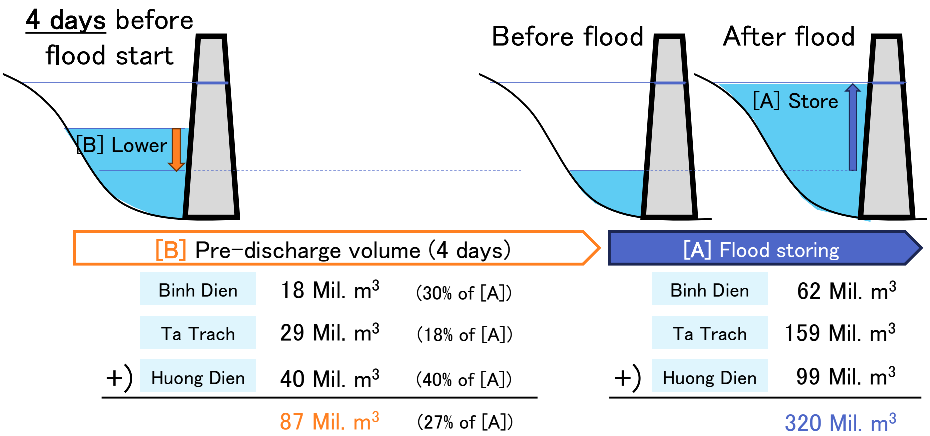
(3) Challenges in flood control through dam operation and desired future actions

Of course, improvements could have been considered, such as increasing the speed of lowering reservoir level in advance. For example, in TT, even though the reservoir level had been lowered after the flood in mid-October, the November flood occurred before the reservoir level was lowered to the "flood season level", (the flood season level in the first half of November was 35.0 m, but the reservoir level was lowered only to about 38.7 m when the flood arrived). Although MARD's safety management guidelines for TT[6)] stipulate that water levels should not be lowered at a rate higher than 1 m/day for TT, as illustrated in Figure 7, the rate of lowering water level in late October and early November was less than 0.5 m/day, suggesting that more water could have been discharged to lower the water level (Note that the water level of the downstream river may have been taken into account on the decision not to discharge water too much, and that this cannot be easily criticized).

Even at the stage of flood control, the extent of flood control could have been reduced and capacity could have been conserved before the peak. For example, as mentioned above, though HD made substantial flood control during the first inflow peak, when the second peak occurred 43 hours later, when the inflow was about 3,300 m^3/s, no flood control was conducted because the dam capacity was exhausted. After the first peak subsided, the capacity could have been preserved a little more if the same amount of water as the inflow was released without flood control (Note that it is not appropriate to release more water than the inflow under the regulations). (see [Figure 4] (c) above)

It is unfair to argue about what should have been done or not done based on the total amount of rainfall and runoff, which is only known after the flood is over. In fact, if rainfall is predicted and the reservoir level is lowered by releasing water in advance, but the actual rainfall is not as great as predicted, the amount of water available for power generation and irrigation may be lost, resulting in economic losses.

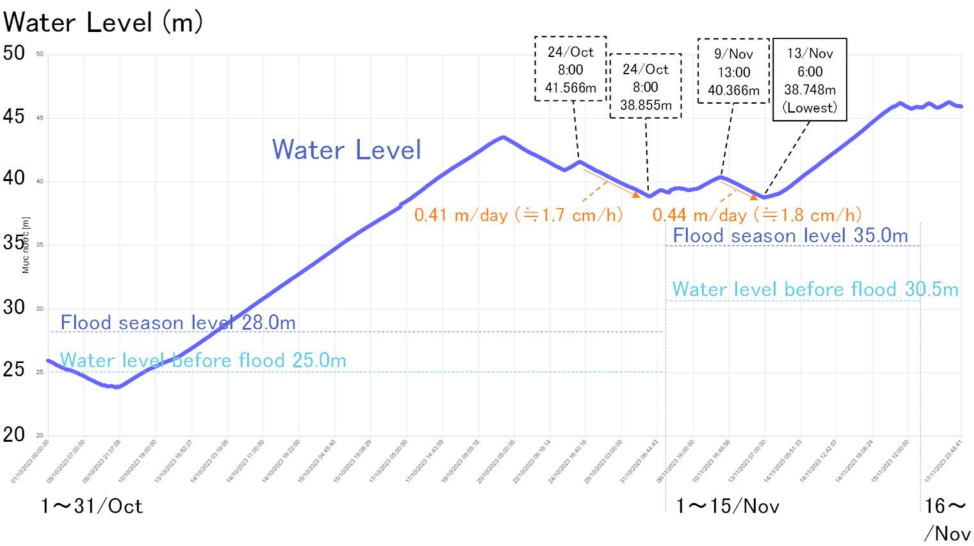
However, in the Huong River basin, observation equipment such as radar and the system to support dam operation have just been introduced through the grant aid as described below. In future, it is important to ensure more effective response including the utilization of such equipment and system, by establishing the PDCA cycle (Plan-Do-Check-Act) to conduct post-event verification and to repeatedly learn lessons from each flood response and apply them to the next.



[Figure 6] Stored water volume [A] and
the capacity secured by the prior lowering reservoir water level [B] in the three major dams

(Data source: MOIT website[3]) for HD, and MARD website[4]) for TT.

Though BD also has data of stored water and level on MOIT website, as the values of water storage volume on MOIT website and of the capacity data indicated in No. 1606/2019/QD-TTg are significantly far apart, estimating the stored water volume of BD using the reservoir water level data on MOIT website and based on the No. 1606/2019/QD-TTg. However, since the reservoir water level data for 9-12/Nov could not be confirmed on MOIT website, for this period, the water storage volume data confirmed in the grant aid project described below was directly used. See also (Note 2) for data processing.)



[Figure 7] Reservoir water level in TT from October to the November flood

(Source: a figure obtained from MOIT website[3]), with author's additions)

3. Effectiveness of the grant aid project "The Project for Emergency Reservoir Operation and Effective Flood Management Using Water related Disaster Management Information System" in response to the November flood

(1) Outline of the project

The Project for Emergency Reservoir Operation and Effective Flood Management Using Water related Disaster Management Information System, which was implemented as a Japanese grant aid from 2017 to 2023, provided the observation equipment for rainfall and water level, including the first high accurate X-band MP radar in Vietnam, as well as an integrated dam management system that supports optimal dam operation by consolidating all relevant data in real time and forecasting flood and inundation up to 72 hours later has been developed and provided. Aerial laser surveying of the basin for flood forecasting, developing a hydraulic model using the RRI model, and the soft components (technology transfer) such as dam operation training simulating an actual disaster were also implemented. (For an overview of the project, see, for example, JICA reference[7)])

(2) Effectiveness of the grant aid project in response to the November flood

Comments from the on-site office about the effectiveness of the project

The Thua Thien Hue Provincial People's Committee reported to the Deputy Prime Minister and shared with MARD, VDDMA, and JICA that the results of the project were effectively utilized in the decision to operate the dam in the November flood.

In particular, according to a hearing from a person in charge of disaster prevention in Thua Thien Hue Province, "Thanks to the radar and flood forecasting that were the results of this project, we were able to increase the amount of water released four days before the floods arrived". In particular, it was also heard that, "Until now, we have only been able to increase the discharge of water two days before the flood, but this is probably the first time that we have been able to increase the discharge four days before the flood.

Approach of this article to expressing the effectiveness

When expressing the effectiveness of the grant aid project, it is necessary to compare the difference in results (such as flood damage) between the case with the project (with-case) and the case without the project (without-case). However, it is difficult to envision what the response would have been if the project had not been implemented ("without case") after the flood response. In addition, the main focus of the grant aid project was originally an integrated dam management system to support optimal dam operation based on flood and inundation forecasts, but this system had not yet been fully utilized as the project was not completed yet.

While it is necessary to take these circumstances into consideration, in light of the aforementioned comments, this article will estimate the effect of lowering reservoir level from 4 to 2 days before the flood (i.e., the "first 2-days" of the 4-day period), and thereby express the effectiveness of this grant aid project.

Effectiveness of lowering reservoir level during the first 2 days of the 4-day period

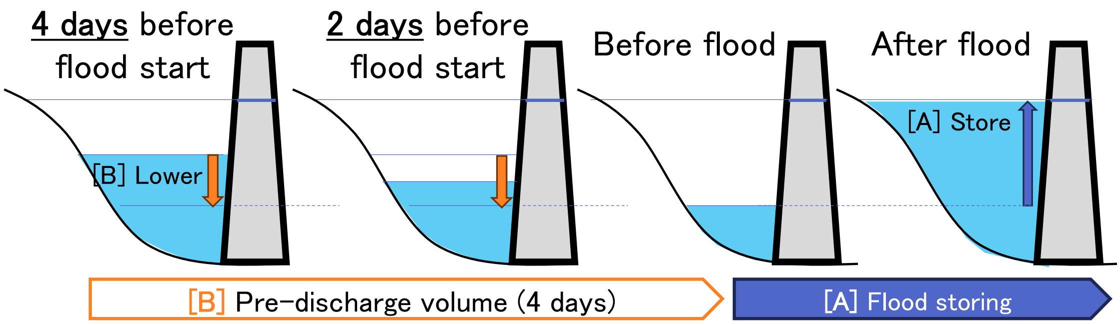
During the period from 4 days before the flood to 2 days before the flood (the "first 2 days" of the 4-day period), the reservoirs increased the capacity of approximately 31 million m^3: 8 million m^3 for BD, 16 million m^3 for TT, and 7 million m^3 for HD. These are about 18-56% for each dam respectively (36% in total) of the aforementioned "secured capacity by lowering reservoir levels 4 days prior to flooding". (see Figure 8).

When the inundation volume is estimated to be approximately 314 million m^3 as mentioned above, it can be assumed that if the reservoir levels had not been lowered during the "first 2 days", the extent of the inundation would have been approximately 10% larger than the actual volume, and here the effectiveness of the project in dealing with the flood can be seen.

(3) Future issues regarding the utilization of project results

Again, in retrospect, there might rooms for thinking that more effective dam operations could have been carried out.

As mentioned earlier, observation equipment such as radar and the system to support dam operations were introduced through the project, and it is important to ensure more effective response including the utilization of them in future, by establishing the PDCA cycle (Plan-Do-Check-Act) to conduct post-event verification and to repeatedly learn lessons from each flood response and apply them to the next. In addition, advancing system familiarization is also an important issue to be addressed from now.



	Binh Dien	18 Mil. m^3	(30% of [A])
	Ta Trach	29 Mil. m^3	(18% of [A])
+)	Huong Dien	40 Mil. m^3	(40% of [A])
		87 Mil. m^3	(27% of [A])

	Binh Dien	62 Mil. m^3
	Ta Trach	159 Mil. m^3
+)	Huong Dien	99 Mil. m^3
		320 Mil. m^3

[C] Pre-discharge (first 2 days)

	Binh Dien	8 Mil. m^3	(12% of [A], 41% of [B])
	Ta Trach	16 Mil. m^3	(10% of [A], 56% of [B])
+)	Huong Dien	7 Mil. m^3	(7% of [A], 18% of [B])
		31 Mil. m^3	(10% of [A], 36% of [B])

[Figure 8] Stored water volume [A], the capacity secured by the prior lowering reservoir water level [B], and the capacity secured during "first 2 days" of the 4-day period of lowering reservoir water level [C] in the three major dams (Data source: same as Figure 6)

4. Summary and Recommendations

(1) Summary

Flood control by dam operation in the November flood

As mentioned so far, the effectiveness of dam operations and the grant aid project on the Huong River basin during the November flood can be discussed as follows:

- The outline of flood control operations for the three major dams in the Huong River basin are stipulated in the Prime Minister's Decision, and according to that, flood control operations are mainly based on the observed (real time) values of downstream river levels and inflow at the dam. However, the operation is not specifically defined, leaving a large part to the on-site judgment.

- The following points became clear from a review of the response to the November 2023 flood of the three main dams on the Huong River basin:

* All of the dams of BD, TT, and HD achieved flood control with a considerable extent of flood reduction, including during peak periods. Estimating based on assumptions, if there had been no flood control at the dams, the extent of inundation would have been about twice as severe as it actually was.

* All of the dams of BD, TT, and HD prepared for flood by starting to lower reservoir water levels approximately 4 days prior to the arrival of flood. The capacity secured by this at each dam is approximately 18 to 40% of the capacity used for flood control respectively (27% in total). Estimating based on assumptions, if the reservoir water level had not been lowered in advance to secure capacity, the extent of the inundation would have been nearly 30% larger than the actual volume.
* In order to find the effectiveness of the grant aid project until 2023, based on the comments that lowering reservoir level started four days prior to the arrival of the flood thanks to the radar and flood forecasting introduces by the project while they have only been able to increase the discharge two days before the flood until then, the capacity secured by lowering reservoir water level during the period from 4 days before the flood to 2 days before the flood was focused. The capacity secured by lowering reservoir water level during the 2 days is found to be equivalent about 18-56% of secured capacity by lowering reservoir levels at each dam respectively (36% in total), and estimating based on assumptions, the extent of the inundation would have been approximately 10% larger than the actual volume, and here the effectiveness of the project in dealing with the flood can be seen.

Toward Improved Operations

While flood control has been achieved in such a way, as mentioned above, further improvements could have been considered, such as lowering the reservoir level earlier in advance or more greatly, and even at the stage of flood control, the extent of control could have been reduced until the peak to conserve capacity. In the Huong River basin, observation equipment such as radar and the system to support dam operations were introduced through the project, and it is important to ensure more effective response including the utilization of them in future, by establishing the PDCA cycle (Plan-Do-Check-Act) to conduct post-event verification and to repeatedly learn lessons from each flood response and apply them to the next. In addition, advancing system familiarization is also an important issue to be addressed from now.

On dissemination of Effectiveness to the Public

Such discussions can be easily conducted with basic data that are publicly available. While dam flood control is of great interest to the public but also difficult to understand, and is often misunderstood and criticized as if the dam release causes or increases flood. In fact, this time the flood control by dams did not increase flood but mitigate flood, and it is important to communicate the reality of flood control and its effects to the public in an easy-to-understand manner.

(2) Recommendations

Based on the above summary, the following points are recommended:

- To establish the PDCA cycle (Plan-Do-Check-Act) to conduct post-event verification after a large-scale flood event, as described in this article, and to repeatedly learn lessons from each flood response and apply them to the next.

In addition, to advance familiarization with the system introduced by the grant aid project through flood responses.

- To conduct simple data analysis and discussion as described in this article after a large-scale flood event, and disseminate the actual situation of flood control and its effects to the public in an easy-to-understand manner, in order to avoid public misunderstanding that floods are caused or increased due to dam releases, and to deepen public understanding of flood control by dams.

- If it is considered desirable to improve or clarify the current operating regulation (Prime Minister's Decision No. 1606/2019/QD-TTg) based on the such considerations, to consider the revision of the operating regulation after careful consultation with relevant ministries and agencies to have a common understanding.

- To apply the know-how in the Huong River basin to other river basins in Vietnam based on the result of the grant aid project. In doing so, to share the experience gained in the Huong River basin with relevant provinces and agencies. In addition, to promote collaboration with VNMHA so that the VNMHA's radar and other observation data can be used in real time by the disaster management offices (VDDMA and provincial DARD) without having to install new radars or other observation equipment. In particular, to share knowledges by having study sessions, for example, on radar between the disaster management offices (VDDMA and provincial DARD) and VNMHA to share knowledge in order to promote understanding of the disaster management offices on radar mechanism and data handling, and to promote understanding of the data providers on the needs of disaster management offices.

(Note 1) Setting an average inundation depth, 1 m, is only an assumption, but it does not seem to be far off from the actual situation, considering based on reported articles on inundation damage, In addition, the Thua Thien Hue Province is later surveying residents to determine the actual flooding in their houses, and as of March 4, the results have not yet been compiled, but once the results are known, a more accurate study would be possible.

(Note 2) The following definitions are used in this article to define the 4 days of prior reservoir level lowering or the first 2 days of the 4-day period.

- Flood start: The time (on the hour) when the inflow first exceeds 400 m3/s for BD and 500 m3/s for TT and HD. (This threshold is the same as the value used in the Prime Minister's decision as one of the triggers for changing the stage of dam operation.)
- 4 days before flood start: 96 hours before the flood start
- Before flood: When the reservoir water level is the lowest immediately before the flood series.
- After flood: When the water level is the highest in the flood event.
- 2 days before flood start: 48 hours before flood start
- Capacity secured by 4 days of prior reservoir level lowering: Capacity secured during period from "4 days before flood start" to "Before flood"
- Capacity secured by the first 2-day of prior reservoir level lowering: Capacity secured during period from "4 days before flood start"

to "2 days before flood start "

Reference

1) No.1606/2019/QD-TTg Prime Minister's Decision - Inter-reservoir operation procedures in the Huong River Basin

https://thuvienphapluat.vn/van-ban/Tai-nguyen-Moi-truong/Quyet-dinh-1606-QD-TTg-2019-van-hanh-lien-ho-chua-tren-luu-vuc-song-Huong-428318.aspx

2) Thua Thie Hue Province website - Information system for natural disaster prevention

https://hochua.thuathienhue.gov.vn/

3) MOIT (Ministry of Industry and Trade) website - Database System

https://thuydienvietnam.vn/index.html#canhbaosolieuquantrac/686f64616e67786126323734

4) MARD website - Database System: Irrigation Industry - Dam and Reservoir Safety

http://thuyloivietnam.vn/home#antoan

5) Sentinel Asia - Satellite image on November 15, 2023

https://sentinel-asia.org/EO/2023/article20231115VN/MBRSC/MBRSC_Vietnam_Flood_Map.jpg

6) Ta Trach Dam Reservoir Safety Management Handbook (Directorate of Water Resources, MARD, 2021)

Part1 (Main part) https://tailieu.vn/doc/so-tay-quan-ly-an-toan-ho-chua-nuoc-ta-trach-phan-1-2595509.html

Part2 (Appendix) https://tailieu.vn/doc/so-tay-quan-ly-an-toan-ho-chua-nuoc-ta-trach-phan-2-2595510.html

7) JICA's Cooperation in Vietnam in the field of Disaster Risk Reduction (JICA, 2023)

(English) https://www.jica.go.jp/vietnam/english/office/others/c8h0vm0000cydg8v-att/sector_07_01_en.pdf

(Japanese) https://www.jica.go.jp/vietnam/english/office/others/c8h0vm0000cydg8v-att/sector_07_01_ja.pdf

(Vietnamese) https://www.jica.go.jp/vietnam/english/office/others/c8h0vm0000cydg8v-att/sector_07_01_vi.pdf

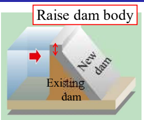
8) For example, the report from the Thua Thien Hue Province Steering Committee for Natural Disaster Prevention and Control, and Search and Rescue to the Provincial People's Committee (on Nov. 17, 2023) No.319/BC-PCTT

Dam Upgrading under Operation

- ✓ Remake existing dams effective.
- ✓ Solve emerging problems like water shortage and flooding.
  (Problems can be found through the dam inspections.)

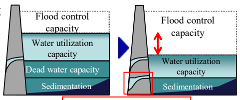
Capacity Enlargement

Dam body heightening



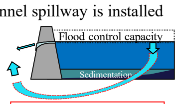
Capacity Transfer

New outlet drilling under dam operation



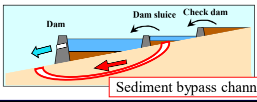
Spillway Expansion

New tunnel spillway is installed



Dam Life Extension

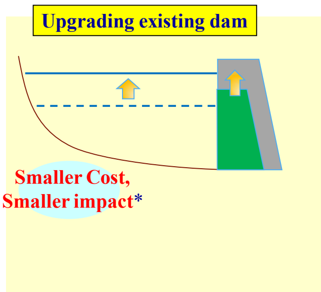
Sedimentation is controlled by installing sediment bypass tunnel

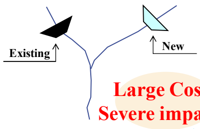


1

Why Dam Upgrading under Operation?

- ✓ Dam upgrading needs smaller cost than newly constructing a dam.
- ✓ Also it affects less on the local community and environment.



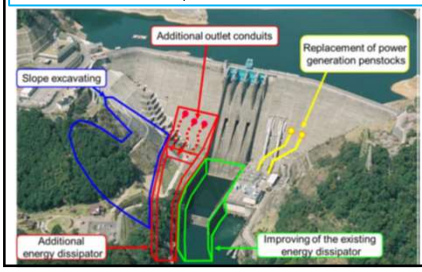


*(e.g.) Newly inundated land, Substitute roads, Ecosystem

2

Dam Body Drilling Technologies for Dam Upgrading

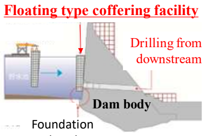
- ✓ At the Tsuruda Dam, constructing new discharge tunnel through the dam body to optimize the operation.
- ✓ Installing deep-water structures for re-arrange the storage capacities without the restriction on the operational function of the existing dam.
- ✓ Significantly reduces underwater work, increases safety, and shortens the construction period.



Improving flood control function

By Dam Body Drilling

Floating type coffering facility



Foundation Pedestal concrete Is Not Required

3

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Key points of successful flood control measures for the Tsurumi River and recommendations based on them

1. Background and issues

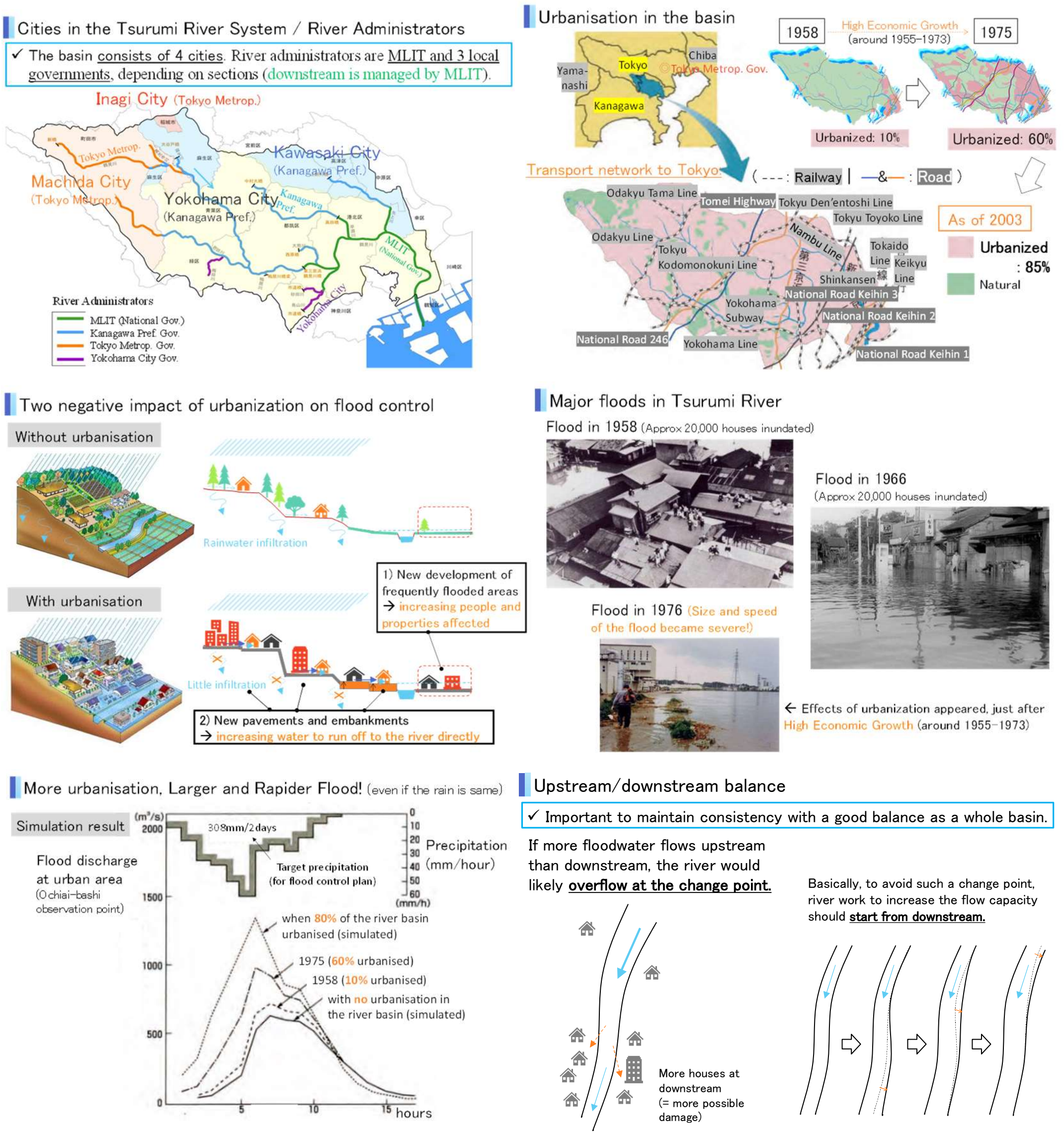
The Tsurumi River is a 42.5 km long river with a basin area of 235 km2 that flows from Machida City of Tokyo, through Yokohama City and Kawasaki City of Kanagawa Prefecture, into Tokyo Bay. The national government is responsible for river management and maintenance in the urban sections of the river downstream, while the Kanagawa Prefecture, Tokyo Metropolitan Government and Yokohama City are responsible for the upper and middle sections, depending on the section. The Tsurumi River basin is small in size, ranking 106th in terms of basin area among all the 109 A-class river systems (*1) in Japan, but its population (2.16 million) ranks eighth and the population density is the highest.

The background to the rapid increase in population in the basin is the High Economic Growth around 1955-73 (*2). The Tsurumi River basin is adjacent to central Tokyo, and during this period, transport networks (rail and road) crossed various parts of the basin and connected it to the central Tokyo, making it convenient for commuters. This led to a 2.7-fold increase in the basin's population in the 17 years between 1958 and 1975, and the development of residential areas led to a rapid increase in the urbanisation rate (the proportion of urban areas in the basin) from 10% to 60%.

Urbanisation has a negative impact on flood control from two perspectives. First, new development of frequently flooded land (low-lying areas) increases the number of people and properties that may be affected. Secondly, new pavements and embankments on upstream farmlands and vacant lands increase the amount of water that runs off downstream into existing urban areas and allow water to reach them faster, as rainfall is no longer able to infiltrate and the previously inundated water has nowhere to go. In the Tsurumi River basin, flooding also became more severe due to these factors.

In fact, in both 1958 and 1966, during the period of the High Economic Growth, some 20,000 houses were inundated by the floods respectively. Even though the Tsurumi River was designated as an A-class river in 1967 and then the national government started river improvement work to improve safety, subsequent analysis of observation data on the 1976 flood showed that both the size and speed of the floods became severe. The adverse effects of urbanisation were manifesting themselves faster than the river improvement efforts.

In addition, as measures had not been considered on a basin-wide scale, in the Hayabuchi River, a tributary of the Tsurumi River, the width of the upstream section managed by the Yokohama City was three times wider than that of the downstream section managed by the national government. The river was in such a bad situation that it was assumed to overflow here in the event of flooding (*3).



2. Measures and methods implemented

<u>(1) Efforts to control run-off</u>

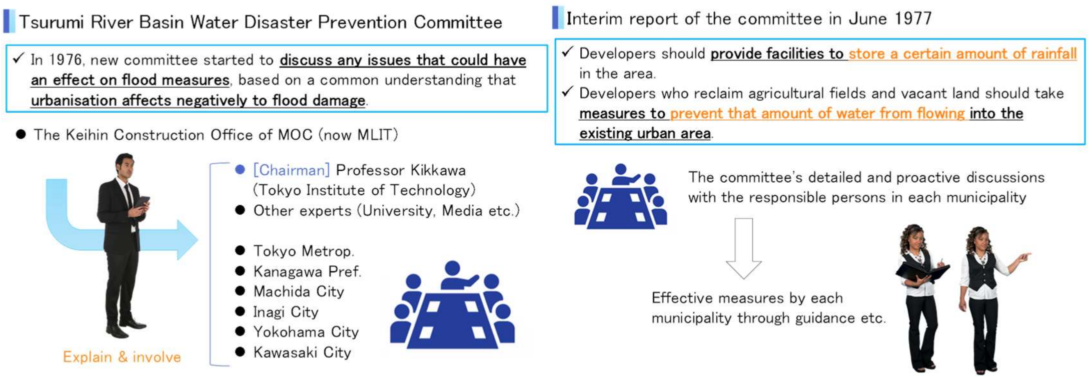
i) Enthusiastic lobbying of local authorities by national officials and collaboraion

In January 1976, a national government official (director of the Keihin Construction

Office of the Ministry of Construction (now MLIT)) visited the director in charge of rivers of Yokohama City Government, which covers more than 60% of the river basin. In order to promote rainwater storage in the basin, he asked if the city could provide guidance and require developers to install rainwater storage ponds, but since he did not receive agreement, he asked him to participate in a new study group on flood damage. Then he also explained to the director of the planning and coordination department of Yokohama City so that the deputy director of the department can participate, and the directors of the relevant departments and other local authorities (Kawasaki City, Inagi City, Machida City) also agreed to participate replying to his request, and in July 1976 the Tsurumi River Basin Water Disaster Prevention Committee was set up. The committee was chaired by Professor Kikkawa of the Tokyo Institute of Technology and included other academics etc., and based on a common understanding that urbanisation affects negatively to flood damage, they decided to discuss any issues that could have an effect on flood countermeasures.

At first, in the committee they faced conflicts such as between upstream and downstream cities, and between the departments in charge of rivers and the urban planning department in the same city of Yokohama, with no way out in sight. However, Professor Kikkawa led the discussions by focusing on the key points, and the directors of the cities began to listen to each other, and eventually the municipalities began to consult the Keihin office whenever they reviewed development plans for their areas. With the discussions thus on track, a major flood inundation in September1976 further spurred the committee's discussions, and the cities began to compete with each other in providing guidance to developers.

An interim report of the committee in June 1977 indicated that developers should provide facilities to store a certain amount of rainfall in the area and that developers who reclaim agricultural fields and vacant land should take measures to prevent that amount of water from flowing into the existing urban area. The committee's detailed and proactive discussions with the responsible persons in each municipality resulted in effective measures, which are then taken by each municipality through guidance etc.



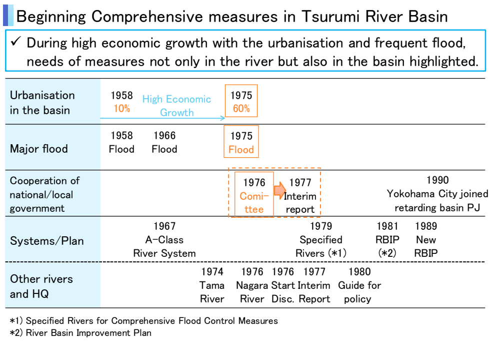
ii) Systems that further encouraged efforts

As major floods occurred frequently in other rivers during this period, the Ministry headquarters also began to study on comprehensive measures (including measures in the basin) with Professor Kikkawa and other academics in October 1976, and compiled a report in 1977 (*4). In 1979, a system of 'Specified Rivers for Comprehensive Flood Control Measures' was created, and rivers designated as such were obliged to compile a 'River Basin Improvement Plan' for comprehensive measures, in return for a priority budgetary investment. The Tsurumi River became the first river in Japan to be designated as a specific river for comprehensive flood control measures in 1979, and in 1981 the Tsurumi River Basin Improvement Plan was formulated, which led to further steady progress in measures such as the installation of regulating reservoirs and storage and infiltration facilities in the basin (and the new Tsurumi River Basin Improvement Plan in 1989).

And based on this context, in the Tsurumi River, mitigation by storage in the basin was taken into account in the setting of the target discharge of river improvement works in the river plan (1994 Basic Plan for Construction Works Implementation), and though the river plan is formulated separately for each administrator in most rivers, in the Tsurumi River it was formulated by four administrators (MLIT, Tokyo Metropolitan Government, Kanagawa Prefectural Government, and Yokohama City Government) in collaboration (River Improvement Plan 2007).

Furthermore, with the enactment of the Law on Measures against Flood Damage to Specified Urban Rivers in 2004, it was legally stipulated that permission is required for development activities above a certain size that obstruct rainwater infiltration. In addition, the concept of run-off control measures stipulated in the Tsurumi River Basin Improvement Plan was re-organised into the ‘Tsurumi River Basin Flood Damage Countermeasures Plan’ in 2007 based on this law, which finally has a legal basis. Countermeasures were more strongly promoted and also the efforts of relevant institutions came to be monitored.

Thus, run-off control, which was originally promoted only by the guidance of local authorities, has gradually become more and more promoted with the backing of systems.



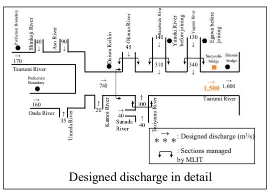
River Improvement Plan (2007)

(Setting the target and decide measures in approx. 30years, based on River Law)

✓ **Mitigation by storage in the basin was taken into account** in the setting of the target discharge (since the plan of 1994).
✓ Uniquely, formulated by four administrators **in collaboration**.

Target Run-off	Target discharge		
		Flood control facility	River channel
2,110 m^3/s	1,860 m^3/s	360 m^3/s	1,500 m3/s

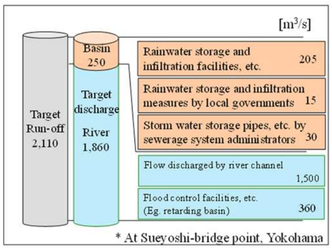
At Sueyoshi-bridge Point, Yokohama City



Designed discharge in detail

Tsurumi River Basin Flood Damage Countermeasures Plan (2007)
(based on Law on Measures against Flood Damage to Specified Urban Rivers in 2004)

- ✓ Formulated by four administrators in collaboration.
- ✓ Storing rainwater function (run-off mitigation) by several measures in the basin was written as a target.



iii) Status of implementation of measures such as regulating reservoirs.

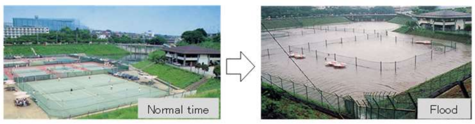
As a result of these efforts, for example, the number of regulating reservoirs for storing rainwater was approximately 3,300 in 2002, and 4,000 in 2007, and continued to increase to approximately 5,000 in 2019 (when Typhoon Hagibis hit East Japan, as described below). Their total storage capacity amounts to about 3.1 million m^3, which is equivalent to 0.8 times the capacity of the Tsurumi River Multi-Purpose Retarding Basin (storage capacity of 3.9 million m^3), as discussed below.

Other measures are also being taken, such as the construction of facilities to store and infiltrate rainwater underground in public facilities such as schools, parks and public housing, and pavements to allow rainwater to infiltrate underground on roads.

Regulating reservoirs etc. to control run-off

Regulating reservoirs for storing rainwater

Example in Yokohama



(Usually used as tennis court but can store nearly 100,000m^3 of rainwater.)
In 2019, there are 5,000 reservoirs with total storage capacity of about 3.1 million m^3.
(*Equivalent to 0.8 times capacity of Multi-Purpose Retarding Basin explained later.)

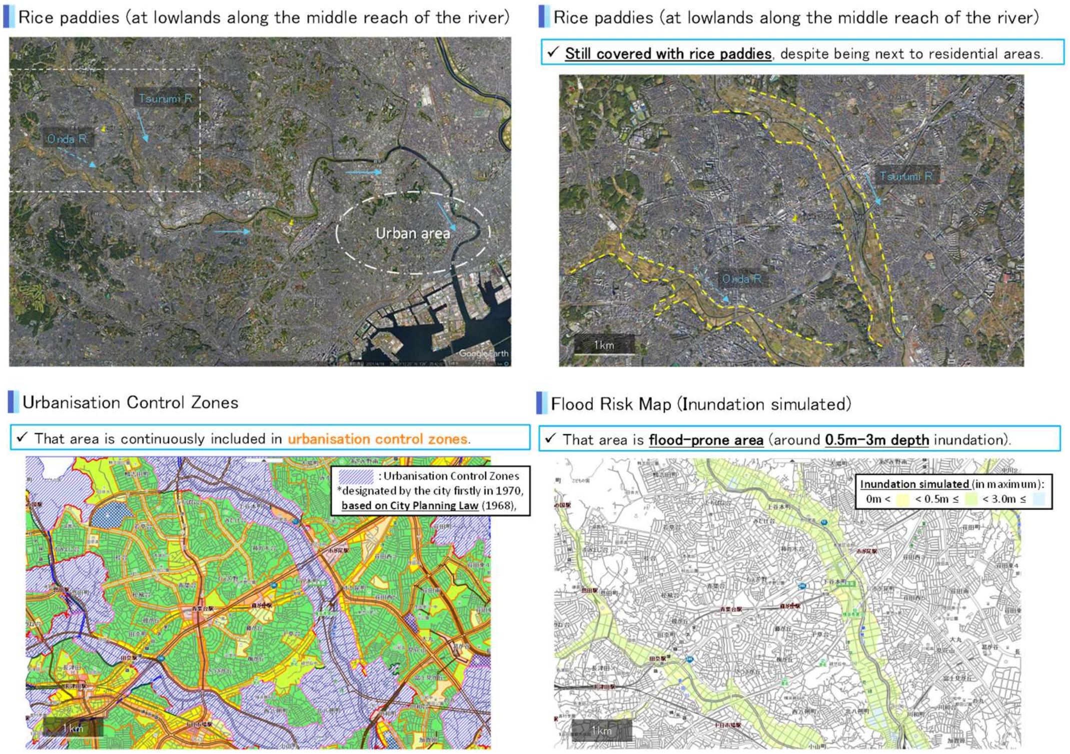
Facilities to store and infiltrate rainwater underground in public facilities
(at schools, parks and public housing)

(2) Land use regulations to avoid increase of potentially affected people and assets

Urbanisation progressed significantly in the Tsurumi River basin during the period of the High Economic Growth, but as mentioned above, new development of frequently flooded low-lying areas may increase the number of people and assets to be affected.

Based on the City Planning Law enacted in 1968, the Yokohama City designated ‘urbanisation zones’ (zones where urbanisation is promoted) and ‘urbanisation control zones’ (zones where development is restricted in order to control urbanisation) in 1970, and at that time some part of the lowlands along the middle reach of the Tsurumi River was included into ‘urbanisation control zones’ to control development. Subsequently, though the designation of the area was reviewed every a few years, those lowlands have consistently been included into urbanisation control area. Despite being right next to residential areas, the area is still undeveloped and covered with rice paddies, which has contributed to preventing more damage from flooding.

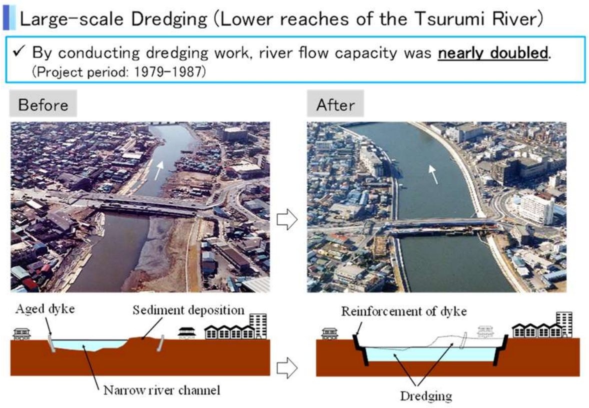
And in 1981, when the Tsurumi River Basin Improvement Plan was drawn up, the inundation record map (showing inundation areas from the floods of 1966 and 1976) was prepared, and later, a flood risk map based on simulations was also prepared. These efforts are also steadily implemented.



(3) Countermeasure works in river areas

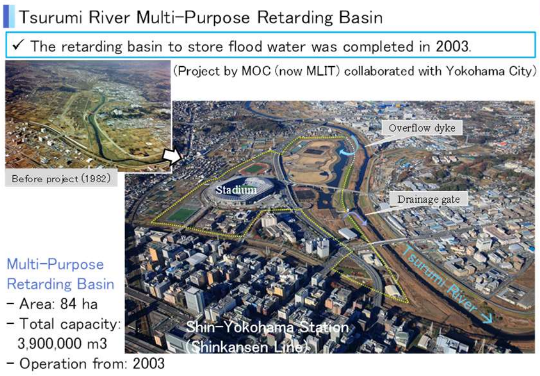
i) Large-scale dredging

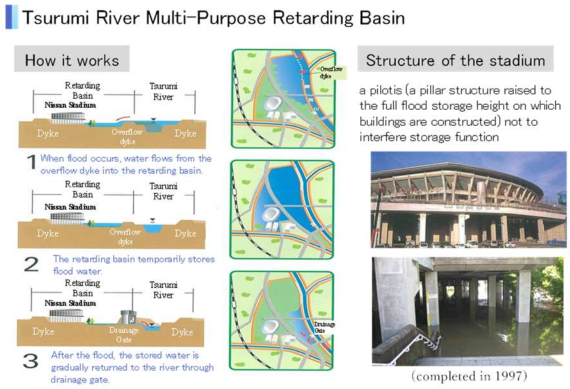
In addition, large-scale works were also carried out in the river area. One of these was the large-scale dredging of the lower reaches of the Tsurumi River, which was carried out for nine years from 1979. The dredging was undertaken because it was difficult to widen the river channel due to the dense urban areas along the river downstream. However, many old, low bridges had already been built over the Tsurumi River and large dredgers could not enter the river, so a special dredger was built to pass under the bridges. And in order to transport the sand and soil to the wharf site under construction at the Port of Yokohama, it was necessary to pass through a sea route on the way, so pumping pipes were passed through the riverbed and seabed from the dredging point in the Tsurumi River to the wharf site. Thanks to these innovations, the dredging work was completed on schedule, and the flow capacity downstream nearly doubled (from around 500 m^3/s before to 950 m^3/s after the work). The director of the office of MOC at the time recalls that the residents in the catchment area understood how serious the office was when this construction work started.



(ii) The Tsurumi River Multi-Purpose Retarding Basin

The next major project after the dredging was the construction of a multi-purpose retarding basin. The site is close to Shin-Yokohama Station of the Shinkansen (bullet train), but at the time of planning the project, the area was covered with rice paddies, and development was also restricted as an urbanisation control zone. In order to ensure the flood storage function through the development of a retarding basin, in 1984 the national government started the project (later with a collaboration with Yokohama City) and it was completed with a total storage capacity of 3.9 million m^3 to operate in 2003. The reason the Yokohama City also participated in the project was to construct an international stadium on the site, which was completed in 1997 in the form of a pilotis (a pillar structure raised to the full flood storage height on which buildings are constructed) in order not to interfere with the flood control function. The stadium hosted the final of the 2002 Football World Cup. And in 2019, the day before the Rugby World Cup match between Japan and Scotland, the Typhoon Hagibis hit East Japan but the match was successfully held while floodwaters were stored there.

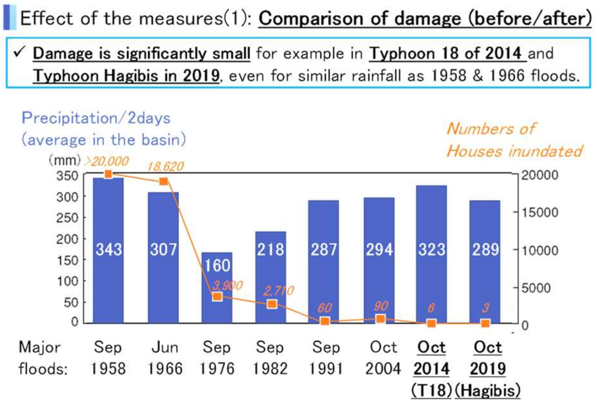




3. What is the effect of those measures?

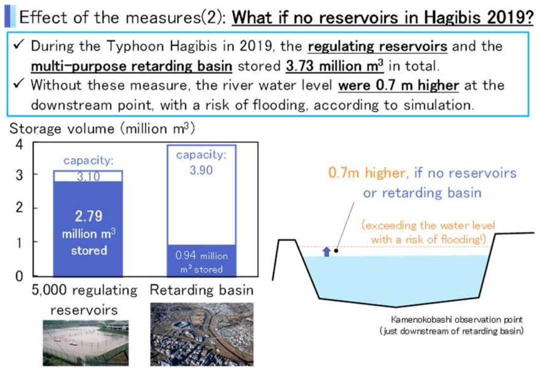
(1) Comparison of flood damage before and after comprehensive flood control measures

A comparison of the amount of rainfall and the number of flooded houses before and after the implementation of the river improvement works and comprehensive flood control measures shows that even if similar amount of rainfall occurred as in the 1958 and 1966 floods before the measures were implemented, the flooding damage has been significantly reduced, for example in the Typhoon 18 in 2014 and the Typhoon Hagibis in 2019.



(2) If there were no regulating reservoirs or multi-purpose retarding basin in 2019

During the Typhoon Hagibis in 2019, the regulating reservoirs in the basin stored approximately 2.79 million m3 (approximately 90% of their total storage capacity at the time). About 940,000 m3 was also stored in the multi-purpose retarding basin (about a quarter of its total storage capacity). Simulations estimate that if these measures had not been taken, the river water level would have been 0.7 m higher at the downstream point, with a risk of flooding.



4. Closing

(1) Key points - why did it work?

The success in the Tsurumi River basin can be attributed to several reasons.

The first is the “background” and a “sense of crisis” that urbanisation was progressing and the adverse effects of urbanisation were beginning to appear in frequent flooding. It is also important to note that urbanisation was 'in progress' rather than 'completed', and if it had been completed, there might not have been any room left to take countermeasures in the basin. As mentioned above, the flooding that occurred around the time when the study of countermeasures began was a spur to the study. Also, as mentioned above, the fact that river development was progressing without a balance between the upstream and downstream areas also contributed to the sense of crisis.

Secondly, the "enthusiasm and tenacious dialogue of officials in charge" based on this sense of crisis. In particular, the 'Tsurumi River Basin Water Disaster Prevention Committee', which served as a forum for discussion, was realised after national government officials travelled to Yokohama City and other municipalities and enthusiastically asked their participation. At the committee meeting, it was explained clearly that urbanisation contributes to increasing flood damage, and the responsible parties enthusiastically discussed any issues that could be expected to have an effect on flood countermeasures, which actually led to the development of measures. This close and tenacious relationship between the central and local authorities and others played an important role. The smooth discussions at the committee meetings were also supported by the participation and lead of academics.

Thirdly, there are “systems” that strengthened such discussions and measures. No matter how enthusiastic the discussions and measures started, if they are not enforced or if the person in charge changes and the enthusiasm drops, the initiatives may stop. In the case of the Tsurumi River, after the start of measures, additional systems and plans based on them, such as the 'Specific River for Comprehensive Flood Control Measures' system and the River

Basin Improvement Plan based on it, and the Law on Measures against Flood Damage to Specified Urban Rivers in 2004 and the River Basin Flood Damage Measures Plan based on it, have further promoted steady and strong measures. The fact that rice paddies are maintained in the lowlands along middle reach is also a result of the designation of zones based on the Urban Planning Law. And incidentally, moves to expand these systems are still ongoing, and in 2021 the Law on Measures against Flood Damage to Specified Urban Rivers and the Urban Planning Law were amended to provide new mechanisms to further restrict development of low-lying areas along rivers.

Finally, it should also be pointed out that “large-scale improvement works (by the national government etc.)” have gained the trust of people and localities of the river basin. The large-scale dredging in particular was technically difficult work, but its implementation greatly improved the safety level of the river, and as mentioned above, the head of the office of MOC at the time recalled that the people in the basin had understood how seriousness the office is once this work was set in motion. It is thought that the national government must first show its seriousness, rather than just making requests to and consulting with local authorities, in order for local authorities to trust and sympathise with the initiatives.

(2) Recommendations based on the Tsurumi River initiative

In line with these points, the following recommendations are considered important when considering and promoting measures in river basins where urbanisation is a concern.

First, it is necessary to take measures to control run-off and limit the spread of damage before urbanisation progresses (or at least before it has completed). It is also important to consider the balance between upstream and downstream areas and to think on a basin-wide scale.

Secondly, it is necessary to continue coordination, discussion and dialogue with enthusiasm beyond the boundaries of national and local authorities. In this process, it is important to explain in a simple manner to be a common understanding that urbanisation may contribute to flood damage, as well as to encourage more enthusiastic discussions among those in charge on any issues that are expected to have an effect on flood control. It is also useful to have academics take the lead in facilitating discussions.

It is also important to have systems to support such discussions and dialogue. Systems for restricting development and guiding land use need to be appropriately prepared.

It is also important, of course, that improvement works by the national government etc. to improve the level of safety and gain the trust of the people and the localities in the basin.

Lastly, the importance of showing the 'effects' of these measures to the people should be highlighted as well. It is important to show how much safety has been improved as a result of the measures taken, so that people can feel the effects of the measures. It is useful not only to show how much the amount of water that can flow through the river improvement works, but also to analyse the data to show how much less damage there was this time compared to past floods, for example, as mentioned above. Simulating how higher river levels would have been if no measures had been taken in the basin is another useful way of communicating the effectiveness. In Japan, in addition to cost-effectiveness analyses in advance for various river improvement works, a simulation is carried out and published every time a flood occurs, showing that the flood would have been even worse this time if those measures had not been taken. The interest of residents in flood control measures increases immediately after a flood, and we believe that by taking advantage of this timing and communicating the effects of the measures, the importance of the measures can be further realised.

(Supplementary information)

*1 River administrators, A-class river systems:
In Japan, the River Law stipulates the administrator of each river, and river systems which have sections managed by the national government (MLIT) are called A-class river systems. Conversely, in the case of a river system other than A-class river systems (e.g. a B-class river system), all sections are managed by the local government (e.g. prefecture). And even for A-class river systems, the national government manages the downstream sections near urban areas, while local authorities manage the upstream sections in mountainous areas.

*2 High Economic Growth:
In Japan, the real economic growth rate averaged around 10% per year around from 1955 to 1973, and this period is called High Economic Growth. At that period, industrialisation, infrastructure development and the concentration of the population in cities progressed rapidly.

*3 Upstream/downstream balance:
When planning river improvement, as the damage flooding is greater downstream comparing to upstream, and in the main river comparing to branch rivers in general, it is important to maintain consistency with an appropriate balance as a whole basin, between upstream and downstream and between main and branch rivers respectively. In particular, if more floodwater flows upstream than downstream, it is obvious that the river will be more likely to overflow at the change point (the point where the amount of water flowing becomes smaller),

so basically, to avoid creating such a change point, river improvement work to increase the discharge capacity should be carried out in order, starting downstream.

*4 On the study with academics and others:
In Japan, when the Government considers important policies, it sometimes takes a procedure whereby the Minister submits a request for consideration to a council made up of academics etc., and after several rounds of discussion, the council responds with a recommendation to the Minister. The government department in charge is responsible for the secretariat of these council discussions. Based on the recommendations, the department then reflects them into actual policy.

River information website provided by MLIT

Reference (8)

Flood results: shown in the town

Reference (9)

Japan

Past flood depth

Hoi An

As of 27/Dec/2022

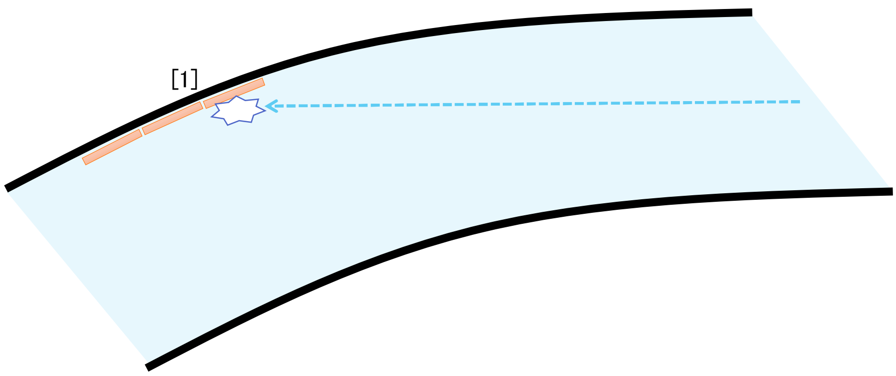
On Countermeasure for Riverbank Erosion

SUZUKI Takashi,
JICA Expert (Advisor for Disaster Risk Management), VNDMA, MARD

1

Two approaches: countermeasures for riverbank erosion

[1] Bank protection



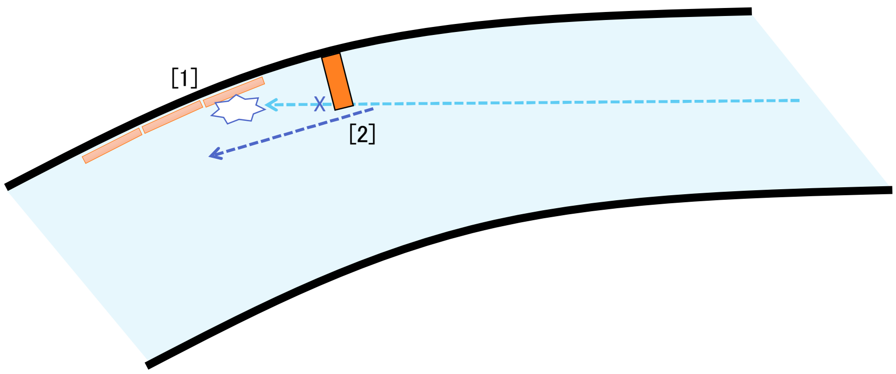
Note that simply installing Bank Protection may increase scouring power by making water flow along the riverbank smooth and speed up, which makes the riverbed and banks more susceptible to erosion.

2

Two approaches: countermeasures for riverbank erosion

[1] Bank protection

[2] River Groyne
(to avoid strong flow (thalweg) away)



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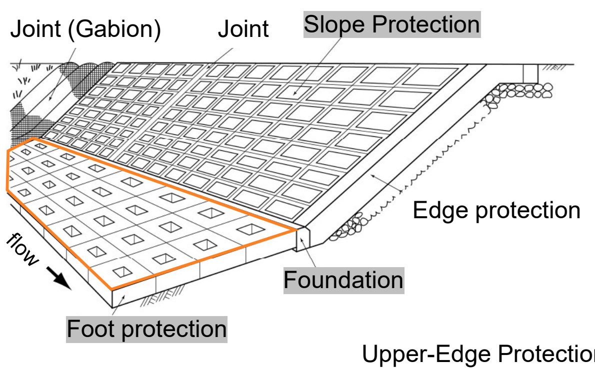
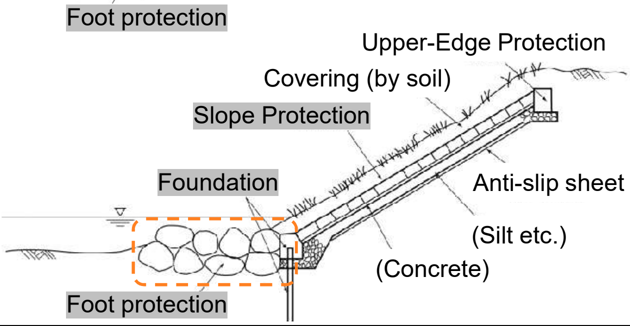
[1]-1 Bank protection



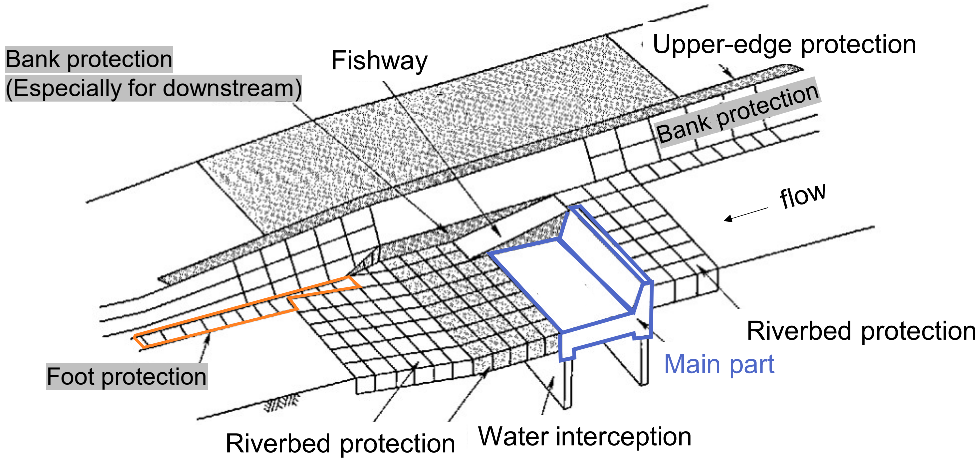


*The most notable damage to bank protection is caused by riverbed scouring in front of it.
In many cases, it is caused by shallow Foundation, or by lack or washed-away of Foot protection.

4

[1]-2 Bank protection <u>at just downstream of a drop-off</u>

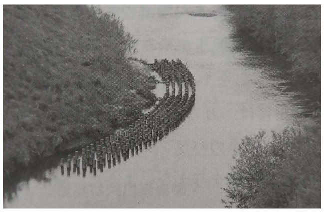
At just downstream of a drop-off, **<u>due to turbulence of flow</u>**, <u>riverbank is prone to be scoured and eroded</u> as well as riverbed.
→ Bank protection (including foot protection) should be provided.



[2] River Groyne (to avoid strong flow (thalweg) away)

Depending on river slope, various types are used, such as concrete blocks, frame-like or pile-like structures.
In addition to **<u>avoiding strong flow (thalweg) away</u>**, protecting riverbank by **<u>promoting sedimentation</u>** behind it. =Utilizing the reaction of river itself.
However, generally not used on rivers with small widths.

Using concrete blocks

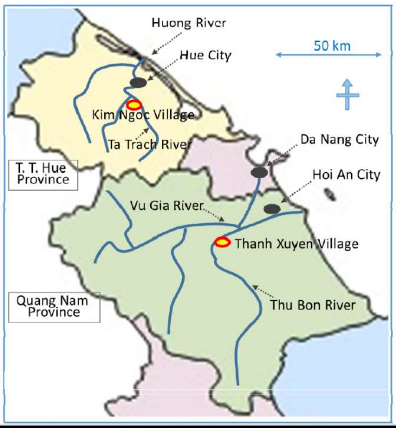


Pile-like structures

Flame-like structures

Countermeasures around 2010 (Central Vietnam)

- At the JICA's Technical Assistance Project in 2009-2012, JICA experts and engineers of locality conducted works as countermeasures for riverbank erosion.
- In 2010, with an emphasis on reducing the flow during floods, and taking into account local material procurement and construction capacity, Foot Protection were constructed on Ta Trach River (Huong River's tributary) and Groyne etc on Thu Bon River.
- They costed relatively cheap, and are ready for repair work by material etc on-the-spot.
- Subsequently, these have promoted sedimentation and effectively protected riverbanks.



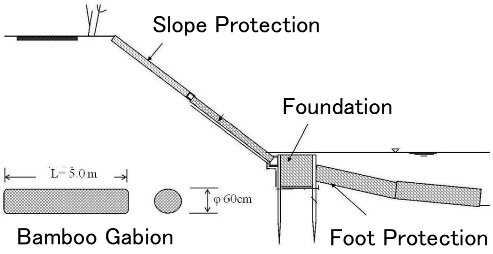
Countermeasure in Thu bon River
(Groyne by stones)

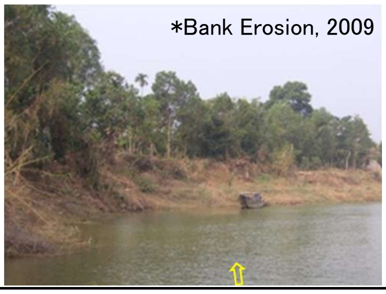
Matsuki(2015), Matsuki(2016) 7

(1) Foot Protection, Ta Trach River

- The 2007 flood eroded 300m of riverbank and a typhoon in 2009 put 120 houses and roads at risk.
- Using bamboo gabion as inexpensive and underwater construction method for the Foot Protection, which tends to be omitted in Vietnam, and made it onsite.
(The foundation etc were designed using standard Vietnamese construction methods.)
- Resulting in promoting sedimentation over that and the bank was stabilized

*Countermeasure
(Cross Section)





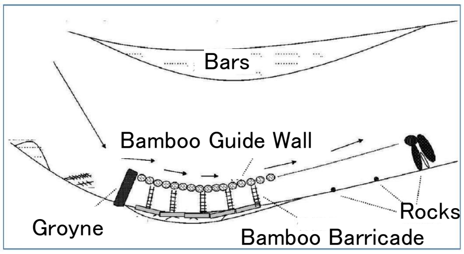
(Foot Protection using Bamboo Gabion, 2012)

8

(2) Groyne etc, Thu Bon River

- The riverbank eroded for 500m during the 2007 floods. Erosion has continued since then. 250 houses and a village road are located on the riverbank.
- As an inexpensive way to keep the strong current away from the riverbank, a **<u>Groyne using stones (masonry)</u>** and bamboo guide wall etc were installed.
- It resulted in promoting sedimentation downstream and bank are stabilized.

*Countermeasure
(Plan View)



*Bank Erosion, 2009

(Groyne using stones, 2010)

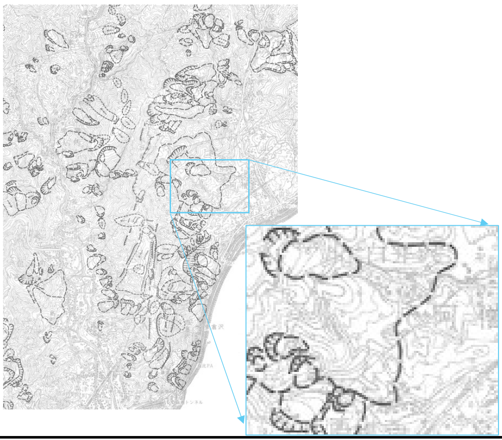
9

Different scale of Landslide/flash flood risk maps

✓ Regarding landslide/flash flood risk maps,
the survey method and purpose of utilization differ depending on the scale.

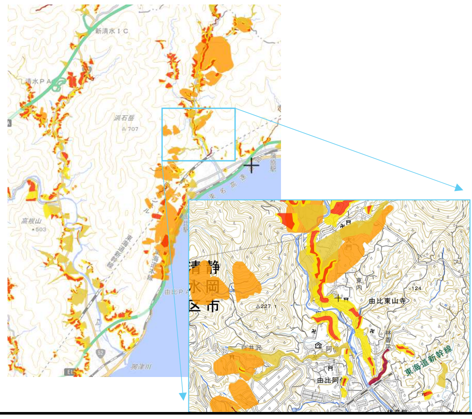
1/50,000

Reading from aerial photos and roughly illustrating. Difficult to use for DRR activities in communities.



1/2,500～1/25,000

Illustrating based on topographic maps and field surveys. Utilized for evacuation and development control in communities.



1

Regarding the maps showing landslide/flash flood risk in Japan

✓ There are several kinds of risk map for sediment disaster (landslide and flash flood) in Japan, but they differ in terms of scale, survey methods, and utilization.

	Target	Area/scale	Survey method	Objective/Who in charge
Landslide distribution map	Landslide	Covers all of Japan 1/50,000	Reading and illustrating relatively large landslide topography (traces of past landslides) from aerial photographs. *In principle, no field survey	Basic data to understand regional characteristics for land development and for landslide research, by the National Research Institute for Earth Science and Disaster Prevention (NIED)
Sediment disaster hazard map	Flash flood/ Landslide/ Steep Slope Failure	All areas(*1) with risk of harm to residents About 1/2,500 (Minimum 1/25,000)	Based on topographic maps and field surveys, illustrating areas(*1) with risk of harm to residents for each disaster type. *Numerical simulation may be used when it is difficult to determine from topographic maps or field surveys.	Prefectures designate zones(*1) for evacuation and development control. Based on it, municipalities publish it with information of evacuation routes and shelters for smooth evacuation. *Sediment Disaster Prevention Act

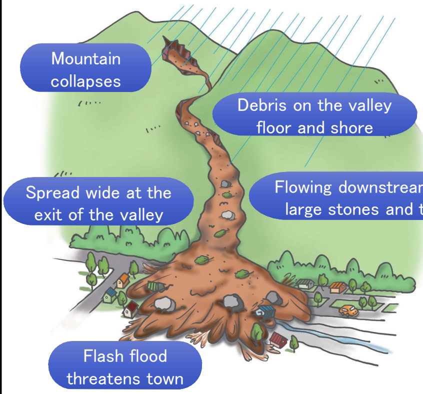
(*1) Areas with risk of harm to residents are designated as **Sediment Disaster Warning Areas** and areas with risk of significant harm to residents due to damage to buildings are designated as **Sediment Disaster Special Warning Areas**, based on technical criteria. In the former, evacuation systems and hazard maps are prepared and distributed, while in the latter, development control and building structure regulations are also implemented.

Others: Landslide prevention area; Steep slope failure danger area; Estimated frequency map of deep failure and Stream level assessment map

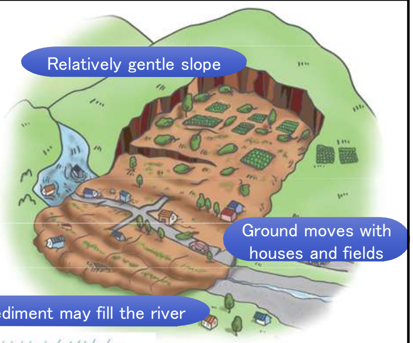
2

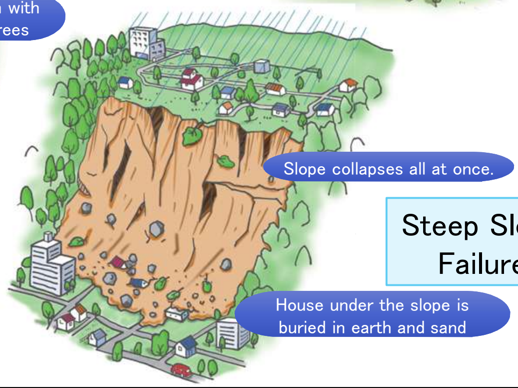
Types of Sediment Disasters in Japan

Flash flood



Landslide





Steep Slope Failure

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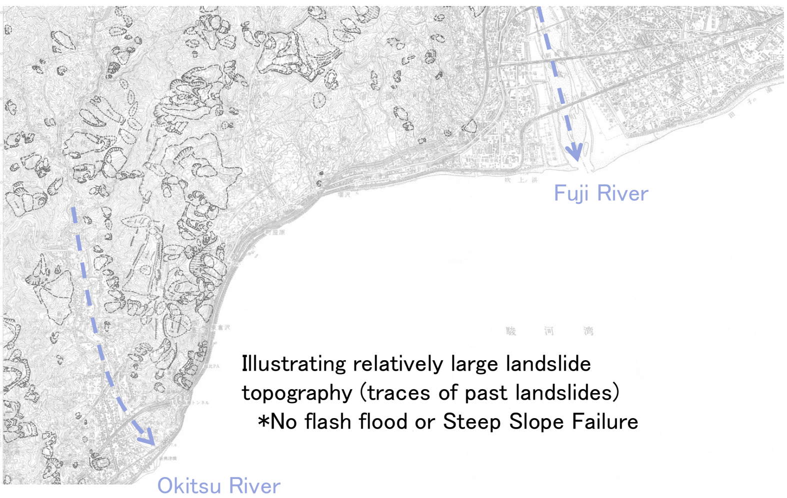
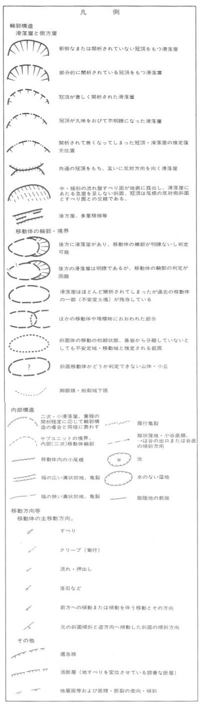
Landslide distribution map (Covers all of Japan, 1/50,000)





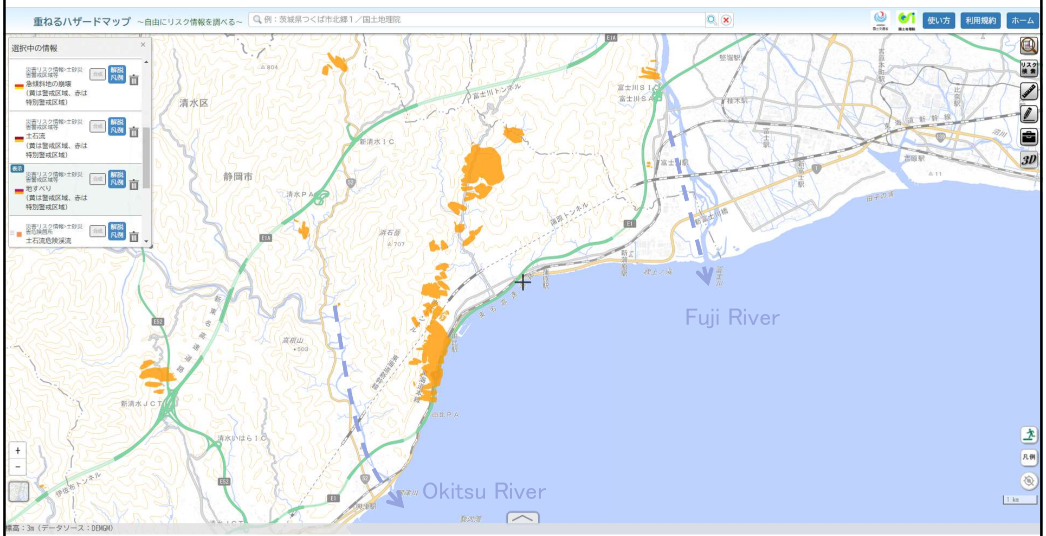
Illustrating relatively large landslide topography (traces of past landslides)
*No flash flood or Steep Slope Failure

*The rivers are illustrated for reference for comparison with later pages.

4

Sediment disaster hazard map (Risk of harm to residents, About 1/2,500)

Landslide

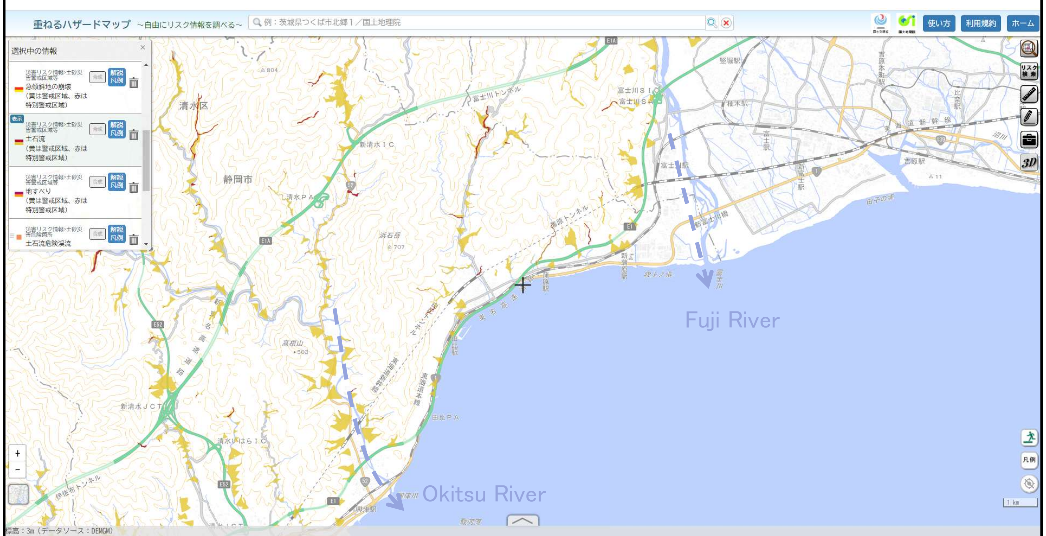


Not limited to large landslide topography, areas with risk of harm to residents are shown.
(Areas with no risk of harm to residents are not shown) → To be used for local disaster prevention

5

Sediment disaster hazard map (Risk of harm to residents, About 1/2,500)

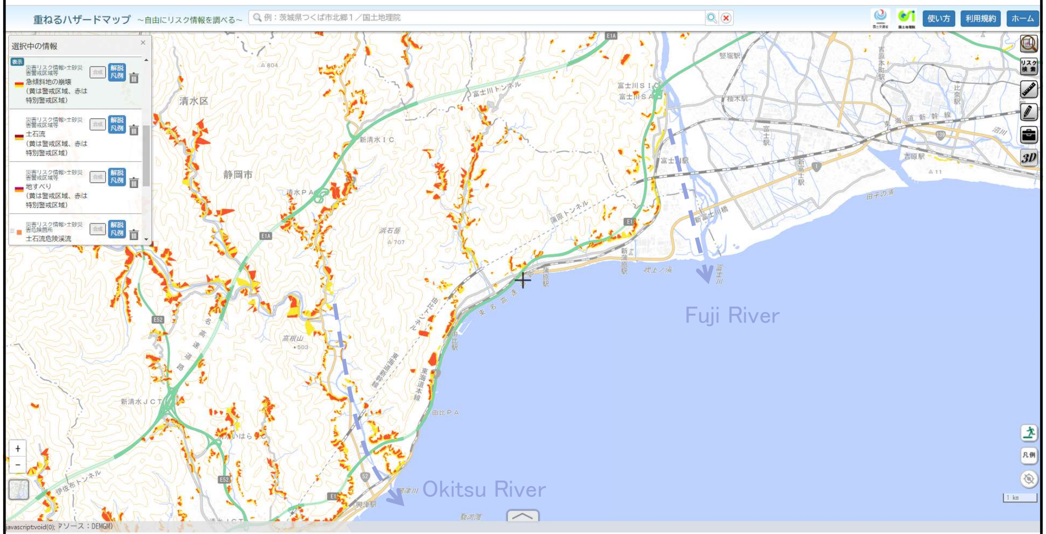
Flash flood



6

Sediment disaster hazard map (Risk of harm to residents, About 1/2,500)

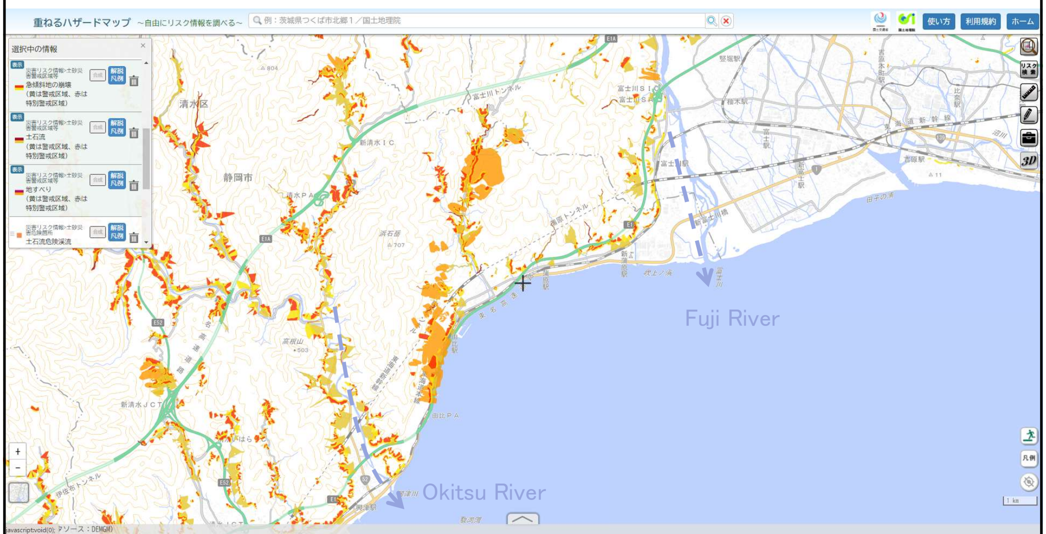
Steep Slope Failure



7

Sediment disaster hazard map (Risk of harm to residents, About 1/2,500)

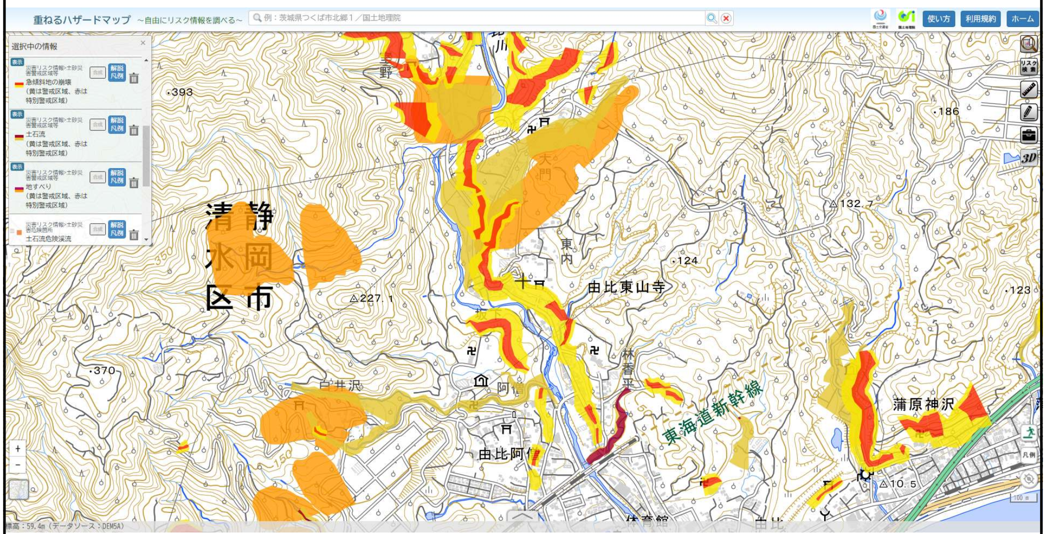
[Overlapping] Landslide + Flash flood + Steep Slope Failure



8

Sediment disaster hazard map (Risk of harm to residents, About 1/2,500)

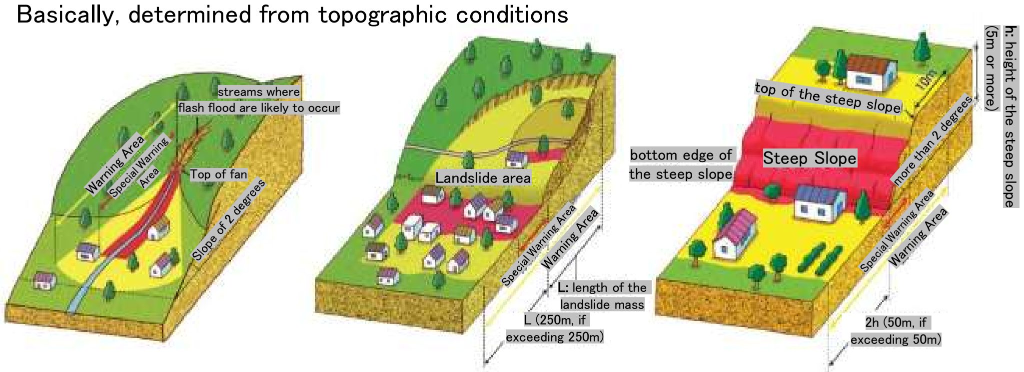
(Enlarged view)



Created and published on a scale useful for disaster management activities at the community level

Scope of Sediment Disaster Warning Areas

Basically, determined from topographic conditions



Flash flood

Areas with a slope of 2 degrees or more and downstream from the top of the fan in streams where flash flood are likely to occur

Landslide

Landslide area and the area within a distance equivalent to the length of the landslide mass (250m, if exceeding 250m) from the lower edge of the landslide area

Steep Slope Failure

- Areas with a slope of 30 degrees or more and a height of 5m or more
- Areas within a horizontal distance of 10m from the top of the steep slope
- Area within twice the height of the steep slope (50m, if exceeding 50m) from the bottom edge of the steep slope

Source: Construction Bureau, Tokyo Metropolitan Government
https://www.kensetsu.metro.tokyo.lg.jp/jigyo/river/dosha_saigai/map/kasenbu0087.html

15/Aug/2023
SUZUKI Takashi
(Disaster Risk Management Advisor, VDDMA)

Road Closure in Advance

(Measure in Japan to close road when rainfall amount reaches the standard value to prevent damage to cars, even if no landslides, flashflood or falling rocks have occurred.)

In Japan, where the land is mountainous and the geology is fragile, landslides, flashflood and falling rocks occur frequently during heavy rains, sometimes causing damage to road facilities and to cars and people traveling on the roads.

Basic countermeasures against such disasters on roads include removing or fixing the causative factors such as sand and rocks, and installing protective facilities. Another example is to prevent damage to cars and people by closing road (restricting traffic) when hazards are anticipated.

In Japan, the first case that triggered the system of closing road due to the threat of landslides, flashflood and falling rocks was the 1968 flashflood accident on National Route 41, which caused two buses to fall off the road. Torrential rains caused a flashflood on the eastern slope of National Route 41 in Gifu Prefecture, hitting two large buses that were passing on the road. This caused the buses to fall into Hida River, which flows on the west side of the road, killing more than 100 people.

Until this accident, it had been common practice to avoid closing road as much as possible since closing road affects local people's daily life and regional economic activity, and actually they intended to wait until after a road had been damaged by a disaster to close it to through traffic. However, this accident changed that.

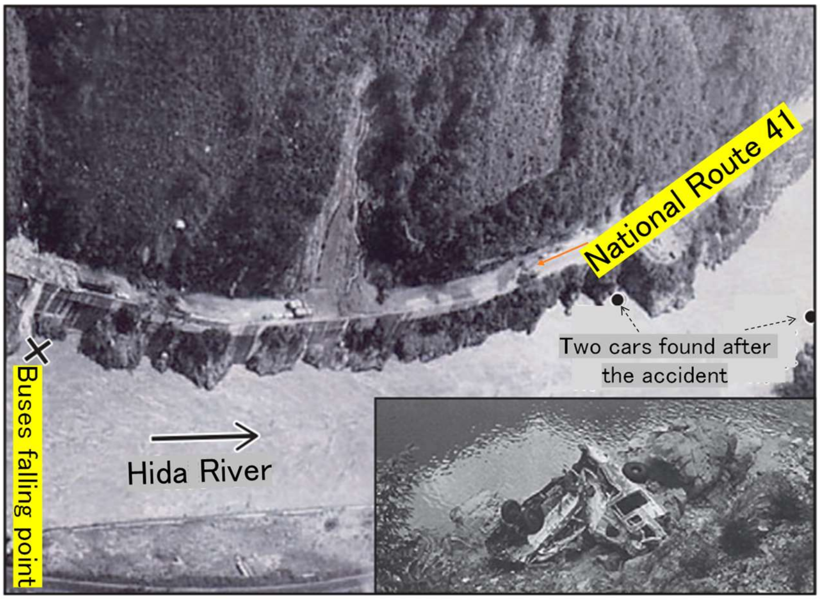
In the year following the accident, the Director General of the Road Bureau of the Ministry of Construction (now MLIT) issued a decision that the government should designate sections where damage had occurred or was likely to occur such disasters in the severe weather, and set the standard rainfall amount as criteria to be followed in order to close the road.

Specifically, when there is a correlation between the occurrence of disasters/accidents (landslides, flashflood and falling rocks) and weather conditions, set the standard rainfall amount (using continuous rainfall, hourly rainfall, or both) based on past records, and when the amount of rainfall reaches this standard, they close the road.

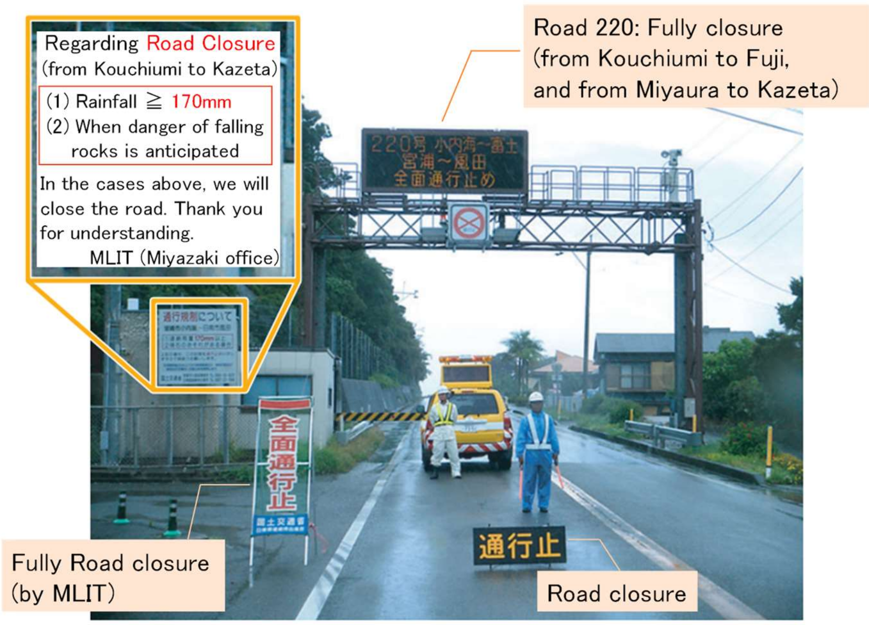
The actual designation of sections was rapidly promoted in a period of about 10 years until around 1980, and more than 200 sections were designated on roads administered by the national government throughout Japan (the number of designated sections has since decreased due to the sequential implementation of countermeasure works).

In addition to these, there are also sections that would be closed when danger is anticipated through patrols and other measures.

If you are interested in more detailed information, please do not hesitate to contact me.



Accident on the National Route 41 and Hida River (Aug, 1968)

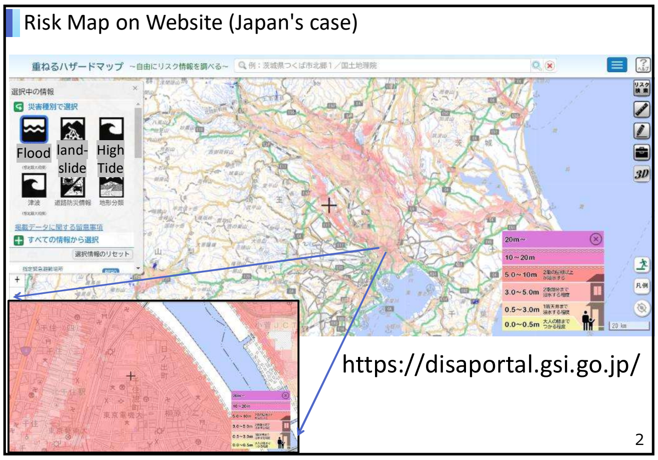


Road closure considering rainfall (Example in National Road 220)

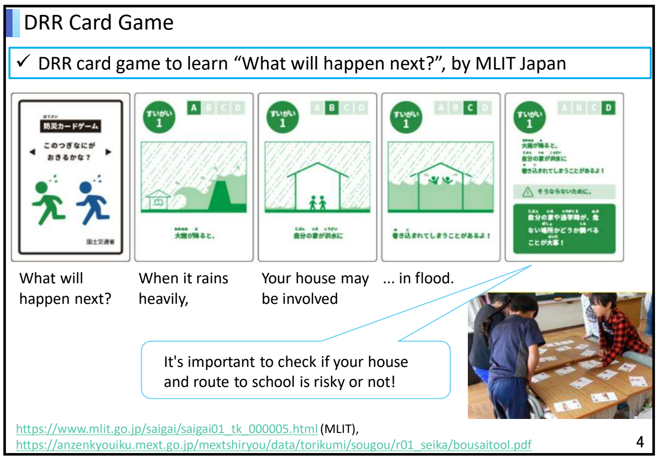
Photos: Road Risk Management Office, Road Bureau, MLIT (2015) (*English explanations added later)

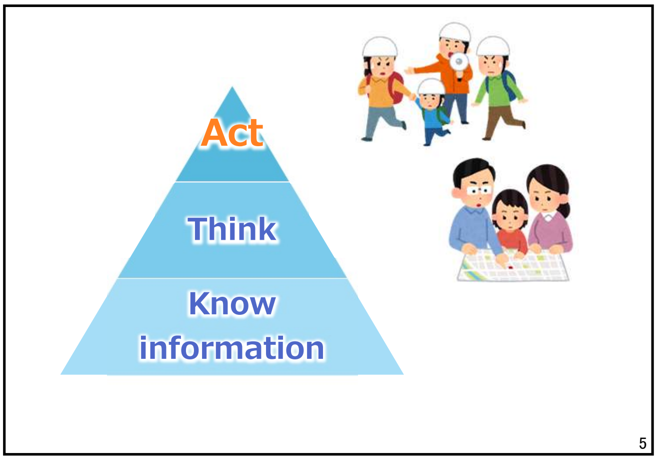
https://www.hido.or.jp/14gyousei_backnumber/2015data/1508/1508gerira_gouu_mlit.pdf

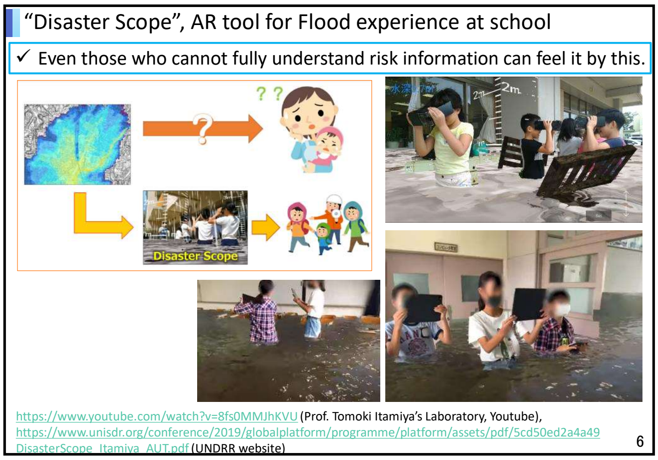

APEC EPWG Workshop
Dec 13, 2024
HCMC
How to help people know, think, and act
based on disaster risk information
— From Japan's experiences —
SUZUKI Takashi
Advisor for Disaster Risk Management (JICA Expert),
Vietnam Disaster and Dyke Management Authority (VDDMA), MARD, Vietnam
JICA


Risk Map on Website (Japan's case)
重ねるハザードマップ
Flood
land-slide
High Tide
https://disaportal.gsi.go.jp/
2


Flood results/simulation: shown in the town
Japan
Hoi An, Vietnam
2.0m
2.0m
Past flood depth
Estimated flood depth
3


DRR Card Game
✓ DRR card game to learn "What will happen next?", by MLIT Japan
What will happen next?
When it rains heavily,
Your house may be involved
... in flood.
It's important to check if your house and route to school is risky or not!
https://www.mlit.go.jp/saigai/saigai01_tk_000005.html (MLIT),
https://anzenkyouiku.mext.go.jp/mextshiryou/data/torikumi/sougou/r01_seika/bousaitool.pdf
4


Act
Think
Know information
5


"Disaster Scope", AR tool for Flood experience at school
✓ Even those who cannot fully understand risk information can feel it by this.
Disaster Scope
https://www.youtube.com/watch?v=8fs0MMJhKVU (Prof. Tomoki Itamiya's Laboratory, Youtube),
https://www.unisdr.org/conference/2019/globalplatform/programme/platform/assets/pdf/5cd50ed2a4a49 DisasterScope_Itamiya_AUT.pdf (UNDRR website)
6

Activities in School

✓ Creating Disaster Risk Map by themselves



Example in Hasuda City, Saitama Pref.
https://www.nhk.or.jp/ashitanavi/video/14108.html (NHK)

7

"My timeline"

✓ Creating their own action plan, in accordance with hours prior to disaster

"Timeline" (Example)

What to do	Hours
Prepare Evacuation Center	**96**
Emergency Declaration	72
Taking Level 3	36
Close Traffic	**36**
Taking Level 4	24
Stop Public Transport	**12**

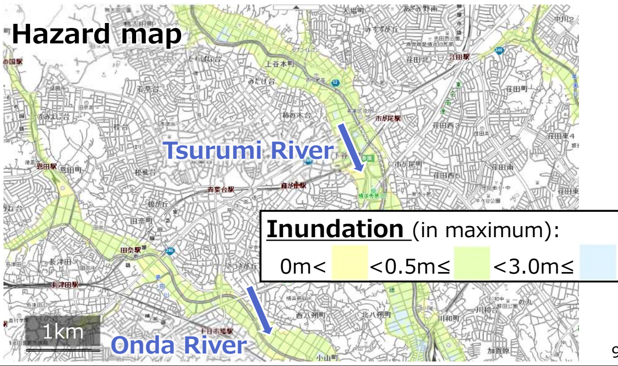


Illustration: Hiroshima Pref
https://www.gensai.pref.hiroshima.jp/mytimeline/

8

A case of Tsurumi River, Yokohama, Japan

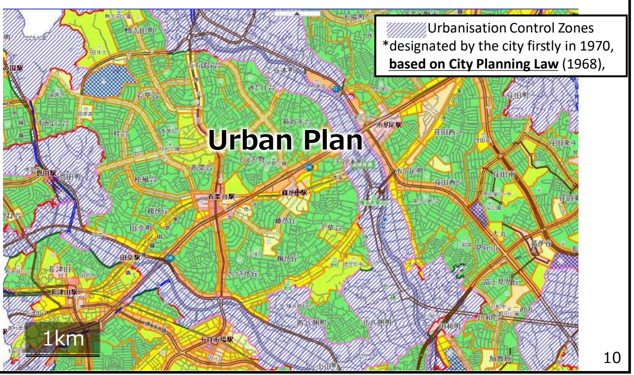
✓ Hazard Map shows all the area along the river as high risk



9

In Yokohama City's Urban Plan

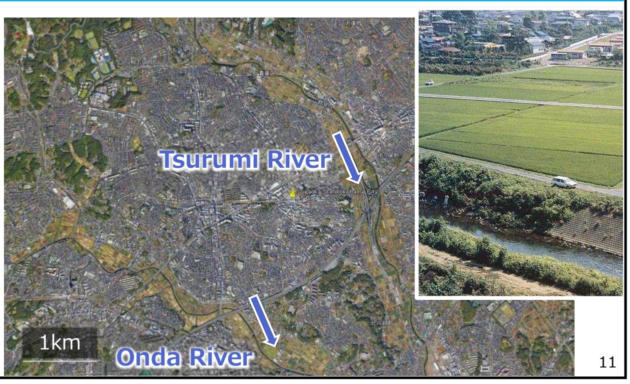
✓ Designated as urbanization control zones, where development is limited



10

Thanks to such efforts,

✓ Still covered with rice paddies even in residential areas in the city



11

River information website provided by MLIT

12

Types of Warning/information

✓ Mayor of the municipality issues evacuation instructions, etc., based on information from MLIT etc., and JMA (Japan Meteorological Agency), etc.

Five Alert Levels

Mayor issues ← Based on: JMA issues / MLIT etc. and JMA issues / Prefecture and JMA issues

	Situation	Information on evacuation etc. (Mayor issues)	Information on Rainfall (JMA issues)	Information on each River (MLIT etc. and JMA issues)	Information on Sediment Disaster (Prefecture and JMA issues)
5	Disaster occurred or Imminent	Emergency Safety Measures	Heavy Rain Emergency Warning	Information on flooding	Heavy Rain (landslide) Emergency Warning
	---Evacuation completed by Level 4!---				
4	High Risk of Disaster	Evacuation Instruction		Information on potential flood hazards	Landslide Alert Information
3	Risk of Disaster	Evacuation of the elderly etc.	Heavy Rain Warning	Information to provide a warning on flooding	
2	Weather Worsening		Heavy Rain Advisory	Information to call attention to flooding	
1	Risk of Weather Worsening		Probability of Warning		

13

Press Conference by MLIT and JMA (Japan Meteorological Agency)

✓ When expecting severe damage, MLIT's officials in charge of rivers and JMA's officials hold a joint press conference to convey a sense of crisis.

(NHK TV News Program)

River Department, Tohoku Regional Bureau, MLIT

Tohoku Regional Bureau, JMA

→ Now, when **MLIT and JMA** hold such joint press conference, the public is cautious.

14

15

Disaster Preparedness Tokyo – detail information for people

Tokyo Bousai (Tokyo Gov 2015)

(English Version) Revised Version, 2023
https://www.bousai.metro.tokyo.lg.jp/_res/projects/default_project/_page_/001/029/136/tb2023_e_00.pdf

Example of contents

〈Vietnamese Translation〉

Mưa lớn và bão

Tầm quan trọng của việc chuẩn bị trước trong trường hợp xảy ra lũ lụt và gió mạnh

Front mưa tĩnh vào đầu mùa hè và mùa thu thường gây ra lượng mưa lớn. Ngoài ra, trong hơn 30 năm qua (1981-2010), trung bình mỗi năm có 26 cơn bão. Nếu những cơn bão này tiếp cận hoặc đổ bộ vào Tokyo, gió cực mạnh và lượng mưa lớn có thể dẫn đến ngập úng và lũ lụt trên sông. Bạn phải luôn kiểm tra thông tin thời tiết mới nhất và tự bảo vệ mình trước thiên tai. Xác nhận trước những địa điểm có rủi ro cao bằng cách kiểm tra bản đồ rủi ro, v.v...

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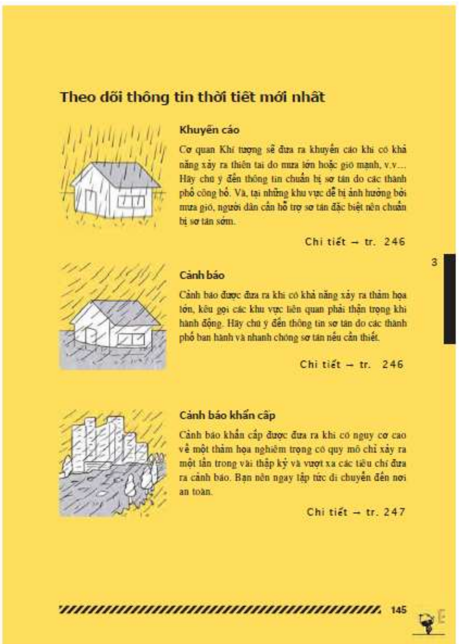

Theo dõi thông tin thời tiết mới nhất

Khuyến cáo

Cơ quan Khí tượng sẽ đưa ra khuyến cáo khi có khả năng xảy ra thiên tai do mưa lớn hoặc gió mạnh, v.v... Hãy chú ý đến thông tin chuẩn bị sơ tán do các thành phố công bố. Và, tại những khu vực dễ bị ảnh hưởng bởi mưa gió, người dân cần hỗ trợ sơ tán đặc biệt nên chuẩn bị sơ tán sớm.

Chi tiết → tr. 246

Cảnh báo

Cảnh báo được đưa ra khi có khả năng xảy ra thảm họa lớn, kêu gọi các khu vực liên quan phải thận trọng khi hành động. Hãy chú ý đến thông tin sơ tán do các thành phố ban hành và nhanh chóng sơ tán nếu cần thiết.

Chi tiết → tr. 246

Cảnh báo khẩn cấp

Cảnh báo khẩn cấp được đưa ra khi có nguy cơ cao về một thảm họa nghiêm trọng có quy mô chỉ xảy ra một lần trong vài thập kỷ và vượt xa các tiêu chí đưa ra cảnh báo. Bạn nên ngay lập tức di chuyển đến nơi an toàn.

Chi tiết → tr. 247

3

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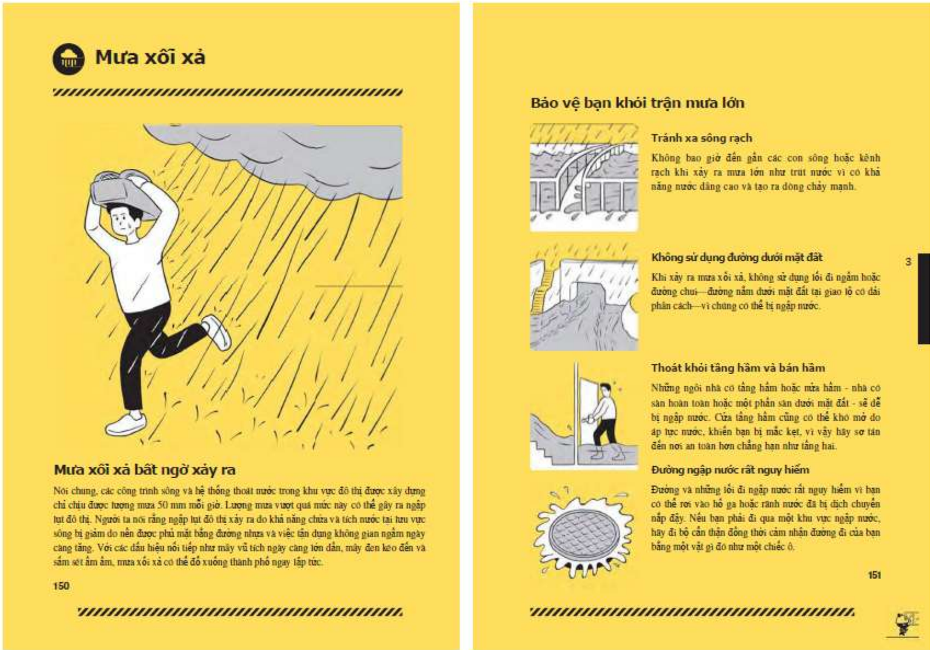
Example of contents

〈Vietnamese Translation〉



Mưa xối xả

Mưa xối xả bất ngờ xảy ra

Nói chung, các công trình sông và hệ thống thoát nước trong khu vực đô thị được xây dựng chỉ chịu được lượng mưa 50 mm mỗi giờ. Lượng mưa vượt quá mức này có thể gây ra ngập lụt đô thị. Người ta nói rằng ngập lụt đô thị xảy ra do khả năng chứa và tích nước tại lưu vực sông bị giảm do nền được phủ mặt bằng đường nhựa và việc tận dụng không gian ngầm ngày càng tăng. Với các dấu hiệu nối tiếp như mây vũ tích ngày càng lớn dần, mây đen kéo đến và sấm sét ầm ầm, mưa xối xả có thể đổ xuống thành phố ngay lập tức.

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Bảo vệ bạn khỏi trận mưa lớn

Tránh xa sông rạch

Không bao giờ đến gần các con sông hoặc kênh rạch khi xảy ra mưa lớn như trút nước vì có khả năng nước dâng cao và tạo ra dòng chảy mạnh.

Không sử dụng đường dưới mặt đất

Khi xảy ra mưa xối xả, không sử dụng lối đi ngầm hoặc đường chui—đường nằm dưới mặt đất tại giao lộ có dải phân cách—vì chúng có thể bị ngập nước.

Thoát khỏi tầng hầm và bán hầm

Những ngôi nhà có tầng hầm hoặc nửa hầm - nhà có sàn hoàn toàn hoặc một phần sàn dưới mặt đất - sẽ dễ bị ngập nước. Cửa tầng hầm cũng có thể khó mở do áp lực nước, khiến bạn bị mắc kẹt, vì vậy hãy sơ tán đến nơi an toàn hơn chẳng hạn như tầng hai.

Đường ngập nước rất nguy hiểm

Đường và những lối đi ngập nước rất nguy hiểm vì bạn có thể rơi vào hố ga hoặc rãnh nước đã bị dịch chuyển nắp đậy. Nếu bạn phải đi qua một khu vực ngập nước, hãy đi bộ cẩn thận đồng thời cảm nhận đường đi của bạn bằng một vật gì đó như một chiếc ô.

3

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Aomori Omamori Note – Worksheet style material

〈Vietnamese Translation〉

"Sổ tay bảo vệ Aomori"
- Tìm hiểu và suy nghĩ đúng đắn về phòng chống thiên tai -
Từ học sinh tiểu học lớp 1 ~ 3

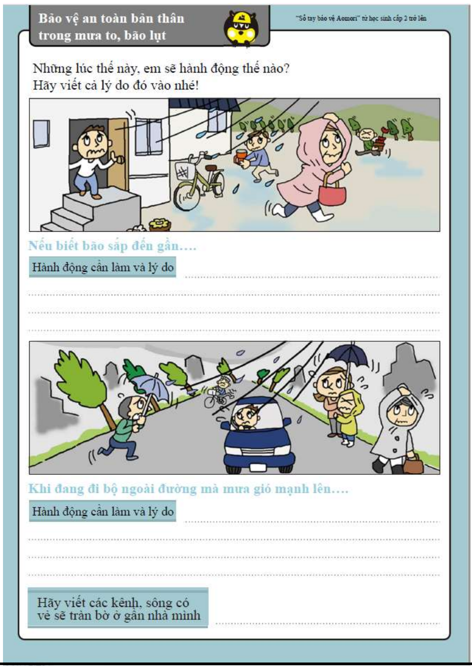
"Sổ tay bảo vệ Aomori"
- Tìm hiểu và suy nghĩ đúng đắn về phòng chống thiên tai -
Từ học sinh tiểu học lớp 4 ~ 6

"Sổ tay bảo vệ Aomori"
- Tìm hiểu và suy nghĩ đúng đắn về phòng chống thiên tai -
Từ học sinh cấp 2 trở lên

Aomori Omamori (Safety) Note, Aomori Prefecture (in Japanese)
https://www.pref.aomori.lg.jp/soshiki/kikikanri/bosaikikikanri/aomori_omamori_note.html

Example of contents

<Vietnamese Translation>



"Sổ tay bảo vệ Aomori" từ học sinh cấp 2 trở lên

Bảo vệ an toàn bản thân trong mưa to, bão lụt

Những lúc thế này, em sẽ hành động thế nào?
Hãy viết cả lý do đó vào nhé!

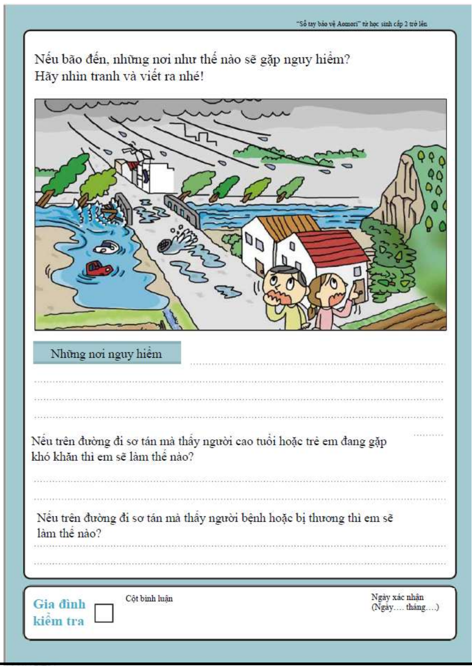
Nếu biết bão sắp đến gần....

Hành động cần làm và lý do

Khi đang đi bộ ngoài đường mà mưa gió mạnh lên....

Hành động cần làm và lý do

Hãy viết các kênh, sông có vẻ sẽ tràn bờ ở gần nhà mình



"Sổ tay bảo vệ Aomori" từ học sinh cấp 2 trở lên

Nếu bão đến, những nơi như thế nào sẽ gặp nguy hiểm?
Hãy nhìn tranh và viết ra nhé!

Những nơi nguy hiểm

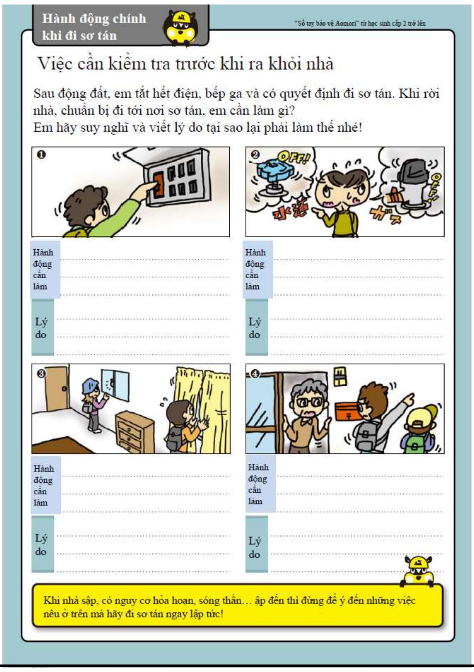
Nếu trên đường đi sơ tán mà thấy người cao tuổi hoặc trẻ em đang gặp khó khăn thì em sẽ làm thế nào?

Nếu trên đường đi sơ tán mà thấy người bệnh hoặc bị thương thì em sẽ làm thế nào?

Gia đình kiểm tra ☐ Cột bình luận Ngày xác nhận (Ngày.... tháng....)

Example of contents

<Vietnamese Translation>



"Sổ tay bảo vệ Aomori" từ học sinh cấp 2 trở lên

Hành động chính khi đi sơ tán

Việc cần kiểm tra trước khi ra khỏi nhà

Sau động đất, em tắt hết điện, bếp ga và có quyết định đi sơ tán. Khi rời nhà, chuẩn bị đi tới nơi sơ tán, em cần làm gì?
Em hãy suy nghĩ và viết lý do tại sao lại phải làm thế nhé!

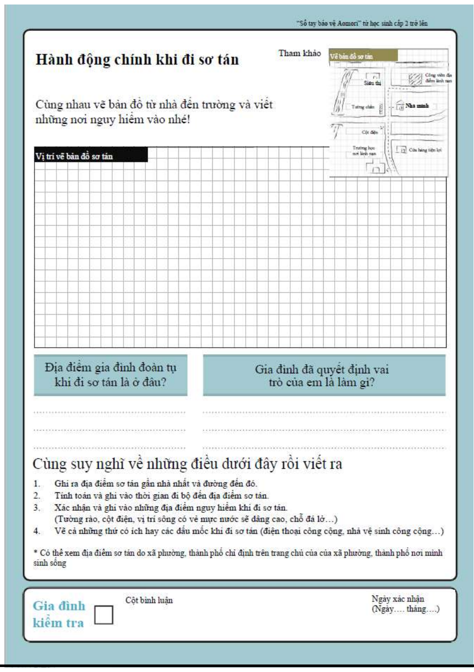
❶ Hành động cần làm / Lý do

❷ Hành động cần làm / Lý do

❸ Hành động cần làm / Lý do

❹ Hành động cần làm / Lý do

Khi nhà sập, có nguy cơ hỏa hoạn, sóng thần… ập đến thì đừng để ý đến những việc nêu ở trên mà hãy đi sơ tán ngay lập tức!



"Sổ tay bảo vệ Aomori" từ học sinh cấp 2 trở lên

Hành động chính khi đi sơ tán

Tham khảo: Vẽ bản đồ sơ tán

Cùng nhau vẽ bản đồ từ nhà đến trường và viết những nơi nguy hiểm vào nhé!

Vị trí vẽ bản đồ sơ tán

Địa điểm gia đình đoàn tụ khi đi sơ tán là ở đâu?

Gia đình đã quyết định vai trò của em là làm gì?

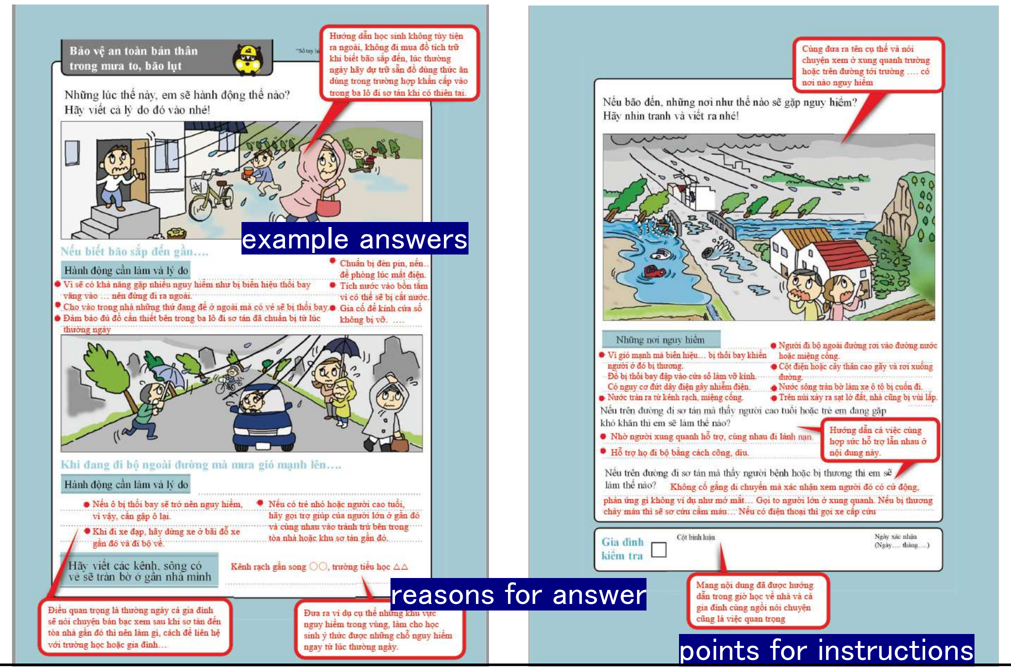
Cùng suy nghĩ về những điều dưới đây rồi viết ra

1. Ghi ra địa điểm sơ tán gần nhà nhất và đường đến đó.
2. Tính toán và ghi vào thời gian đi bộ đến địa điểm sơ tán.
3. Xác nhận và ghi vào những địa điểm nguy hiểm khi đi sơ tán. (Tường rào, cột điện, vị trí sông có vẻ mực nước sẽ dâng cao, chỗ đá lở…)
4. Vẽ cả những thứ có ích hay các dấu mốc khi đi sơ tán (điện thoại công cộng, nhà vệ sinh công cộng…)

* Có thể xem địa điểm sơ tán do xã phường, thành phố chỉ định trên trang chủ của của xã phường, thành phố nơi mình sinh sống

Gia đình kiểm tra ☐ Cột bình luận Ngày xác nhận (Ngày.... tháng....)

Example of contents – instructors' guide 〈Vietnamese Translation〉



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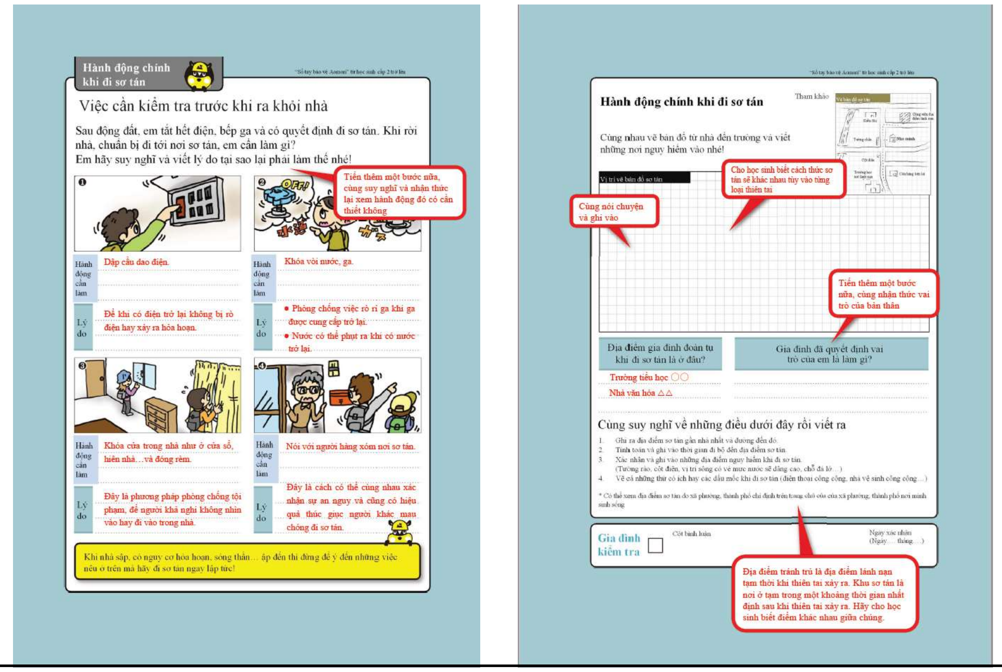

Making water-related disasters personal matters and engaging more stakeholders in countermeasures for River Basin Disaster Resilience and Sustainability by All

Aiming strategically at River Basin Disaster Resilience and Sustainability by All

August 2023

Working Group on Making River Basin Disaster Resilience and Sustainability by All a personal matter - through making water-related disaster risk a personal matter and increasing stakeholders engaged in River Basin Disaster Resilience and Sustainability by All

Contents

Preface

- ○ In the last few years, various parts of the country have been hit by severe water-related disasters. In 10 years by 2020, 1700 municipalities experienced at least one event of water-related disaster or landslide, accounting for 98% of municipalities nationwide. In response to the frequent occurrence of water-related disasters, the reference rate for fire insurance has been raised continuously, and there is a tendency to revise the flood damage premium rate, which used to be the same nationwide, by dividing it into five levels for each city, ward, town, or village depending on disaster risks. However, in fact, the number of residents have experienced repeated impacts from wind and water-related disasters is small.

- ○ Moreover, climate change is increasing rainfall and the frequency of heavy rains, making the country more vulnerable. Events such as the July 2018 Western Japan Heavy Rain, the 2019 Typhoon Hagibis in Eastern Japan, and the July 2020 Heavy Rainfall showed this trend. It is estimated that the amount of rainfall has increased by about 10% compared to the 1980s

- ○ In early June this year, Typhoon No. 2 and the rain front brought the most ever heavy rainfall to be recorded at 24 Automated Meteorological Data Acquisition System (AMeDAS) observation stations in the center of the Tokai region. The seasonal rain front that began in late June caused damage in the Kyushu, Sanin, Hokuriku, and Tohoku regions. Although international efforts are underway to reduce greenhouse gas emissions, we must keep in mind that even if we can limit the global temperature increase by 2°C compared to the pre-industrial level as defined by the Paris Agreement, climate change cannot be stopped immediately, and heavy rains will continue to increase.

- ○ Since the Meiji era, with the promulgation of the River Law and Flood Control Law, river management authorities at the national and prefectural levels have become the main actors, and local governments have been responsible for flood prevention. Government agencies played a vital role in effective implementation of countermeasures, succeeding in a significant reduction of disaster damages. However, facing an increase in the severity and frequency of water-related disasters caused by climate change, the River Subcommittee of the Social Infrastructure Development Council published a report in July 2020 calling for “a shift to river basin-wide flood management involving all stakeholders”. As a result, in July 2021, a part of the “River Basin Disaster Resilience and Sustainability by All” Related Act was enforced and different systems were developed to promote “River basin Disaster Resilience and Sustainability by All" (RBDRSA). Additionally, the Cohort of Related Ministries and Agencies Practitioners for the Promotion of Basin Flood Management is being set up.

○ It is essential that efforts on RBDRSA involve as many stakeholders as possible, including residents and businesses. However, it is insufficient to take only these measures. We must keep in mind that water-related disasters constantly become more severe and occur more frequently due to climate change. We cannot be satisfied with coping with the current situation. It is important to be visionary and have more stakeholders engaged. It will continuously improve our efforts and make reliable water-related disaster responses a prerequisite for regional sustainable development, leading to an increase in the effectiveness of RBDRSA. Apart from the fact that residents and businesses are aware of their water-related disaster risks, treat them as their own personal matters and act proactively, our perspective should be broadened while recognizing the potential damage in the entire river basin, realizing an overall picture of water-related disaster countermeasures and improving our own actions for RBDRSA.

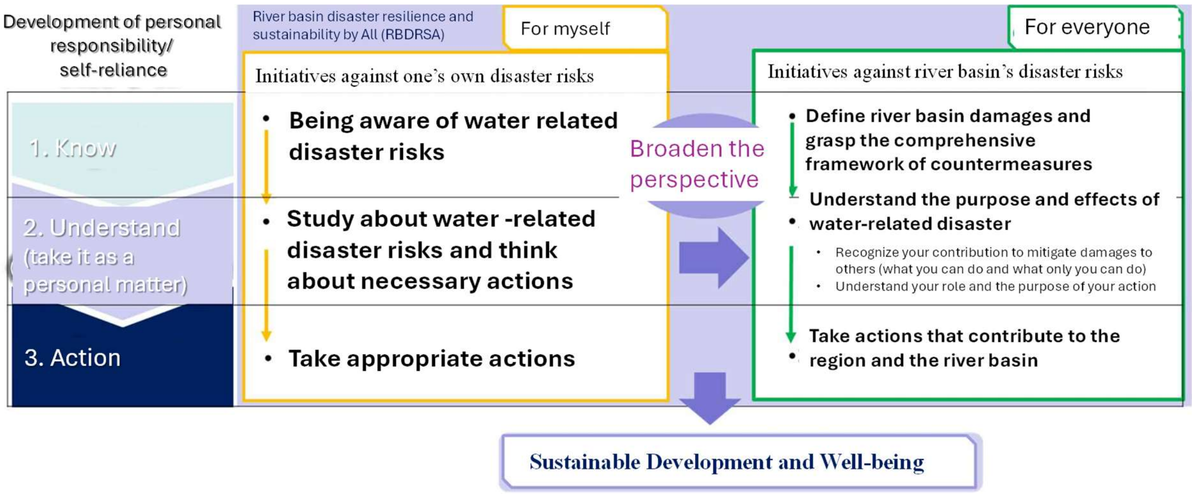

Figure: Concept of making water-related disaster risk as a personal matter

1. Background

○ In recent years, to reduce damage caused by frequent flood disasters, in addition to emergency measures such as the development of flood control facilities and evacuation when risks are particularly high, preparation works such as planned suspension of railway services, preventive road closures, school and store closures need to be implemented beforehand. While these measures have significant impacts on social and economic activities, they also mean switching to “water-related disaster mode" to respond to water-related disaster events, allowing the entire society and even the entire nation to be well-prepared for water disasters.

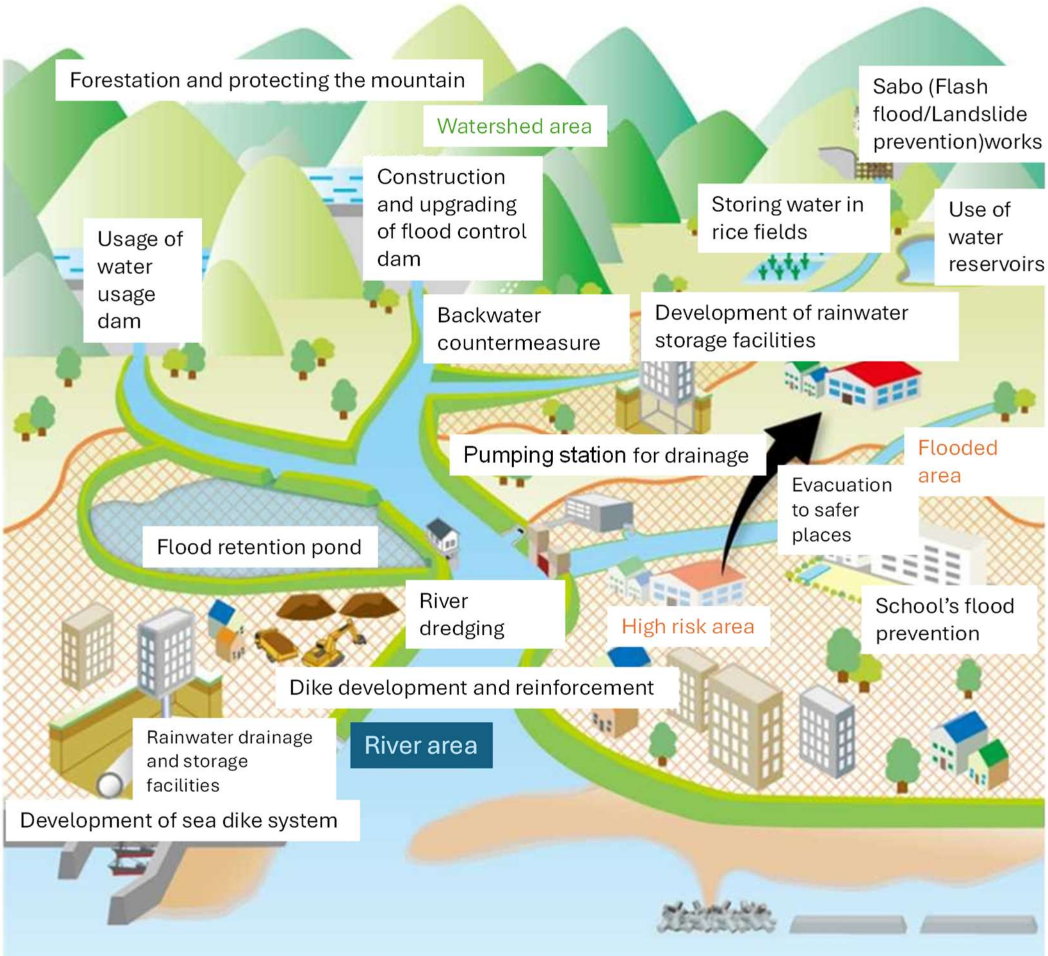

Figure: Image of River Basin Disaster Resilience and Sustainability by All (RBDRSA)

○ However, according to a questionnaire survey, approximately 80% of the respondents do not know the content of “River Basin Disaster Resilience and Sustainability by All (RBDRSA)" which is a concept describing the involvement of all stakeholders working together to respond to water-related disasters. The awareness of this concept is still low.

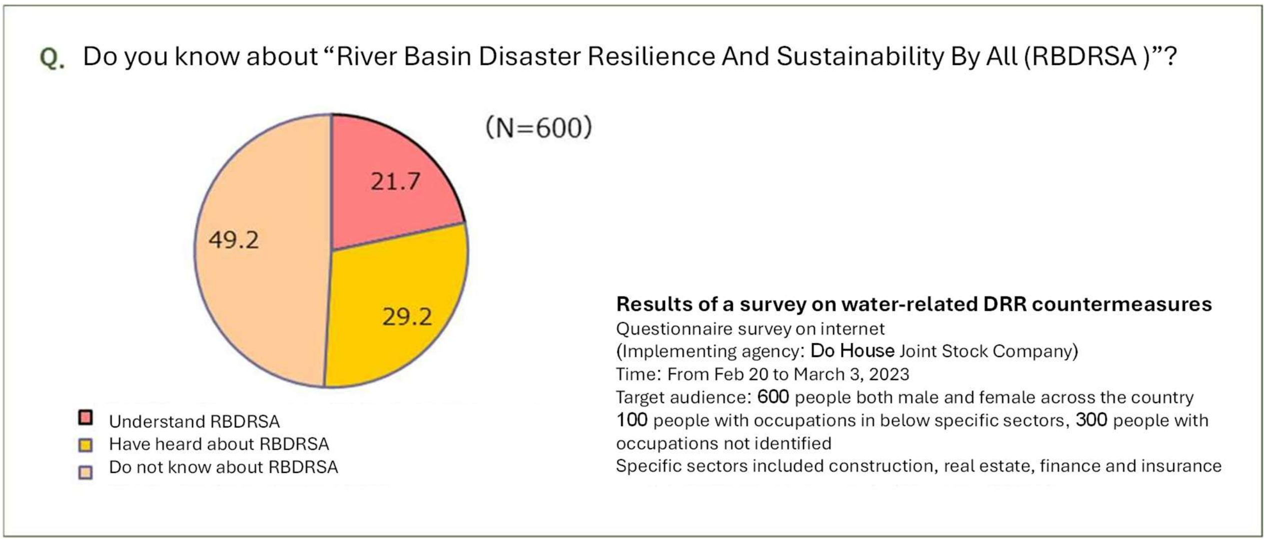

Figure: Example on Awareness level of River Basin Disaster Resilience and Sustainability by All (RBDRSA)

○ Although water-related disaster events occur every year across the country and are widely reported in the media, people do not take matters into their own hands even when the risk to themself increases as consequently, it will not lead to appropriate behavior changes such as evacuation actions and in the worst case, it would result in casualties and extensive damage. This scenario happens repeatedly every time a disaster occurs. Moreover, it would not be easy to take different preventive measures before a disaster risk increases.

○ To protect lives and minimize damage from water-related disasters, it is necessary to create a society where all concerned parties can obtain knowledge about the risks of water-related disasters, while considering water-related disasters as their own personal matters, and transform their awareness into actions. More elaborately, we will create a society in which people can define their own water-related disaster risks and become aware of what responses should be taken in the entire river basin area when a water-related disaster occurs. They also can think through beforehand how to act promptly to reduce damage not only to themselves but to the whole society.

○ Here are some examples such as evacuating is for one's own benefit, however, it is also for the benefit of society as it helps reduce the effort and risk that rescuers must face when rescuing people who cannot evacuate. Furthermore, if you can support others to a certain extent such as by calling your neighbors when evacuating the site, it will help lessen the total damage. Furthermore, securing supplies in advance to prepare for a disaster is apparently not only useful for yourself in the event of a water-related disaster but also makes it easier for others to obtain supplies at supermarkets when needed. In other words, by reducing the effort on the part of those providing support, it is possible to help adequately provide support to those who are most in need of special care and as a result, there would be a reduction in damage to the whole society in the event of a disaster.

○ RBDRSA is based on strengthening the functions of social infrastructure which prevents and reduces the occurrence of water-related disasters and landslides, improving the way people live and preparing for disasters in advance, and also working as a whole society with each entity cooperating to reduce disaster damage and recover quickly after the disaster. In other words, each individual is a player to implement water-related disaster countermeasures. In addition, preparing for a disaster by carefully planning and slowing down gradually social and economic activities before a disaster hits the region, such as planned suspension of railway operations or precautionary road closures, minimizing damages and recovering quickly even after a disaster occurs are becoming the prevailing approaches in recent times. Therefore, it is necessary to involve more individuals in initiatives on water-related disaster response.

○ Additionally, it is important to have diverse perspectives. The region develops along with the rivers. On one hand, the rivers express their fierceness during heavy rains. On the other hand, at normal times they bring richness and natural moisture to the region. When integrated with riparian spaces, the town becomes a lively place that is full of energy. It is necessary to create a society that can smoothly respond to water-related disasters and landslides by increasing opportunities for people to understand the rivers when they are peaceful.

○ Therefore, the concept of RBDRSA can be understood as being centered around the keywords of "connection" and "interconnect". Specifically, there are (1) connections between people and people, (2) connections between people and nature, and (3) connections within the nature itself, including the water cycle. Enhancing the understanding of these various connections will lead to stronger disaster prevention and mitigation measures. For educational activities that cultivate responsiveness to disasters, a community with connections between people and people plays an extremely vital role.

○ The purpose of RBDRSA is to have countermeasures against water-related disasters. However, through different connections mentioned above, it is also closely linked with conservation of ecosystems and the natural environment, the sustainability of sectors such as agriculture, and the improvement of people's life and their living environment. In other words, promoting RBDRSA not only makes the region safer but also leads to better well-being (happiness and health), which produces interaction.

○ In a society where people are aware of these different connections, there will be more opportunities for people to interact with local rivers, nature, industry, etc. by participating in community activities, which will make the region more vigorous and broaden the perspective of the region and the river basin. It leads to the regional sustainable development and continued enjoyment of the blessings from the river.

○ Furthermore, when considering climate change, “mitigation measures” and “adaptation measures" are two wheels that are linked together. To involve as many people as possible, it is important to define clearly the two wheels of RBDRSA i.e. measures such as river maintenance and flood prevention implemented by river management authorities and local governments, and measures undertaken by residents, companies, etc. visualizing the relationship between them for better collaboration.

○ Climate change is related to not only river floods but also various water-related disasters such as storm surges, landslides, and inland water floods. Mountains, rivers, and oceans which are places of blessing at normal times could turn into places of disasters due to heavy rains. Since different disasters occur depending on the location in a river basin, when developing a RBDRSA program, it is necessary to take a bird's eye view of the entire basin to build effective measures. Additionally, besides climate change that is induced by global warming, we also know that the risks of water-related disasters are unevenly distributed in different forms, depending on topographical conditions. We must be aware of water-related disasters during our daily activities and also work with others to understand that we need to create our safety by ourselves. We want to make RBDRSA become a national movement as a part of Japanese culture, aiming at the goal of enjoying the blessings of water to the fullest and achieving sustainable regional development.

○ At this working group, all stakeholders, including residents and private sector companies, discussed measures to accelerate efforts to minimize damage caused by water-related disasters while maximizing the blessings of nature and regional attractiveness. We also considered policies to expand the concept of RBDRSA and compiled a system of measures and action plans.

2. Challenges

○ In addition to water-related disaster countermeasures undertaken by river managers and local governments, it is desirable that the idea of increasing the effectiveness of river basin flood management, which will lead to sustainable development of the region, be generalized throughout society e.g. residents work together to protect their life and property while companies continue and advance their activities. Therefore, it has become an important social challenge that individuals and businesses can enhance their understanding of the significance and effects of RBDRSA and expand their own efforts.

○ In recent years, as water-related disasters have occurred more frequently in different places, individuals and businesses have become more concerned and interested in water-related disasters and disaster prevention than ever before. It is necessary to consider guidance and support that will translate their increasing interests into more concrete actions.

○ In terms of concrete response efforts when a disaster happens, at first, basic perceptions such as evacuating for self-protection as the risk increases and considering flood risks when deciding where to live should be ingrained in society. Furthermore, opportunities should be created to pass on experiences of water-related disaster events to others in the community and younger generations, expanding the scope of actions and broadening the perspective in the river basin. When the local government develops the town, making it prosperous and convenient and strengthening the community should be implemented in tandem with sharing awareness on the linkage of water-related disaster resilience and sustainable development. The same principle should be applied to companies' initiatives.

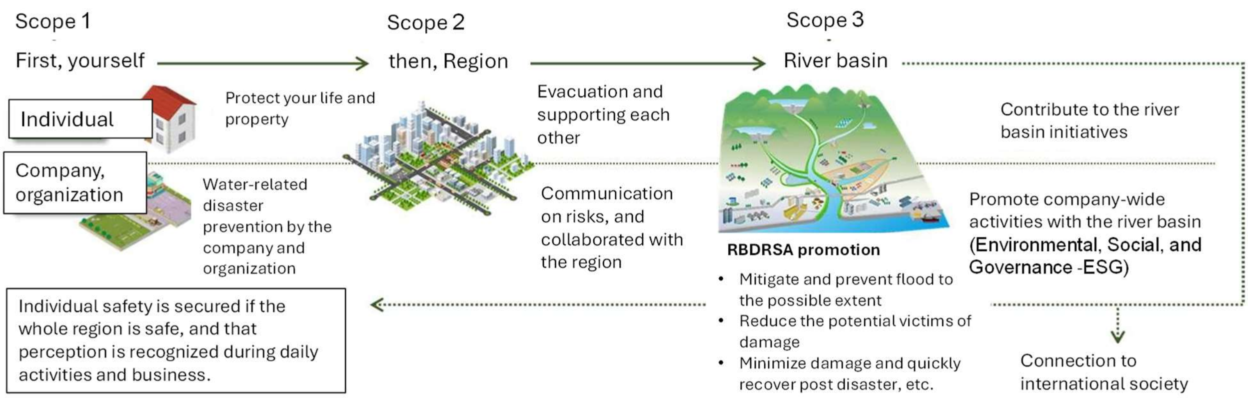

Figure: Broader Initiatives
(Broadening the perspective from personal/individual to the region, and to the river basin)

○ The process of spreading the concept and actions of river basin flood management among individuals, companies, and organizations consists of three steps. First, people become aware of RBDRSA. Second, they recognize that RBDRSA is their own matter, deepen their understanding and take action. Third, they develop proactive actions which can bring sustainable benefits for the whole society. Among these three steps of to "know", to "take it as a personal matter" and to "take action", the step of "taking it as a personal matter" can be considered as filling the gap between "knowing" and "taking action".

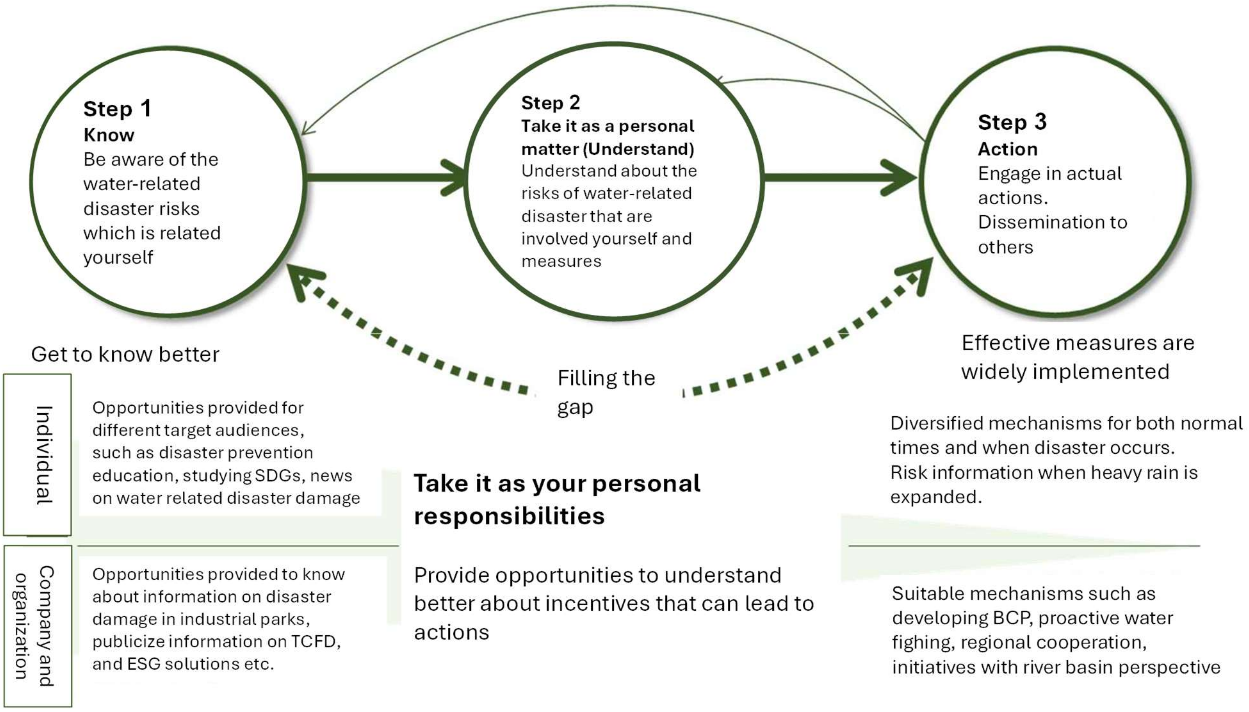

Figure: Issues toPromoting RBDRSA (make it a personal matter)

○ Additionally, it should be noted that the flow of "knowing", "taking it as a personal matter", and "taking action" is not one-way. It is a two-way flow as an individual can become aware of a problem by participating in some action, and he or she might even consider it her or his own matter. In this context, the local community provides information to individuals while activities are conducted by many people, companies, and the community. Therefore, individuals and companies will gain knowledge and take it as "their own matter/business". To develop "self-reliance" initiatives, we will need to focus on filling the gap between "knowing" and "taking action" while considering a diversity of self-reliant models.

○ Such efforts in Japan link disaster prevention measures with international standards and standardization such as TCFD. Communicating efforts of RBDRSA and its know-hows both domestically and internationally will lead to mainstreaming of disaster prevention around the world as the concept is introduced worldwide.

3. Policy to increase stakeholders involved in RBDRSA.

(1) Increasing opportunities to become aware of the logic RBDRSA and water-related disaster risks as the first step

○ Being aware of flood risks helps individuals and companies understand that water-related disasters can occur in their neighborhood, and it is an issue that concerns them. However, the awareness of RBDRSA and water-related disaster response measures is still low. Therefore, raising awareness and understanding is the first step to develop a disaster-resilient society. Efforts to provide information on local flood risks, including outreach programs by government agencies, and increasing opportunities for people to understand the necessity and significance of RBDRSA in society and even in daily life should be implemented.

(2) Filling the gap between "knowing" and to "taking action"

○ In general, even if a person can obtain the information and knowledge, it is not necessary that he or she will take appropriate action based on that information. Separate motivation is needed for taking action. Particularly, since disaster occurrences have a normalcy bias that it is easy for people to think they would be fine even when the risk increases. Filling the gap between knowing and taking actions is crucial.

○ First, through providing risk information and disaster prevention education, we will provide individuals, companies, and organizations with ingredients and opportunities to consider the possibility and the effectiveness of their own actions.

○ Thus, in principle, people need to be aware of and understand river basin disaster management and they must process it to make it their own matter before translating it into actions. However, in some cases, they still can take action when they do not have sufficient knowledge or understanding. Their actions might be induced emotionally by their interests or hobbies, i.e. they might take action as the first step because of their sentiment or if they have experienced flood damage in the past or they live and do business in areas protected by a polder where water-related disaster risks are high.

○ Additionally, once a person takes action, a desire to learn arises leading to increased awareness, which in turn can improve one's own actions. It is also understandable that actions lead to knowledge, and it generates further actions, creating a spiral of self-reflection (virtuous cycle) through PDCA.

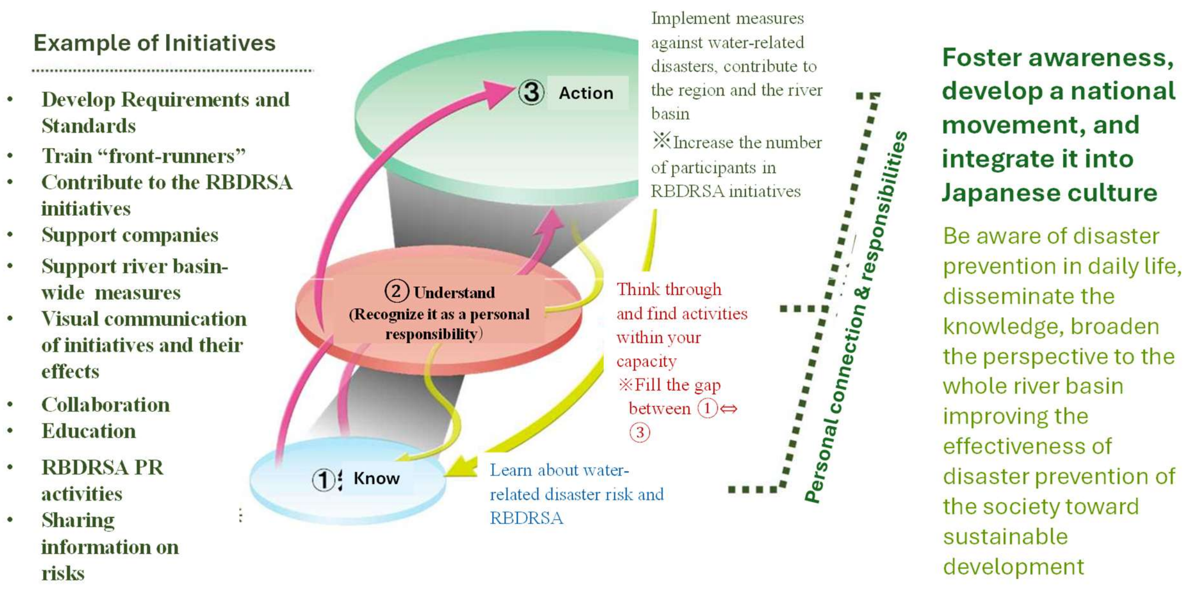

Figure: Approach to increase participants of the RBDRSA initiative

(3) Encouraging actions and promoting RBDRSA

○ Motivation for actual behavior can be subjective by increasing one's level of interests, such as the desire to act independently and responsibly, or the desire to be recognized by others. On the other hand, it also can be passive, such as peer pressure, for example, the feeling that others are doing the same thing, or the thought of being a nuisance to others if one does not do it. It is necessary to combine measures that allow all actors to take action, depending on the individual personality and the popularity of the measures.

○ At the stage where the concept of RBDRSA is not widely known, as the first step, it is necessary to strengthen efforts e.g. introducing specific initiatives linked with RBDRSA, visualizing their impacts, and providing incentives for actions such as supporting and subsidiary policies, to connect a large number of stakeholders. Furthermore, with promotion campaigns by the government and through mass media to showcase widely ongoing actions, it is desirable to generalize disaster response actions and make them become common sense. At the stage when many people have already started applying it, a regulatory approach might be needed to encourage a required behavior at a minimum level. Therefore, we should consider increasing the number of participants of concrete actions for RBDRSA.

(4) Making the effort a sustainable and effective initiative

○ Even if disaster risk increases, it does not necessarily mean that a disaster will occur, and at some points, people may think that their actions are meaningless or fruitless. However, they must continue their efforts because there is a possibility that they will be impacted by a disaster someday.

○ Furthermore, creative tactics of each entity can serve as a reference for others, and their efforts can organically link resulting in an increased effectiveness. Therefore, criteria for financial support should be developed for entities that implement better initiatives/efforts. Moreover, apart from visualizing efforts, through an awarding system and communication of success stories spear headers can be nurtured, broadening the perspective of RBDRSA. Additionally, it is also possible to standardize different initiatives and establish an evaluation system (ranking) for projects of each entity.

○ Moreover, apart from creating different synergies by sharing the individual efforts in the local community and making the regional effort everyone's "our own matter", we also aim to create an environment where people can be aware of water-related disasters in daily life, making transformational changes to the society, and eventually turning it into a national movement and culture.

○ Consequently, the effectiveness of RBDRSA can be improved by involving more actors (scaling up) and making our efforts more effective. The same result can also be achieved by promoting the efforts of each actor sustainably and effectively throughout the basin.

4. Focus points and specific implementation measures

(1) Increasing the number of people who are aware and communication methods

○ It is necessary to disseminate the concept of RBDRSA widely based on cooperation with all stakeholders and to encourage people to recognize their roles as key players in countermeasures to water-related disasters. As the first step, efforts should be implemented to increase opportunities for people to learn the overall picture of RBDRSA, including the necessity, concept, and measures.

○ First, we must make people realize that water-related disasters are becoming more severe and occurring more frequently as consequences of climate change. They should understand that although mitigation measures are undertaken, this trend cannot be easily changed. It is necessary for people to understand that it is impossible to tell when a water-related disaster will affect them and they should not consider the occurrence of a water-related disaster as "someone else's problem".

○ Furthermore, the intensity of water-related disasters is increasing due to climate change while the impacted society is also constantly changing over time. The society's resilience and vulnerability to water-related disasters change accordingly. We need to leverage experts' expertise to better understand such changes and improve our predictability. It will help us better prepare and respond to these changes.

○On the other hand, rivers, which can bring such disasters, also bring natural blessings and moisture to the region. People's interests change, and it is difficult to get them to always focus on water-related disasters. Therefore, we should utilize the diversity of rivers to resonate with the interests of each entity to link each entity's interests with water-related disasters prevention and use different ways to make them interested in nature and water-related disaster prevention. Stories need to be developed, and storytelling techniques should be considered to make people become interested in flood prevention and people will see it as their own personal matters. There are various ways of communicating messages to different target audiences, and it is necessary to consider how to communicate the information properly. (refer to the Column article)

○ For example, infrastructure tourism, such as visiting dams and erosion control facilities for sightseeing purpose, are effective in raising awareness on disaster prevention and flood control, as it provides opportunities to gain knowledge of the necessity and significance of RBDRSA. A key perspective here is how individuals can take the water-related disaster risk problem as a personal matter and expand this viewpoint to the whole river basin. It is important not only to have people see the facility but also to have them aware of the importance of the facility by listening to explanations from the tour guides.

○ First, ① as an initiative to increase opportunities to gain knowledge/ to know in, in order to provide opportunities for people to see the concept in their daily lives and develop content that can trigger their interests, we will promote initiatives such as creating logo marks and posters, creation of “River Basin Disaster Resilience and Sustainability by All Days and Weeks”, Raising awareness through using river spaces, Information dissemination through SNS, etc., Collaboration with infrastructure tourism, and the “Dynamic SABO Project”.

(Column Article)

Communication techniques

How can we make something as negative as a flood become our own personal matter? The Working group discussed the importance of communicating different connections between people and water, such as the frequent occurrence of heavy rains and weather conditions that cannot be blamed on others, and the fact that people enjoy various blessings from the river including agricultural products or people using the river basin water resources. Eventually, the question is how these messages are conveyed to people not only from public organizations but also via the media and SNS in a certain form.

However, if the topic or content is dogmatic or worrisome, people will not listen. To reach people's hearts and get them to take it as their own personal matter, communication methods are critical. The review committee received valuable opinions on this point. The discussion is summarized below.

Part 1 Spread the idea

There are different efforts for ways of communication. At first, you can change your perspective and focus on the enjoyable things that make you look fashionable and cool, even if it is a negative thing. Opportunities to think about water-related damages can be created through many "fun activities" such as fishing and camping by the river, and experiences of interacting with the local nature, industry, and the water cycle. There are also creative initiatives such as developing cider made from rainwater and creating an opportunity to think about water quality and resources. The concept of RBDRSA should be broadened to make it a social trend.

Part 2 Not too much information

When conducting different activities to promote RBDRSA efforts, people who promote the efforts must not provide too much information to the audience. The reason is that you receive a hint from a bit of information, thinking through it proactively and turning it into action. It makes what you have experienced become your own personal matter.

Part 3 Not too many people

It is one of the tactics that the number of audiences should be limited when you organize an event or deliver a lesson. The organizers of the lecture or event, and the local host community should limit a certain number of participants, which will help them remember the names of all the participants. Therefore, the participants feel that "somebody is watching out for them" and they also feel comfortable. Under such circumstances, they can be easily motivated to think and act proactively.

This sensibility has to be included in the government's efforts in the future as we aim at making flood risk a personal matter and expanding our viewpoint to the river basin area. Therefore, it will make the audiences think that "people are looking out for them through implementing RBDRSA" and or they might think that "it is certainly safer for me to get involved".

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(2) Creating opportunities to make it a personal matter and methods

1) Making it an individual's personal matter

○ It is important to create opportunities for people to grasp the mechanisms of water-related disasters and to prepare for disaster risk reduction (DRR) from educational activities, and the content related to RBDRSA should be included in educational materials. It is not only the opportunity for the students (children) to think about water-related disasters, but it is also a chance to communicate it to their parents, acquaintances, and others, eventually resulting in increasing the disaster prevention capacity of the community. In Kurashiki City, Okayama Prefecture, which was severely damaged by the heavy rains in western Japan in July 2018, efforts were made to deliver lessons on DRR at elementary and junior high schools, and disaster risk management (DRM) education is also conducted targeting general public such as sharing experiences of past water-related disasters as a part of the lifelong learning process.

○ Additionally, many regions have a history of water-related disasters, however as time passes by, the memory of these water-related disasters fades. Therefore, residents themselves must reflect on their community's history of disasters and be aware of the risks in the region, making proper preparations and passing this information on to the next generation. As time goes by, the number of people who can recall the historical water-related disasters decreases and it is vital to have local leaders for disaster prevention and those who used to be affected by disasters to talk about what happened in the past with a sense of presence.

○ Efforts to communicate the history of water-related disasters in local communities have begun to take diverse forms, tailored to the unique characteristics of each region. and we can see different lessons learned from both success stories and failures, and we need to share information in a way that people can have a sense of the context and impacts. It is necessary to utilize platforms like websites etc. to publicize educational contents on the RBDRSA concept and the initiatives implemented in each region and also collaborate with traditional media like television.

○ At first, apart from ongoing initiatives such as developing a "hazard map at the whole town" (initiatives to show the historical/simulated depth at the town area), we will promote the effort of "providing materials related to disaster prevention education" which can be used as school teaching materials, and the "Dissemination of information (content) on flood disaster folklore" as an initiative to pass on the history and experiences of water-related disasters to the next generation. We will also strengthen our collaboration with educational organizations at the national and local levels.

2) Making it a matter of each company and organization

○ Many companies are already promoting BCP (Business Continuation Plan) initiatives to respond to water-related disasters, and some are even promoting initiatives on tackling climate change and cooperating in local water-related disaster prevention activities as their Corporate Social Responsibility (CSR)[1]. Social incentives are also emerging to promote investment in companies that announce their efforts to reduce physical risks. To further promote corporate activities related to RBDRSA, systems such as providing political incentives should be considered.

○ As RBDRSA efforts are promoted nationwide, and the concept of RBDRSA becomes mainstreaming as a disaster risk management initiative around the world, companies would treat water-related disaster risks as their issues and implement flood prevention measures. At the same time, there would also be opportunities for companies and organizations to participate in DRR-related businesses. In addition to the motivation to contribute to the society, when companies can highlight their activities to make the region or the river basin safer bringing their own safety and profits, this will motivate them to broaden their horizons to the river basin.

○ When the widespread expansion of corporate activities in the basin and activities related to basin flood management leads to the sustainability and vitality of the local economy and better regional safety, it also has a positive impact on the local government's finances resulting in better supporting policies for companies and organizations.

○ It not only makes companies themselves more resilient to water-related disasters, but they also can contribute to improving regional safety by signing DRR cooperation agreements with local governments and developing rainwater storage and infiltration facilities.

[1] Corporate Social Responsibility: a company takes responsibility for the impact of its activities in order to coexist with society and the environment aiming at achieving sustainable growth. It also refers to the way a company operates in order to gain the trust of its various stakeholders
https://www.meti.go.jp/policy/economy/keiei_innovation/kigyoukaikei/index.html

○ Furthermore, from an ESG perspective, promoting disclosure of information on climate change within frameworks like TCFD[2], which is an advanced international initiative, is linked to an increased value of companies. However, as the concept of RBDRSA becomes recognized not only domestically but also globally, it will be easier for companies to get attention from all stakeholders on their own initiatives related to RBDRSA.

○ In addition to the current initiatives such as financial support including subsidies or tax exemption and technical support to provide manuals and guidelines, as ③ countermeasures to induce actions, at first, we should promote the "Participation of companies in flood prevention activities contributing to the local community", and the "RBDRSA official supporter system" to publicize the contribution of companies for RBDRSA and also initiatives such as "promoting disaster prevention/disaster mitigation business (utilizing open data)" to contribute to company profits.

3) Throughout the whole

○ It is important that individuals, companies, and organizations can visualize and define the roles and effects of their own efforts as their incentives. Understanding the impacts on downstream areas that upstream river programs can produce and the effects on surrounding areas will make people treat it as a personal matter or their own business. Additionally, when promoting each initiative, it would be effective to share the common goals that the whole society is aiming at and each entity can set these goals as their indicators.

○ In that context, digital technology will be an extremely effective tool, including the development of cyberspace for visualizing the impacts of RBDRSA efforts and utilization of geographical location information. Using these tools not only makes it easier for individuals, the private sector, and the government to collaborate but also allows each entity to share the progress of their efforts. It would increase motivation and ensure stakeholder participation. It is suggested that a "digital testbed"(River basin digital twin) to be developed to visualize the river basin as a virtual space and envisage the impacts of different measures.

○ There are a variety of available measures to promote self-reliance and the target audience is also diverse. To effectively expand RBDRSA efforts, each entity e.g. the national government, local governments, companies/organizations, and research and educational institutions, needs to cooperate at different levels from the national, and regional to the basin levels. As an example, in terms of disaster prevention education, the national government develops an information

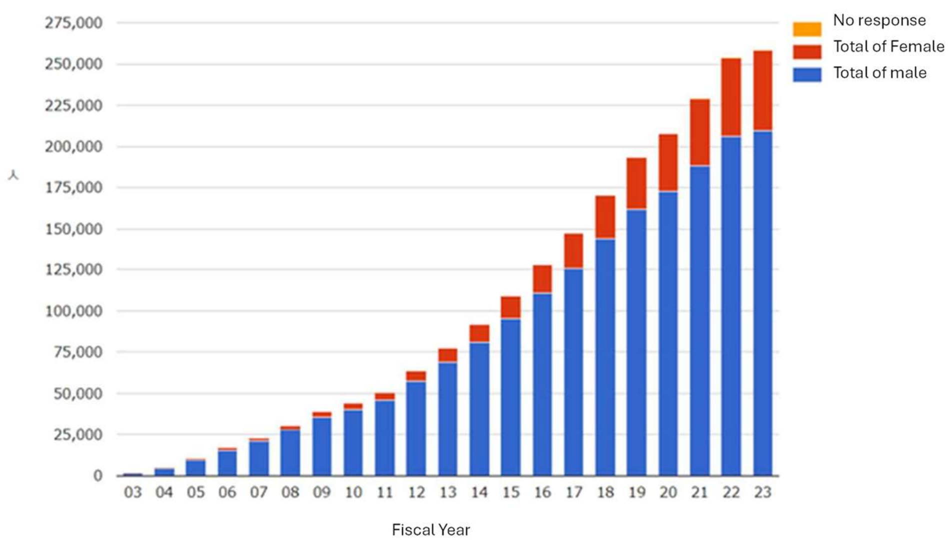
[2] Task Force on Climate-related Financial Disclosures (TCFD). Established by the Financial Stability Board (FSB) based on requests from G20 finance ministers and central bank governors. A report recommending the disclosure of climate-related information that has a financial impact (TCFD recommendations) was published in June 2017.
https://www.mlit.go.jp/river/shinngikai_blog/tcfd/index.html

infrastructure, collects and provides different kinds of information. The infrastructure is used to allow local governments and different organizations to implement educational activities for schools and local communities.

(3) Understanding and creating focus groups to promote "self-reliance"/ "personal connection" towards DRR and RBDRSA (attributes of outreach side and target audience)

1) Attributes of outreach side

○ It is important to identify key individuals ("key persons") and encourage them to actively disseminate information and involve those around them. Collaboration with certified disaster risk management specialists (Bosaisi) and meteorologists as facilitators should be considered . It is important to take advantage of such voluntary efforts as the number of people who are certified as disaster risk management specialists has increased recently.



Number of people who are certified as disaster risk management specialists - Bousaisi (Source: Website of Japan Bousaisi Organization)

○ We can have influencers communicate the necessity and importance of RBDRSA, content of the initiative or conduct interviews with local governments and provide field reports because video messages they distribute via SNS are effective.

○ Moreover, when looking at each unit of a region, some people[3] actively support the local community, and some organizations promote different river and water-related initiatives depending on the characteristics of each river. It is also possible to have them become leaders to expand the RBDRSA.

[3] Voluntary disaster prevention organizations and community managers

2) Attributes of the target audience

(Individual)

○ In public relations, the content for each target audience must be created differently. When we consider widely promoting the "self-reliance" and the concept of "taking water-related disaster as your own personal matter" to a range of target audiences from individual residents to private sector companies or an organization, it would be more effective if the number of the audience is controlled. The topic should be decided depending on the characteristics of the audience.

○ Taking the connection between rivers and people as an example, there are different people, including people using the open spaces of rivers for sports and other events, some engaging in entertaining activities, some with a passion for the river's natural environment, some being knowledgeable about historical disaster damages through an interest in flood prevention, and some being curious about historical linkages between rivers and the daily life. This diversity depends on the extent of the river and its natural conditions, as well as the social situation of the local community. Therefore, we should understand different factors of each region while designing our collaboration efforts to suit each regional situation.

○ Also in DRR education, families work together to put into practice what their children have learnt in school and it is also an opportunity to improve the DRR awareness of the whole family. Therefore, in DRR education, it is important not only to convey the past events and memories, but also to provide information on the mechanisms of water-related disasters and various lessons learnt that one can apply for his or her own actions. The children who are the future of the community can play a critical role and they can involve their families in concrete actions.

○ The number of disaster-vulnerable people who are unable to escape during flood events will be increasing while the number of people who can help them will also decrease, as the population is aging. It is necessary to develop a society that can respond to changes by building sustainable management during disaster time, particularly for people who need special care in each region e.g. the senior citizens and considering suitable locations of welfare facilities for them.

○ Many young people understand and proactively engage in SDGs activities and participate in volunteer activities. Since there is a strong compatibility between the concept of RBDRSA and SDGs, mechanisms to inspire young people and make it a movement should be considered.

○ Apart from the above targets, we will continue to consider narrowing down our target audience while encouraging them to take responsibility for water-related disaster risks as their own personal matter. Additionally, efforts must be made to disseminate information in multiple languages to respond to future internationalization and the increasing number of foreign tourists.

(Private sector and organizations)

○ Although the private sector has made progress in developing Business Continuation Plans (BCPs), the level of effort varies, with some companies thoroughly discussing and recognizing the importance of BCPs, some companies only starting to take shape, and some companies recognizing the importance but being unable to allocate the resources for implementation. To promote corporate initiatives, it is necessary to consider the development and dissemination of necessary services in alignment with the status of corporate initiatives e.g., providing information on tools so that the company can easily formulate their BCP.

○ While companies are making progress in their efforts on SDGs, it is necessary to strengthen their efforts by linking the SDGs with RBDRSA as well as encouraging people to get involved. First, it would be more useful to have companies in the construction field who are more interested in RBDRSA take action, and as the next step, they can involve other companies.

(Throughout the whole)

○ We should keep in mind that basically each measure should be effective through collaboration with different disseminators and continuously, while understanding the characteristics of the recipients (people who we want to encourage to take action) and considering a ripple effect, when we undertake measures to encourage people to take ownership of water-related disaster risks and expand the idea to the river basin.

○ RBDRSA requires different actions at different levels, from the first step of protecting oneself to the efforts of increasing the safety of family and friends, and activities to improve the safety of the river basin with rainwater harvesting and other methods. It is necessary to disseminate information at multiple stages, considering the diversity of the audience's viewpoint and motivation.

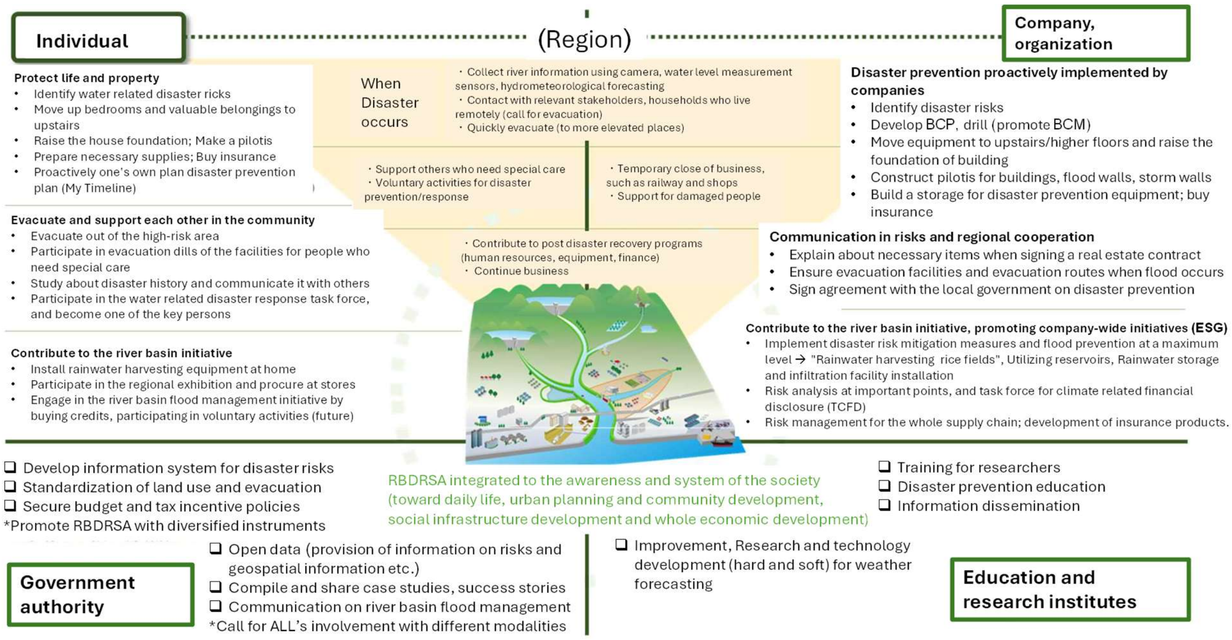


Figure: Examples of activities for River Basin Disaster Resilience and Sustainability by All (RBDRSA) centered at individual residents, private sector companies and organizations

(4) Setting up the environment for a proactive initiative

1) Developing a system to implement the initiative

○ From the perspective of the relationship between rivers and people, rivers sometimes cause water-related disasters while they are also essential water resources for daily life and different industries. They also provide riverside spaces or the natural environment that enriches our lives. Therefore, when working with rivers, there are three big elements: flood management, water utilization, and environment, which are not independent but intertwined. In promoting RBDRSA, it is also necessary to proceed with efforts that include "flood management" in the narrow sense just to protect people's lives and their properties, "utilization" of local resources such as town development and agriculture, and finally "environment" including the connection with nature and ecosystems (image on p. 25).

○ Thus, to involve as many stakeholders as possible in RBDRSA, it is necessary to proceed with a diversity of initiatives toward RBDRSA with different perspectives, not only from the viewpoint of flood management. It is expected that sharing concrete case studies and lessons learned will help expand the scope of RBDRSA.

○ Therefore, it is recommended that a system should be in place such as river offices and the local government in each river basin to collect information to share case studies and analyze different issues and efforts which have been identified for the region. For example, we promote the role of RBDRSA Meeting.

○ Ideally, the entity promoting the initiative will be aware of these case studies and solicit support from leaders who conclude the community's opinions and develop cooperation between upstream and downstream areas, between the public and private sectors, and among the private sectors. Therefore, this is expected to create an organic connection among all entities and further expand the circle.

○ At the national level, as part of ③ policies to induce action, efforts, such as the development of a "sharing platform (Website Kawanavi on national RBDRSA)", are promoted to consolidate RBDRSA projects across the country and share/collaborate among each basin and among different actors. It thereby contributes to knowledge sharing and cooperation between different actors.

2) Social transformation

○ It is believed that people feel and act with their hearts and our emotions have influence on us. Emotions might stimulate people to act if the idea that what we are working on makes us look great or if it is just a simply positive feeling, as in the case of initiatives related to the SDGs. Negative factors include peer pressure, fear, and anxiety such as wearing masks during the coronavirus pandemic and also some situations in which people feel ridiculous if they don't know or don't do something and even some cases when they feel like they'll be talked behind their back if they don't do it.

○ Therefore, ultimately, it is the best to consider making the social paradigm shift when encouraging more people to consider flood risks as their own personal matter and take action. If the awareness of a certain group changes, the perception of the whole population might change. We must endeavor to make the paradigm shift in society by disseminating a variety of information while incorporating different elements of public health and behavioral economics.

○ In principle, the main entity who is responsible for disseminating information is the national government agency. However, it is also effective to disseminate information through collaboration between government agencies and the mass media such as producing special programs. Additionally, various types of information should be publicized and people who are interested can obtain knowledge by themself. As a result, apart from key people and influencers, companies who are working in the DRR sector can communicate about RBDRSA from their viewpoints creating synergies.

3) Accelerating the private sector's initiatives

○ In recent years, companies have made progress in responding to climate change. As mentioned above, information is disclosed based on frameworks such as the TCFD. Increasing knowledge of flood risks and countermeasures are implemented throughout the supply chain. Additionally, the framework of the TNFD (Task Force on Nature-Related Financial Disclosures) was established and the initiative to disclose information on natural capital has been expanding. Therefore, it is recommended that support for such information disclosure should be provided to companies, and it can promote different initiatives that directly or indirectly link with RBDRSA.

○ One of the reasons why companies are accelerating their efforts is that institutional investors around the world are starting to judge corporate value based on their efforts to combat climate change, and companies' efforts to combat climate change are also leading to an improvement in corporate value. Therefore, collaborating with institutional investors and others who influence investment activities and having them understand the necessity and importance of RBDRSA will stimulate the private sector’s funding and initiatives.

○ In addition, some companies implement activities that not only directly bring direct profits for their businesses but also contribute to solving various social problems such as sustainable growth of local communities and improvement of social value. To encourage more companies to recognize the importance of RBDRSA and treat it as their own matter, it is recommended to implement policies to encourage them to get involved as part of their corporate activities.

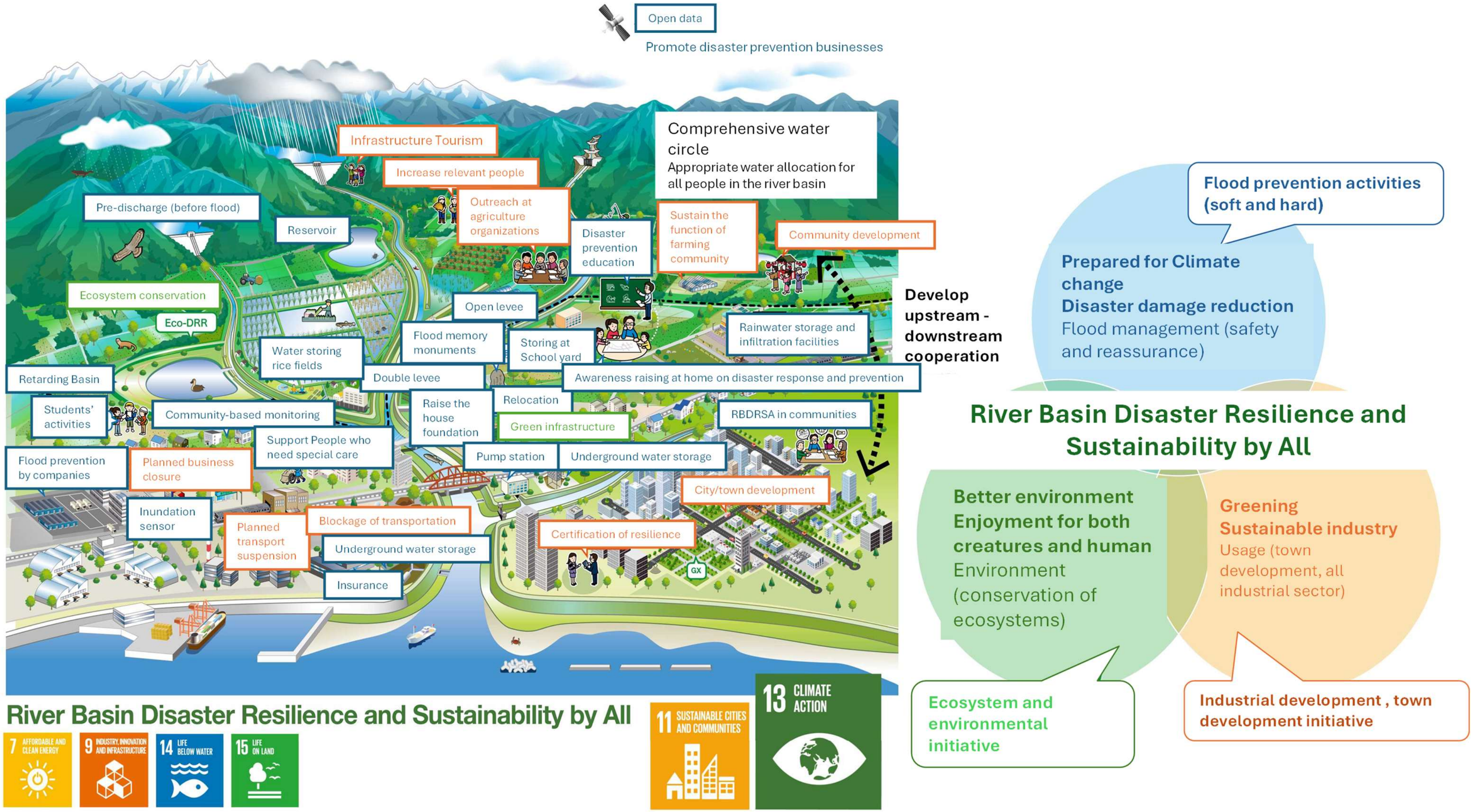


Figure: Promotion of River Basin Disaster Resilience and Sustainability by All (various opportunities)

(5) Sustainable promotion of River Basin Disaster Resilience and Sustainability by All

1) Nurturing “front-runner”

○ In order to promote activities for RBDRSA, a cycle of spiraling up that the scope of efforts expand and it results in expanded activities). Thus, it is important to have an opportunity to help people learn about basin flood management, to provide an opportunity for them to consider it as their own problem, and to induce them to take action. The RBDRSA activites has just started and as the first step each entity needs to give different initiatives a go and it is expected that these so-called “front-runners" will spearhead the overall RBDRSA effort.

○ Therefore, it is important to foster the spear headers and make their presence visible and it is also effective for them to act as facilitators and communicate about RBDRSA not only within their region but also throughout the country. Additionally, at the individual level, once an action is undertaken in reality, the individual can seize the opportunity to reflect and refresh their knowledge to have more meaningful actions, he/she needs to have information on case studies and data on storm and flood damages and also advices from facilitators that have professional knowledge are very important.

2) Regional intitiatves

○ To sustainably advance a RBDRSA effort, it is useful to define the purpose, direction, and vision of the effort to work on them on a regional basis and to identify how it would link with regional safety and sustainable development. Consequently, it effectively helps instill disaster prevention education in local communities as a part of the regional culture and also strongly increases awareness of disaster prevention.

○ In agriculture and rural areas, it is important for local communities throughout the basin to come together and understand that increasing rainwater storage in rice fields and properly managing agricultural irrigation facilities, which is a place for agricultural production that truly support Japan's food security, not only leads to sustainable development of the region and the agriculture sector but it is also an effective flood management approach for the whole river basin. Moreover, in order to help sustain the effort and strengthen the function of RBDRSA, it is important to create a system for local farmers, and water managing organizations such as the water users association and land improvement district which have a connection with farmers, can collaborate with other stakeholders in the local community to support the implementation of RBDRSA. Furthermore, in a rural area, it is important that the local community, which includes both farmers and non-farmers, functions properly , and it is desirable that the function be enhanced and disaster prevention become sustainable and feasible through activities to protect the lives of the local people in the community are reviewed by themselves.

3) Detailed policies and important considerations

○ Related to 1) and 2), for initiatives related to ② encouraging people to see DRR as their own matter, or ③ inducing people to take action, we will promote development of initiatives such as providing materials related to disaster prevention education, which can be used as school curriculum, and Dissemination of information (content) on flood disaster folklore to convey the history and experiences of water-related disasters to the next generation. ④As part of efforts to broaden our perspective to include the entire river basin, we will promote the establishment of a system for dispatching facilitators to train top runners who will lead local disaster prevention efforts, support for private sector initiatives in climate change risk disclosure (TCFD), and the establishment of an awards system (RBDRSA Grand Prize) to increase the number of advanced initiatives that can serve as models for each stakeholder.

○ Regarding the implementation of specific measures, it is necessary to consider the priority of initiatives and define distinct roles by different actors involved since it is not efficient to advance everything at once on a national level. On the other hand, since some initiatives can be conducted independently by each region, it is necessary to follow up adaptively by collecting appropriate information on the implementation status and impacts of different initiatives of each entity, making use of a forum such as the RBDRSA meeting.

○ As mentioned above, in promoting disaster resilience and sustainability, it is necessary to take into account the entire basin, from the mountains to the sea, and not only consider direct countermeasures of water-related disasters and landslides but also different initiatives such as ecosystem conservation and improving industrial sustainability and to link it with sustainable development of the region. It requires a comprehensive approach, including the implementation of green infrastructure and sustainable land use. It is crucial to note that rather than making water-related disaster countermeasures a priority, we have to proceed in a manner that enhances the understanding of many stakeholders, so they can be aware of the issue of water-related disasters in their daily activities, through increasing the number of stakeholders involved in RBDRSA as many as possible.

5. Dissemination policy (Annex 1)

① Initiative to increase opportunities to know about RBDRSA
② Initiative to encourage people to see DRR as their own matter

③ Initiative to induce action

④ Initiative to broaden the perspective to the whole river basin

6. Roadmap (Annex 2)

○Timeline of each item and initiative

一刻もはやく

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Technical Emergency Control FORCE

緊急災害対策派遣隊

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