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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.

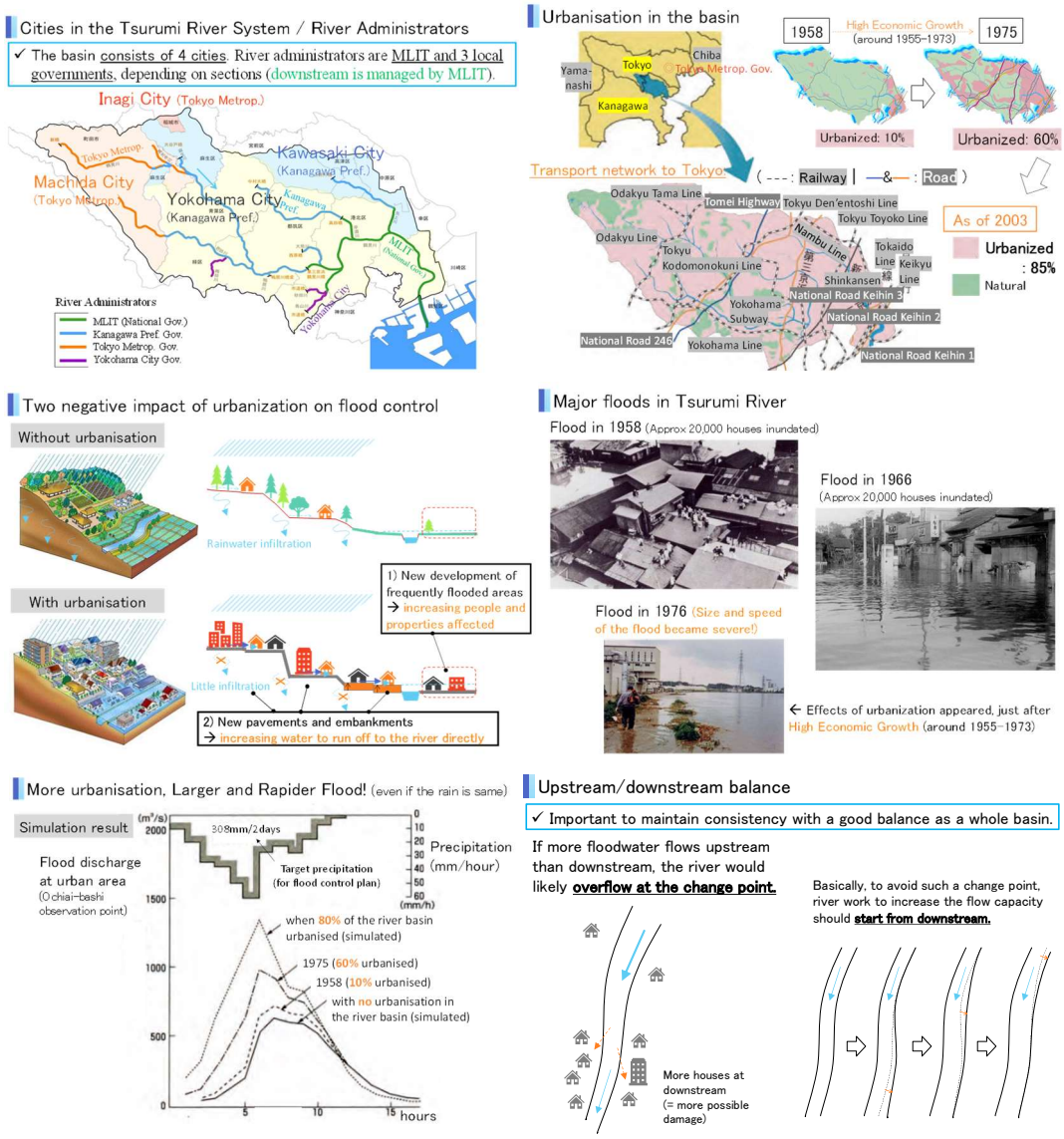
The background to the rapid increase in population in the basin is the High Economic Growth around 1955-73 (*2). The Tsurumi River basin is adjacent to central Tokyo, and during this period, transport networks (rail and road) crossed various parts of the basin and connected it to the central Tokyo, making 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

(1) Efforts to control run-off

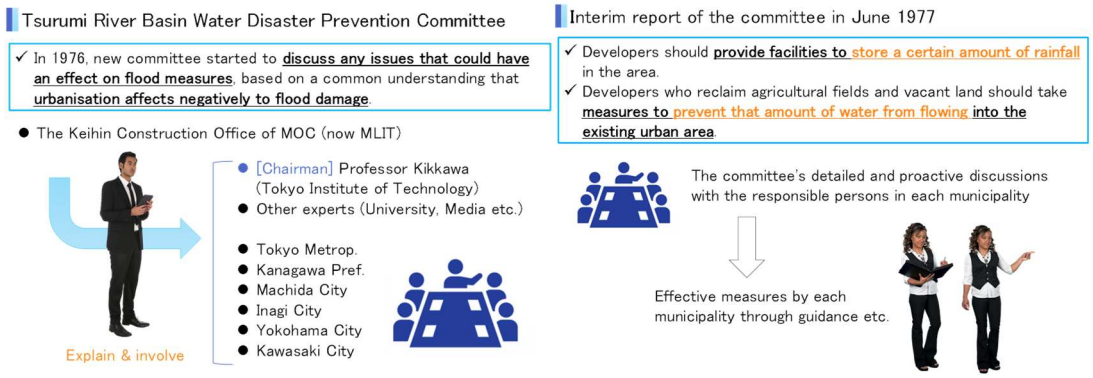
i) Enthusiastic lobbying of local authorities by national officials and collaboraion

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.



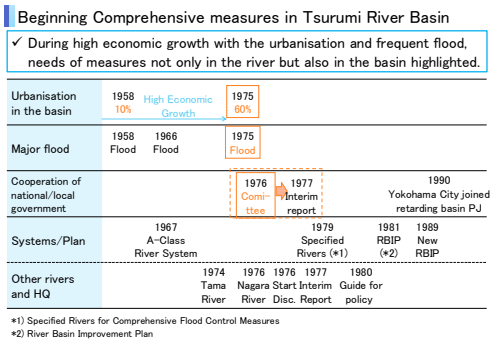
ii) Systems that further encouraged efforts

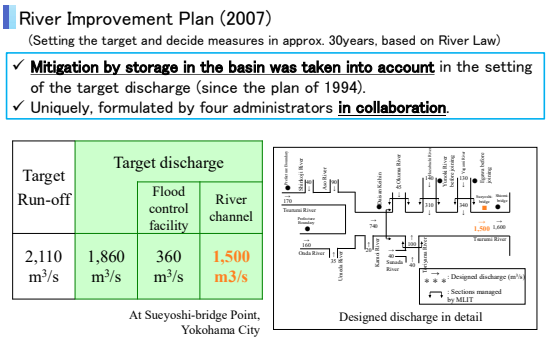
As major floods occurred frequently in other rivers during this period, the Ministry headquarters also began to study on comprehensive measures (including measures in the basin) with Professor Kikkawa and other academics in October 1976, and compiled a report in 1977 (*4). In 1979, a system of 'Specified 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).

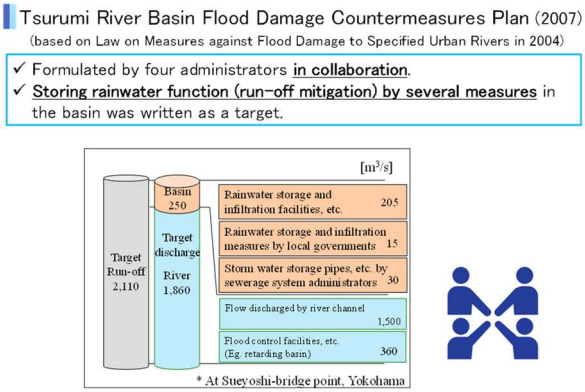
And based on this context, in the Tsurumi River, mitigation by storage in the basin was taken into account in the setting of the target discharge of river improvement works in the river plan (1994 Basic Plan for Construction Works Implementation), and though the river plan is formulated separately for 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.







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.

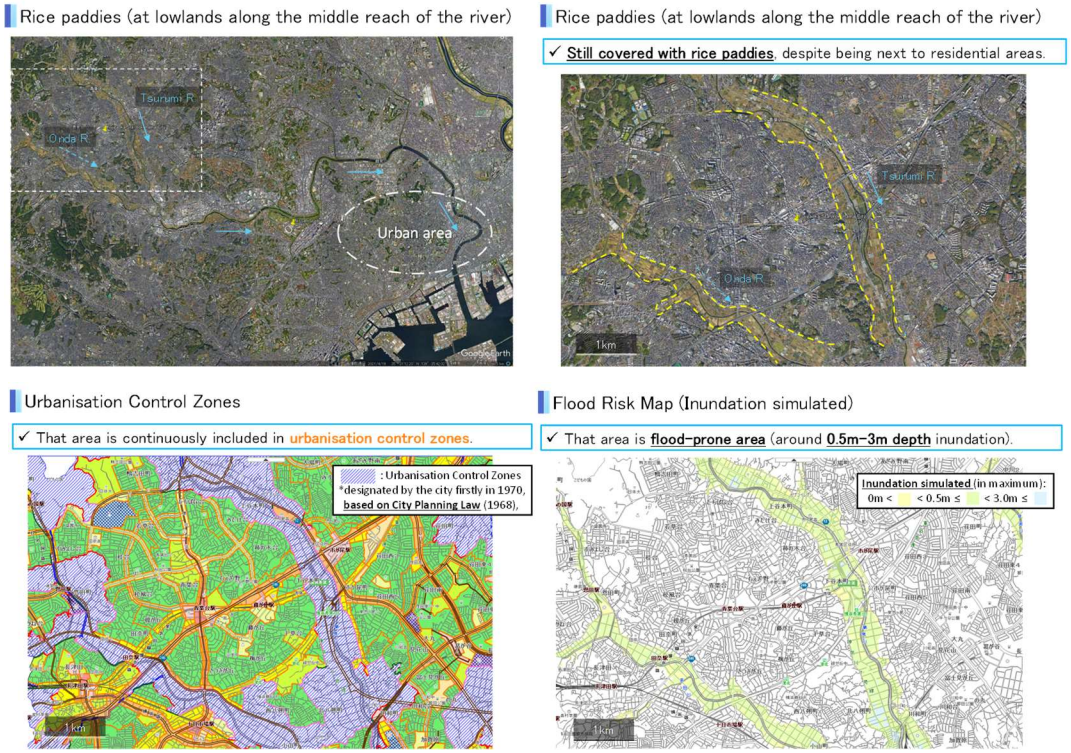
(2) Land use regulations to avoid increase of potentially affected people and assets

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.

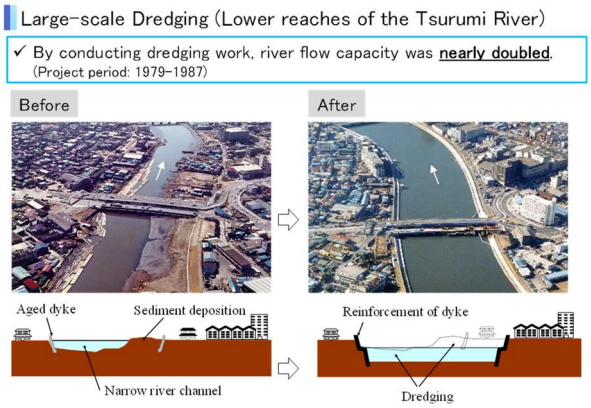


(3) Countermeasure works in river areas

i) Large-scale dredging

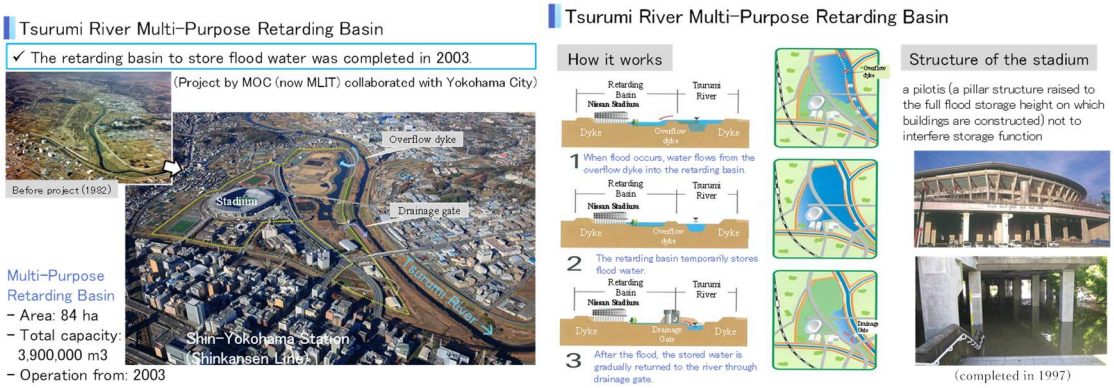
In addition, large-scale works were also carried out in the river area. One of these was the large-scale dredging of the lower reaches of the Tsurumi River, which was carried out for nine years from 1979. The dredging was undertaken because it was difficult to widen the river channel due to the dense 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

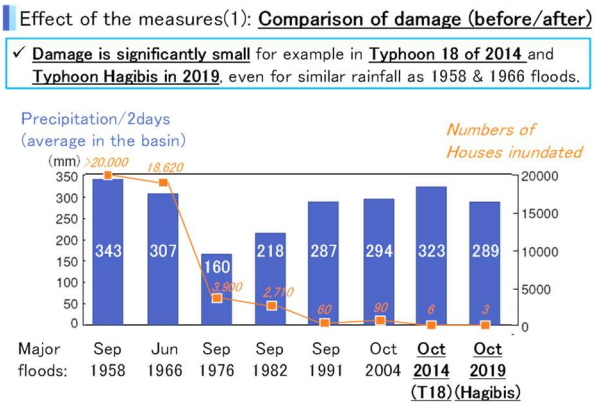
The next major project after the dredging was the construction of a multi-purpose retarding basin. The site is close to Shin-Yokohama Station of the Shinkansen (bullet train), but at the time of planning the project, the area was covered with rice paddies, and development was also restricted as an urbanisation 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?

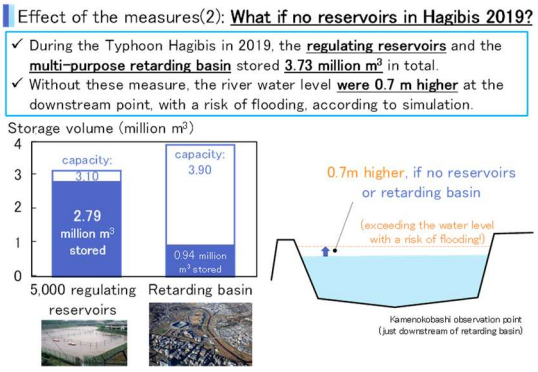
(1) Comparison of flood damage before and after comprehensive flood control measures

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.