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A LOT OF APPROACHES FOR RESTORATION OF NATURAL ENVIRONMENT IN THE DOWN-STREAM RIVER OF DAMS IN JAPAN [*]

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1. INTRODUCTION

Japan is located in the far Eastern Asia, climatically, Japan belongs to the Asian monsoon region, which is one of the highest levels of precipitation in the world. The mean annual precipitation is about 1,718 mm, which is nearly twice the mean annual global precipitation of 880 mm. [1].

Currently, 51% of the population and 75% of their properties are concentrated in flood-prone regions that comprise a mere 10% of the total land area of Japan. Due to the characteristic morphology of alluvial plains, much of the urban areas that lie in the flood plains are lower than the water levels of the rivers during floods. Combined with the aforementioned terrain characteristics, this leads to large-scale flood damage if a bank break occurs. Under such hard geographical conditions, Japan has experienced countless episodes of floods,

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with serious injury and property damage. Dams are extremely effective for dealing with the problems posed by these natural conditions such as climatic and geomorphologic conditions, and by social conditions such as the concentration of the population and properties in the flood plains. Therefore, in Japan dam construction has been widely promoted as means of flood prevention and water resource development. Dam projects in Japan have proven effective in the prevention of disasters during floods, in the appropriate utilization of rivers, in the sustention of the normal river functions, and in the conservation of river environments [2].

However, in recent years, public perspectives have diversified, and a dramatic shift has been seen in public awareness from the pursuit of economic development to concerns over the quality of life and the natural environment. With such growing awareness of the environment, the public's interest in the river environment has also increased, and demands on river management have diversified to include not only increased safety in flood control and water utilization but also conservation and utilization of the river environment, such as the creation of environments for diverse ecosystems and designs suited for the various local landscapes. In accordance with such social demands on wholesome water circulatory system, the MLIT has implemented policies for improving the river environment, such as the "creation" of a pleasant waterfront space," the "securing of clean and abundant water flow and quality," the "creation of aquatic environments filled with life," and the "ensuring of a healthy hydrologic cycle[3], [4]."

With the modification of the River Law in 1997, the "improvement and conservation of the river environment" is explicitly specified as the purpose of river management, in addition to "flood control" and "water utilization," and the importance of environmental management in river management has increased with each passing year. To create a pleasant and rich natural environment, environmentally friendly dam management must also be promoted in the coming years. However, researches on a comprehensive ecological environmental conservation management program have yet to be conducted.

In this paper, the effects of dams on the ecosystem, particularly on the downstream regions, will be compiled using the results of the National Census on River Environments, and the present state of implementation of environmental conservation measures against these effects will be reported. A general discussion on the planning and implementation of ecological environment management will also be held, and the philosophy behind the planning and management of ecological-environment conservation projects around dam reservoirs is researched and investigated.

2. ENVIRONMENTAL CHANGES IN DOWNSTREAM REGIONS

Dam projects have been associated with various adverse effects on the natural environment as a direct result of their construction or due to the large-scale alterations in the terrain involved with the construction of the dam body, the building of alternative roads, and the creation of reservoirs [5], [6], [7]. Examples of such adverse effects include the reduction or disappearance of habitats of fauna and flora due to the changing of forests and streams into reservoirs with the completion of the dam [6], [7]. Furthermore, structures such as the main dam body and the dam reservoir that cut through the habitats cause habitat fragmentation by blocking the upstream and downstream movement of fish and inhibiting the movement of land animals [8], [9], [10]. In addition, the appearance of the new dam reservoir environment will lead to changes in water quality and silting within the reservoir [11], [12], [13], and the arrival of new biotic communities such as fish suited for the dead-water environment of the reservoir and waterfowl [6], [14].

The anticipated effects of dams in the downstream region include changes in water temperature and quality with the appearance of the reservoir, changes in flow conditions such as the generation of reduced-flow zones and a reduction in deluge frequency, making of river beach forest, and a reduction in sediment supply to downstream regions due to sedimentation in the reservoir [15], [16], [17]. Works about concerning the influence of the downstream of dams is in the increasing tendency in Japan. The special edition of the paper about the influence of a dam is constructed in the society magazine of an ”ecology and civil engineering meeting”, attention is increasing about the influence to the downstream region of dams. The results of the National Census on River Environments have revealed that these changes may alter the habitat conditions of organisms in downstream regions in the manner presented in Table 1.

Based on the above survey results, the changes in fish and bottom dwellers will be discussed as representative cases of changes observed in downstream regions.

Table 1
Summary of Ecological Changes in Dam Downstream Regions
Synthèse des modifications de l'écosystème en aval des barrages

Items	Changes observed in the downstream region of Dams
Fish	▪ No significant change in fish fauna ▪ Reduced population of fish living in gravel beds ▪ The increase in an introduced species
Bottom dwellers *Zoobenthos*	▪ Increased percentage of web-builders, which species like stable river bed ▪ Increase in percentage of borrowers, which species like Muddy river bed
Zooplanktons and phytoplanktons	▪ Increased mass of plankton flowing downstream
Vegetation	▪ Increase in degree of vegetation cover on riverbanks and transition to tree-form vegetation
Birds	▪ No significant change in bird fauna ▪ Reduced spotting frequencies of riverine birds such as the greater pied kingfisher
Amphibians, reptiles, and mammals	▪ Reduced spotting frequencies of riverine amphibians such as the kajika frog (*Buergeria buergeri*)
Land insects	▪ Unknown without The increase in an introduced species

2.1. CHANGES IN HABITAT CONDITIONS OF FISH

Table 2 shows the secular change in the populations of bottom-dweller species observed at the dam where 13 years after completion passed in the Kanto Region. In the inflow rivers, muddlers, indicator species used as good mountain stream environment, because of showing the fastidiousness have been confirmed continuously, though not in downstream rivers.

Table 2
Secular changes in the population of bottom-dwelling fish species
Évolution du nombre d'espèces de poissons benthiques

Family	Species	Inflow rivers		Downstream rivers	
		1996	2001	1996	2001
Gobiidae *Gobiidés*	*Rhinogobius* sp. OR *Rhinogobius sp.OR*	0	0	0	5
Cottidae *Cottidae*	*Cottus pollux* *Cottus pollux*	7	1	0	0

2.2. CHANGE IN HABITAT CONDITIONS OF BOTTOM DWELLERS

Fig. 1 shows the number of species of the orders *Plecoptera*, *Ephemeroptera*, and *Trichoptera,* indicator species used as good mountain stream environment, observed at the same above Dam. Generally, the number of

confirmed species is smaller in the downstream rivers, and fewer species were confirmed in FY 2000 compared to FY 1995. The number of aquatic insect species is an indicator of a healthy mountain-stream environment, and its transition must continue to be monitored in the future.

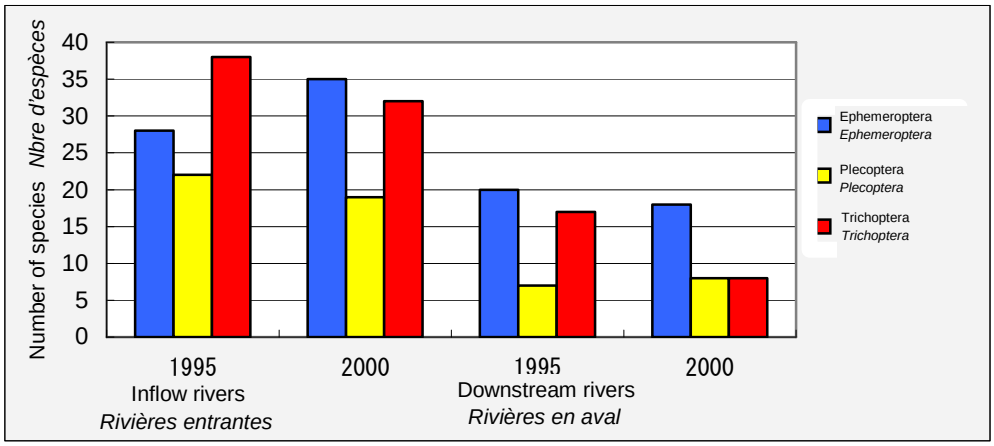


Fig. 1
Secular changes in the populations of bottom-dweller species
Évolution des espèces de poissons benthiques

3. THE SUBJECT AND BACKGROUND OF DAM MANAGEMENT FROM THE ECOSYSTEM

The announcement of the result "the limit of growth" of the request research by Club of Rome in 1972, every country in the world is jointly continued in efforts towards sustainable development in order to stop advance of the aggravated environmental destruction. It's efforts is such as the effectuation of the Convention on Biological Diversity which aims at preservation of biodiversity(1993). Written in the report of WCD, It is asked for coexistence with the development enterprise of dams and natural environmental conservation. In a dam enterprise, in order to aim at coexistence with natural environmental preservation, it is required to investigate what kind of environmental change arose when dam completion. In Japan, The National Census on River Environments which is basic investigation of the natural environment of the national scale is carried out in dams from 1990, before Issue of the treaty of Convention on Biological Diversity.

As an environmental preservation measure of Japan was shown in table 3, while the Environmental Assessment Act was enacted in 1997. And the River Law was revised and, added "maintenance and preservation of river environment" to purpose of dams and river management, they are the former two purpose "river improvement" and "irrigation".

Furthermore, in FY 2003, legislation such as the Law for the Promotion of Nature Restoration and the Law for Enhancing Motivation for Environmental Conservation and Promoting Environmental Education has been introduced, requiring dam businesses to take a more active role in conserving the natural environment and supporting biodiversity, as well as to cooperate with local residents to offer environmental education. Thus, in the future, dam management will be required to be more environmentally conscious, and environmental management of the surrounding regions must be designed in consideration of the environmental education program [18].

Table 3

Background on the Necessity of Environmental Conservation in Dam Management

Chronologie sur la nécessité d'intégrer la protection de l'environnement naturel dans la gestion des barrages

1990	The National Census on River Environments	109 Class-A river systems in Japan, as well as the dams under the direct jurisdiction of MLIT and JWA, to promote adequate river and dam management
1993	Enactment of the Convention on Biological Diversity	Signed at the United Nations Conference on Environment and Development (Earth Summit) in Rio de Janeiro in 1992, and came into effect in 1993
		The purpose of this convention is to prevent the extinction of biological species, and to utilize biological species to meet our needs while ensuring that we preserve as much biodiversity as possible for future generations.
1995	Approval of the National Strategy for the Conservation and Sustainable Use of Biological Diversity	The draft plan was drawn up at the inter-ministerial liaison meeting between relevant ministries and agencies in 1994, and was concluded at the ministerial meeting (composed of the entire cabinet).
		Created to define and publicize the basic policies for implementation of the "Convention on Biological Diversity" and the direction of future policy-making to the nation and the world
1995	Report of the River Council	In the "Present and Future of River Environments," the securing of diverse habitat conditions for living organisms" was advocated as one of the basic policies in river management in Japan.
1997	Revision of the River Law	The "improvement and conservation of river environments" were set as the goals of river management.
2002	Notification of "Implementation of the Follow-Up System for Management of Dams, etc."	Based on an accurate assessment of the dam management conditions and the social and economic situation surrounding dam projects, the efficacy and environmental impacts of dam projects will be analyzed and evaluated, and remedial actions taken whenever necessary.

In 2007, after 10 years of revised the River law, the policy review at river environment maintenance and conservation are carried out.

As a result of environmental policies of dams, a lot of effective environmental conservation has been confirmed such the Flexible Dam Operation, the Guidelines for Maintenance Flow upon Renewal of Water Rights for Hydropower Generations, Environmental Impact Assessment and Implementation

of Follow-up System for Management of Dams and the National Census on River Environments [39].

4. MEASURES FOR DOWNSTREAM-RIVER-ENVIRONMENT IMPROVEMENT

Measures have been taken for conservation and restoration of the environment in the dam downstream regions to counter the effects on habitats caused by the presence of the dam. The two most actively pursued themes in such improvement measures currently in Japan are flow-condition improvement, which involves the securing of maintenance flow and regular flushing discharge, and the restoration of sediment to downstream rivers in order to compensate for the reduced sediment supply.

Below, we will introduce some examples in which these countermeasures have been implemented.

4.1. FLOW-CONDITION IMPROVEMENT MEASURES

(1) Subsidized projects for the improvement of reservoir water environments

The low water flow section has produced by power generation to take water at the dam's water intake point, also in the multipurpose dams.

This projects of improving flow conditions fixes the discharge equipment which maintenance flow discharge makes possible directly under a dam, and aims at promoting the clear stream recovery in downstream regions of Dams. By this enterprise, the number of species and individuals of fishes or aquatic insects increase, and the good river ecosystem is restored in downstream regions of Dams [29].

(2) Improving Flow Conditions in Downstream Regions of Hydroelectric Dams

In the days that of their construction, hydroelectric dams have satisfied society's demand for efficient water utilization, and so all or most of the river water was taken at the dam's water intake point. As a result, a zone of extremely low water flow (waterless river) emerged between the water intake and discharge points. To overcome this problem, conservation measures involving securing river maintenance flows have been implemented since 1988. Below is a summary of the policy evaluation made in 2003. The Ministry of Construction (the current MLIT) and the Ministry of International Trade and Industry (the current Ministry of

Economy, Trade, and Industry), which are in charge of river management, drew up the “Guidelines for Securing Maintenance Flow Upon Renewal of Water Rights for Hydropower Generation” (hereinafter referred to as the “Hydroelectric Generation Guidelines”) in July 1988 to restore the river environment.

The “Hydroelectric Generation Guidelines” make it compulsory for hydroelectric generation businesses to augment downstream river flows by releasing a preset river maintenance flow volume in order to secure the minimal flow required for conservation of the river environment. A survey was conducted to check the degree of improvement between before and after the maintenance flow was secured [3].

Many hydropower plants were designed so that most of the river water is taken in at the intake in order to use water efficiently to respond to the high public priority on hydropower at particular age. As a result, hydropower production causes a variety of problems such as the change in the native habitat of the fishes, a section of river with extremely little water between the intake and the out let from the hydropower plant because of the usage of the high volume of water.

MLIT in charge of the management of rivers and the former Ministry of International Trade and Industry responsible for supervising hydropower plants cooperatively enacted the guideline, “Guarantee of the river maintenance flow at the new and renewal case of the water use license for hydropower plant” (hereafter called the “Hydropower Guideline”) in July 1988 to restore river environments.

Under the Hydropower Guideline, hydropower plant operators ought to discharge the fixed maintenance flow from hydroelectric dams, guaranteeing the minimum required river discharge for river environments.

Hydropower plants to which the Hydropower Guideline is applied are as follows.

1) Interbasin transfer of water.
2) The length of river which discharge is reduced is more than 10 km and its catchments area is 200 km^2 or more.
3) The hydropower plant operator agrees with local government to discharge the river maintenance flow.

Figure 2 shows the discharge under the Hydropower Guideline. It improves a river environment from the intake dam to the power plant outlet by supplying the river maintenance flow.

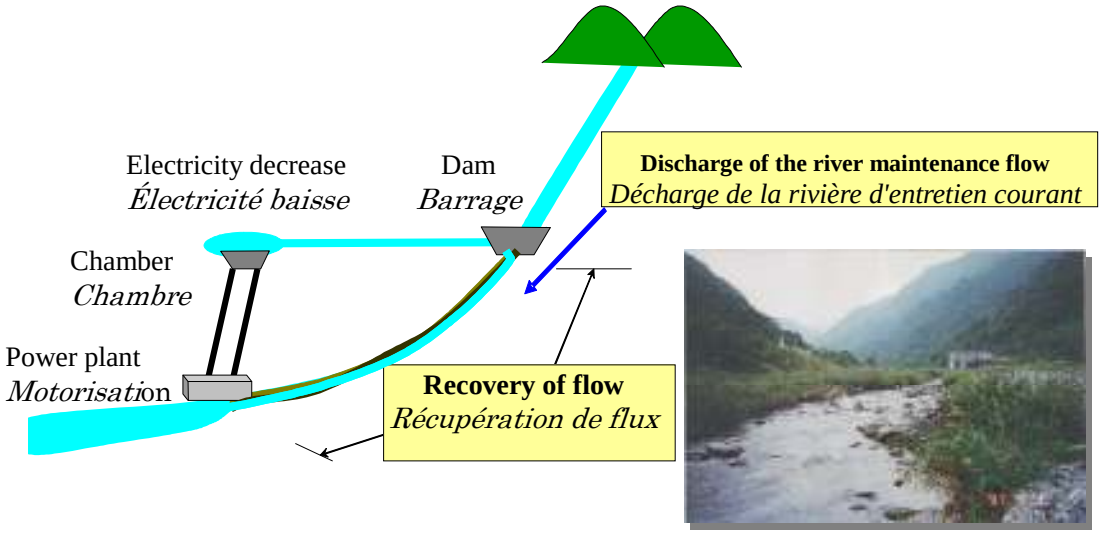


Fig. 2
Discharge of the river maintence flow
Lâcher du débit d'entretien

Performing concrete investigation of necessary items from among the objects—protecting plants, sets the scale of the river maintenance flow and animals, improving scenery, and guaranteeing the purity of the flowing water, and the river administrator then approves the discharge.

The permission period of the water rights of the generation of electricity is a principle thirty years. The discharge of the river maintenance flow is done at 267 power plants that meet the water rights renewal in the guidelines applicable power plant of 505. In March 2000, the maintenance flow was discharged in the river of approximately 3,100km out of 9,500 km of class A rivers that discharge is reduced.

Up to March 2000, 79.4% of all dams discharged a river maintenance flow from 0.2 to 0.4 m^3/s per 100 km^2, and the average was 0.309 m^3/s per 100 km^2. Now in 2007 from latest result, the maintenance flow was discharged in the river of approximately 6,500km out of 9,700 km [39].

Some cases given in response to the questionnaire survey are not based on data obtained by a field survey. So at three model dams, field surveys and hydraulic calculations etc. were carried out in order to investigate the effectiveness of river maintenance flow based on the Hydropower Guideline. The results confirmed that, at all model dams, there was a diverse range of fishes including Dace (leuciscus hakonensis), Pale Chub (Zacco platypus), Ayu (Plecoglossus altivelis), Yamame Salmon (Oncorhynchus), and so forth. The discharge survey and hydraulic calculations confirmed that the discharge of the river maintenance flow has improved the habitat for species such as Ayu. As

shown in Figure 3, at the Aimata Dam, parts of the rivers dried up by their underground flow and the intake of large volumes of water for irrigation were eliminated, greatly improving the physical environment for fishes (increased depth and velocity).

Before discharge
Avant lâcher

After discharge
Après lâcher

Fig. 3
Photographs of the flow regime downstream from the Aimata Dam
(600 to 800 m downstream from the dam)
Photographies du régime d'écoulement en aval du barrage Aimata
(600 à 800 m en aval du barrage)

The survey conducted on river managers shows that that the percentages of those who felt that the (1) flora and fauna and (2) scenery had improved [(a) “improved significantly” and (b) “improved somewhat”] were 66% and 77%, respectively. Some of the apparent effects of the improvement were “improved habitat conditions, and increased species and population of fish,” and “increased river width and improved waterfront conditions [30].”

(3) Flexible Dam Operation using Flood Control Capacity

Since 1997, a “Flexible Dam Operation Trial,” in which operational rules during normal operation are applied flexibly, has been underway at dams under the jurisdiction of MLIT with the purpose of improving the river environment downstream of dams. In the trial runs, studies are being conducted to improve the scenery and habitat conditions of fish and other organisms downstream of dams by releasing flushing discharges or increased maintenance flow volumes[30], [31].

In a flexible dam operation, the utilization water level is set higher than the regular maximum operational water level during seasons in which there is no risk of flood, and inflow water is stored below the utilization level. This extra volume of newly stored water is allocated to the improvement of downstream rivers, and is released as necessary according to the downstream conditions. Such release of water will be referred to as “utility discharge.”

At dams controlled by MLIT on the other hand, flexible discharge management that means flexible operation magnifying the normal operating rules is tentatively carried out to improve the quality of the environment downstream[31].

MLIT has started the flexible dam operation tests since 1997. In 2007, the flexible dam operation tests were carried out at 24 Multi-Purpose Dam[39].

a) Utilization Storage Capacity

As shown in Figure 4, storage by flexible dam operation is performed by designating part of the flood control storage capacity as utilization storage capacity and the water for improvement of hydrological regime of downstream is temporarily stored by using this capacity. In other words, when there is no danger of flooding, the utilization storage capacity is set an elevation higher than the limit water level in flood season and inflow water is stored within a range that does not exceed the utilization water level. This utilization storage capacity that has been newly created is used for utilization discharge that includes discharge of water to increase the maintenance flow and sediment flushing in downstream.

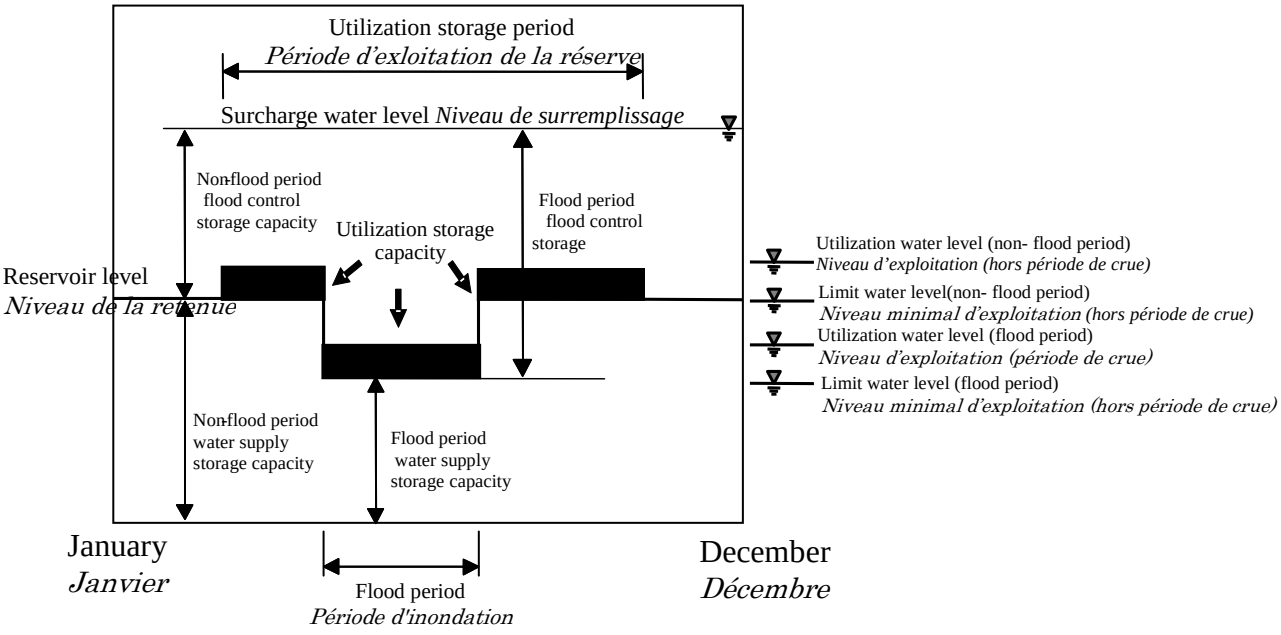


Fig. 4
Utilization storage capacity setting method
Méthode d'exploitation du volume de la retenue

b) Discharge before Flood

Because the utilization storage capacity is a part of the flood regulation storage capacity, the water level must be lowered by discharge before a flood flows into the reservoir to guarantee the flood control in downstream. This is called advance discharge before flood. This means that during a period of flexible operation, daily inspections must be done whether the in discharge will reach the flood discharge or not. When a flood has been predicted, advance discharge before flood must be done promptly to lower the water level to the limit water level.

c) Utilization Discharge

Inflow water stored at the utilization storage capacity is discharged in order to improve the environment downstream river according to the hydrological regime. This discharge is called the utilization discharge.

There are two patterns of utilization discharge shown in Figure 6.

(1) Discharge to increase the maintenance flow: Its purpose is to improve the scenery and the habitat for fishes.

(2) Flushing discharge: Its purpose is to stir up the riverbed and flush out silt and slack water on the riverbed.

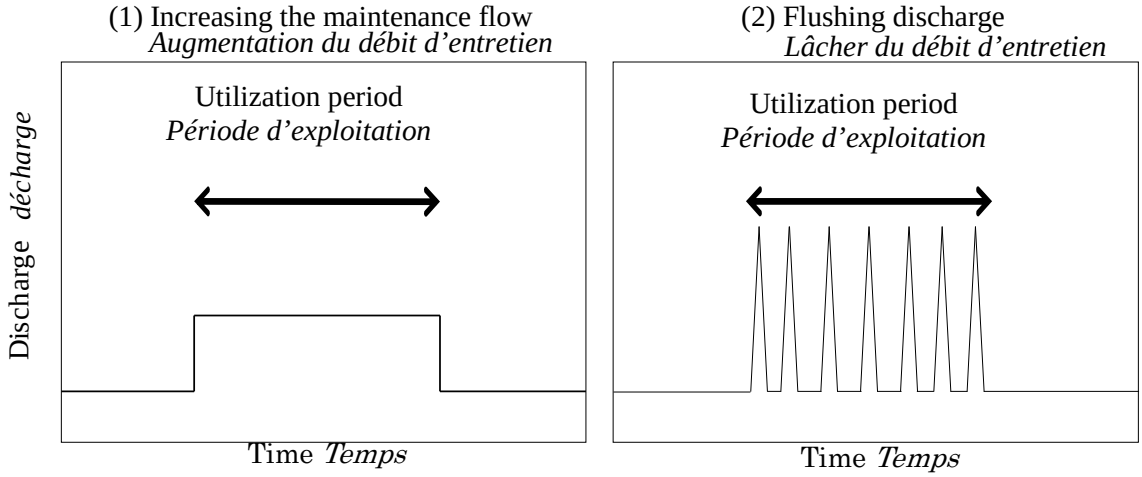
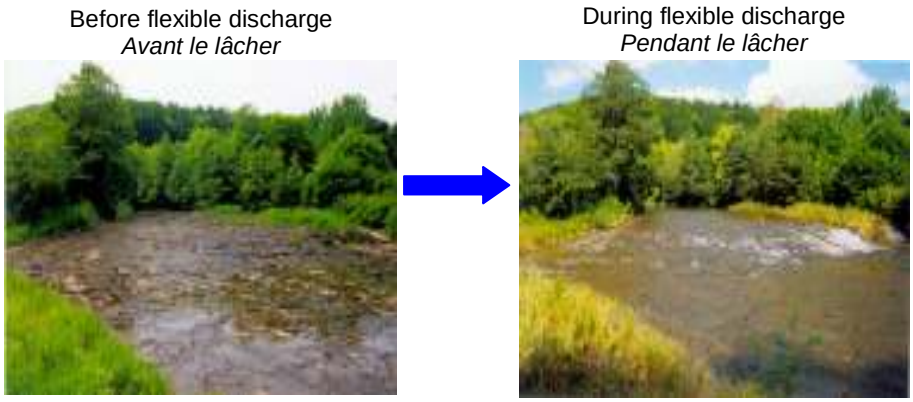
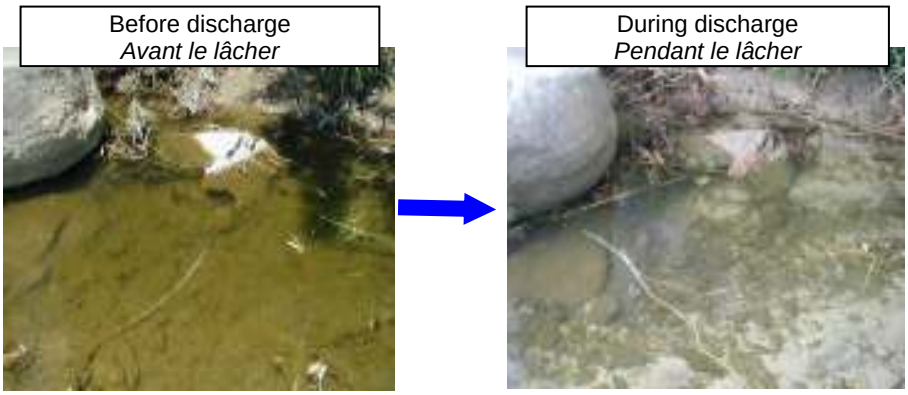


Fig. 5
Discharge patterns of stored inflow water
(Discharge in the river downstream from the dam)
Représentation du lâcher de débit entrant stocké
(lâcher en aval)

Figures 6 show the effects of increased maintenance flow and flushing discharge, respectively.



(a) Improved Conditions in River Landscape by Securing Maintenance Flow
(5 km downstream of Izarigawa Dam)
(a) Amélioration du paysage de la rivière par le lâcher du débit d'entretien
(5 km en aval du barrage Izarigawa)



(b) Removal of river-bottom sediment by flushing discharge
(3 km downstream of Miharu Dam)
(b) Élimination par le lâcher des dépôts accumulés au fond de la rivière
(3 km en aval du barrage Miharu)

Fig. 6
Improvement of River environment by Flexible Dam Operation
(Figure from Tanaka et.al. 2004 [30] Changed by Author)
Amélioration de l'environnement de la rivière grâce à l'exploitation flexible du barrage
(Par Tanaka et autres. 2004 [30] Modifications par l'auteur)

d) Matters for Noting of Flexible Dam Operation

We should establish the purpose of the utilization, the discharge method, and survey planning in the tests of flexible dam operation while considering the fact that the utilization capacity is limited. And, it is important to perform adequate preliminary surveys and suitable monitoring after the tests. If possible, studies of discharge patterns will be carried out as ways to further improve the hydrological regimes effectively.

4.2. MEASURES FOR SEDIMENT RESTORATION

The problem of changing sedimentation conditions in downstream riverbeds has been pointed out, and to counter it, measures have been taken in order to restore sediments to downstream regions [32], [33].

In FY 2004, sediment restoration trials were conducted at over 15 dams belonging to the MLIT, JWA, and other agencies. The number of dams undertaking such trials is increasing every year, indicating the rising interest in the effort. As effects, it has been investigated that the improving scenery by the appearance of gravel river beds, and that the restored sediments are being used as spawning beds by Japanese dace (*Tribolodon hakonensis*) [34][35].

Based on the above, it may be concluded that the evaluation of the effects and impacts of sediment restoration is now on development.

5. FLUSHING DISCHARGE PATTERNS TO IMPROVE THE ENVIRONMENTS EFFECTIVELY

Natural rivers experience seasonal changes in their flow, and various scales floods occur from time to time. Many riparian plants and animals are known to survive by adapting their living patterns to such changes. Seen from a slightly different angle, floods of a reasonable magnitude help maintain biodiversity of aquatic plants and animals in rivers by occasionally disturbing their communities and introducing changes to their habitat to a modest degree [39].

As we already pointed out, at dams supervised by MLIT, the “flushing discharge” is practiced as an experimental flexible dam operation tests to preserve the natural river environment downstream.

However, ways to determine the actual flushing discharge method including its peak flow, timing, frequency, discharge patterns, etc. are still virtually unknown. We indicate one case study how to establish flushing discharge methods

promoted by the MLIT. The aim of this case study is to improve the conditions of habitats of riparian plants and animals in the stretch of the river where water flow has decreased substantially.

5.1. Approach to Setting Targets for Improvement of the River Environments

The targets for improvement the river environment focused on the creatures in the river have been set through the study process shown in Figure 7.

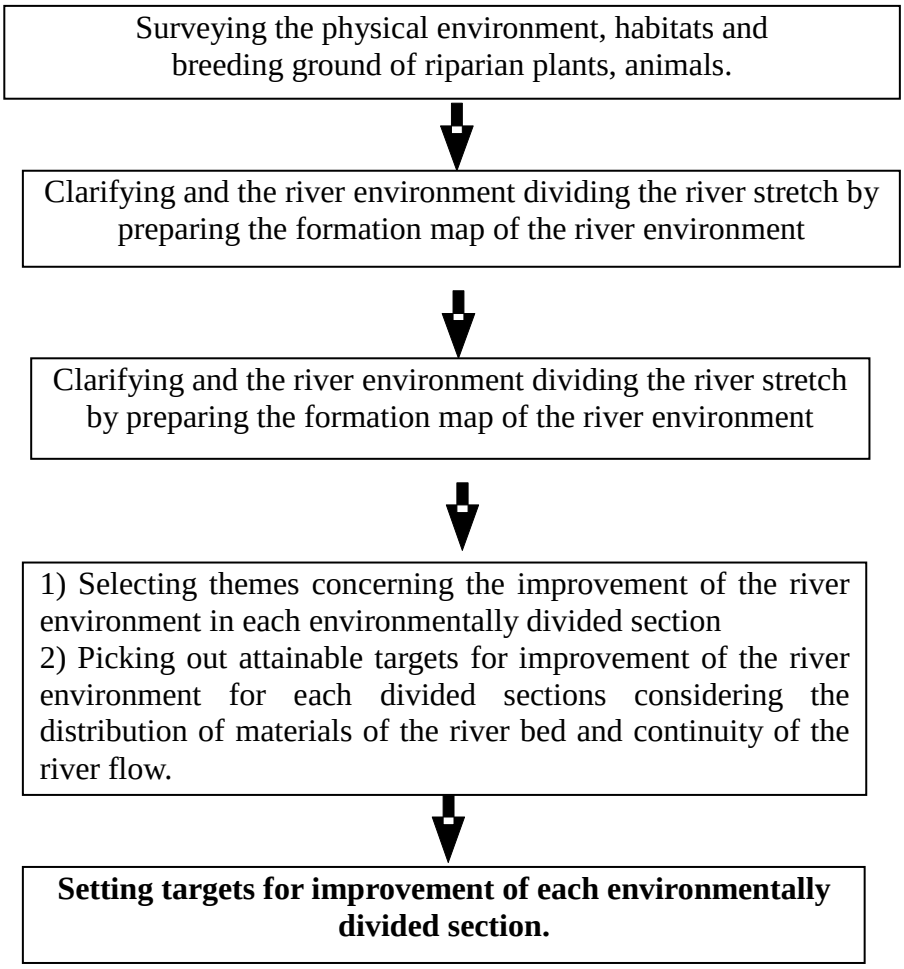


Fig. 7
Flow of the setting
Flux de la mise en œuvre

In this case, the targets were focused on Fishes, Benthic animals and attached algae shown in Table 4.

Table 4
The results of setting the target for improvement
Résultats de mise en œuvre des objectifs d'amélioration

Subject animals		Section		Target for Improvement	Purpose of flushing discharge	Conditions required
		A-1	A-2			
Fishes	Breeding ground (Dace))		●	Breeding ground	To flush off the silt sediment from the gravel riverbed where Ugui spawn.	Flow velocity high enough to move riverbed gravel with about 5 cm diameter.
	Important species (Reddish Bullhead)		●	Habitats	To flush off the silt sediment from the gravel riverbed	Flow velocity, high enough to move riverbed gravel with about 5 cm diameter.
	Focus of local interest (Ayu)		●	Reproduction of diatoms as food for Ayu fishes	To secure sufficient smooth replacement of peeled-off attached algae.	Flow velocity of 70cm/sec/ or above.
Benthic animals		●	●	Restoration of the original mix of species that lived in the natural hydrological regime.	To flush off silt deposition.	To be determined considering the natural hydrological regime.
Attached algae	Attached algae	●	●	Detachment and regeneration	To help promote smooth replacement of peeled off algae	Flow velocity of 70cm/s or above.
	Filamentous algae	●	●	Flush sweeping	To flush off filamentous algae.	

5.2. PEAK DISCHARGE

Next we studied the necessary discharge from dams to achieve the improvement goals in the downstream river.

The average section flow velocity and the depth of water were calculated in each section from the discharge. The flow velocity was obtained by Manning's mean velocity formula. In fact, the flow velocity varies laterally in a section. Therefore they were calculated with the section divided into 1m parts.

The tractive force was calculated in each divided 1m-part of the section.

5.3. FLUSHING DISCHARGE TIMING

To perform a flushing discharge, it is very important to determine the discharge timing appropriately considering the improvement targets.

To set the discharge timing considering the natural hydrological regime is better selection.

In this study, the flushing discharge timing was determined primarily to achieve the respective improvement targets in Table 3, followed by cross-checking and, if necessary, adjustment for the risk of adverse effects on the other targets, to finally settle on the schedule shown in Table 5 below.

Table 5
Timing/Frequency of flush discharge to achieve the improvement targets
Calendrier / fréquence de lâcher pour répondre aux objectifs d'amélioration

Improvement targets	Required timing/frequency
Improvement of egg laying environment for Dace	During and before the spawning season
Improvement of living environment for Reddish Bullhead	Seasons when the fishes are active
Improvement of living environment of Ayu	Seasons when the fishes are active following release from fishes farms
Improvement of living environment for benthic animals	Throughout the year, as close to natural as possible
Smooth replacement of removed Attached algae	Throughout the year, as close to natural as possible
Flushing off of filamentous Attached algae	Throughout the year, as close to natural as possible

5.4. FLUSHING DISCHARGE FREQUENCY

The following factors were considered to determine the number of discharges per month.

i) To set it as close to natural as possible,
ii) As it will take algae two weeks on average to attach and start growing, twice a month would be appropriate in summer months,
iii) Not performing flushing discharges in the winter would allow the silt to settle and attached algae to develop into a dense community, so it is appropriate to perform the flushing discharge once between one month and two months.

As a result, the flushing discharge frequency at this case study Dam has set as shown in Table 6.

Table 6
Number of times of flush discharge
Nombre de lâchers

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov	Dec	Total
Times	1	0	3	2	2	2	2	1	2	0	2	0	16

CONCLUSION

It has been pointed out that the construction of a dam unavoidably changes the downstream hydrological regime, which in turn triggers various impacts on the plants and animals living in the affected areas. Recently, the change of the downstream flow regime has become an issue.

As has been reported above, various measures to preserve river environments of downstream of dams are promoted under the initiative of the MLIT. They are discharge plans to maintain flow downstream from hydraulic power generation dams, flexible dam operation tests at multi-purpose dams, and scientific studies of flushing discharge and their effects. These efforts have already achieved a certain degree of success.

To achieve the goals for conservation of the natural environment in regions surrounding dam reservoirs, investigation for solving the causal relationship of the influence of the dam exerted on ecosystem change and analysis of a cause are performed, It is necessary to implement the required measure against conservation. After conservation of the natural environment, it is important to conduct detailed surveys for monitoring on the habitat conditions of organisms at each stage of the conservation effort. And then, it is more important to take an “adaptive management”. This method is that the conservation program is changed step by step at each conservation stage by monitoring results [38], [39].

We shall respond to this change by continuing research and development to pursue the goal of harmony between human beings and other creatures.

Thus, it is performing a rank division with a priority for every measure, it can consider as a standard with a dam administrator able to carry out a measure from what kind of item. We hope that the information provided here will be beneficial to our readers.

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SUMMARY

The construction of a dam unavoidably changes the downstream hydrological regime, which in turn triggers various impacts on the plants and animals living in the affected areas. Recently, the change of the downstream flow regime has become an issue.

The impacts of dams on the ecosystem, particularly on the downstream regions, will be compiled using the results of the National Census on River Environments promoted under the initiative of the Ministry of Land and Transport.

A lot of various efforts to conserve river environments of downstream of dams have been made, such as discharge to maintain flow downstream from hydraulic power generation dams, flexible dam operation tests at multi-purpose dams, and scientific studies of flushing discharge and their effects by administrator of Dam. These efforts have already achieved a certain degree of success. After conservation of the natural environment, it is important to conduct detailed surveys for monitoring on the habitat conditions of organisms at each stage of the conservation effort. And then, it is more important to take an “adaptive management”.

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RÉSUMÉ

La construction d'un barrage modifie inévitablement le régime hydrologique en aval, ce qui entraîne diverses répercussions sur les végétaux et les animaux vivant dans les zones touchées. Le changement de régime d'écoulement en aval devient aujourd'hui une source de préoccupation.

Les impacts des barrages sur l'écosystème, en particulier sur les régions situées en aval, seront calculés en utilisant les résultats de l'étude nationale sur l'environnement des rivières lancée par le ministère de l'Aménagement du territoire et des transports.

Toute un série d'efforts ont été menés à bien dans le but de préserver l'environnement des rivières, comme par exemple les lâchers qui visent à maintenir le flux en aval des barrages hydrauliques, des tests de fonctionnement flexible effectués sur différents types de barrages et des études scientifiques portant sur les lâchers et leurs effets menées par l'exploitant. Ces initiatives ont déjà rencontré un certain succès. Au-delà de la protection du milieu naturel, il est important de mener des enquêtes de suivi sur les habitats des organismes, à chaque étape de l'effort de protection. Enfin, il est plus crucial encore d'adopter une « gestion adaptative ».