Integrated Action Plan for *Inba-numa* Lake Watershed Management

K.Musiake[1], T.Inoue[2], M.Sato[2], M.Yoshida[2], M.Ito[2], T.Yuasa[3], et al.
[1] *Chairperson of the Committee for Lake Inba-numa Watershed Management, Fukushima University, Japan;* [2] *Secretariat of the Committee, Chiba Prefecture, Japan;*
[3] *Secretariat of the Committee, Pacific Consultants Co., Ltd, Japan*
takashi.yuasa@tk.pacific.co.jp

1. Background and introduction

1.1 Lake *Inba-numa* and its watershed

Lake *Inba-numa* is located in the northwestern part of *Chiba* Prefecture in Japan and drains a 541-square-kilometer watershed. The population in the watershed is 722,000, which accounts for about 12 percent of the total population in the prefecture. The water quality of Lake *Inba-numa* has been deteriorating rapidly since around the mid-1970s mainly because of the urbanization in the watershed. Today, Lake *Inba-numa* is ranked as a lake with the worst water quality among lakes which are being used as water supply sources in Japan (Figure 1 & Table 1).

Chiba Prefectural Government and other organizations concerned have drawn up and implemented a number of plans for the lake's sewerage system construction and lake water quality conservation. Despite various measures taken under those plans, the water quality has not yet improved significantly.

Table 1 Specifications of *Inba-numa*

Lake surface area	11.55km^2
Storage capacity	19.7 million m^3
Circumference	26.4km
Water depth	1.7m (average)
Retention time	About 22days
Watershed area	541.1km^2
Watershed population	727,000

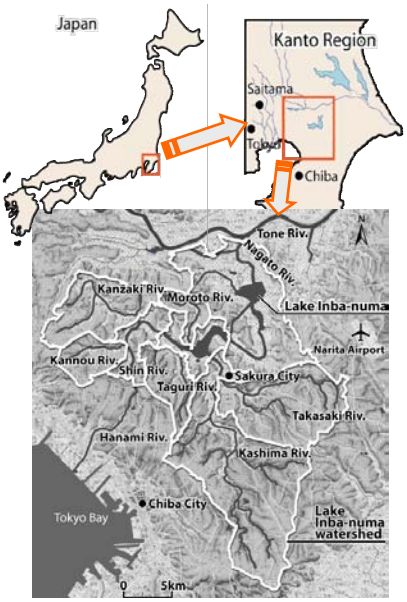


Figure 1 Location of Lake *Inba-numa*

1.2 The Committee for Lake *Inba-numa* Watershed Management

Toward a sweeping improvement of the water quality, *Chiba* Prefecture decided to deal with Lake *Inba-numa* watershed management in view of water quality, amenity, ecosystem, water use, and flood control, considering achievement of a sound water cycle system. We also launched "the Committee for Lake *Inba-numa* Watershed Management (Chairperson: Dr. *Katumi Musiake*, then prof. of the University of Tokyo)" in October, 2001. This committee consists of about 40 members, who are scholars, experts, NGOs, related organizations, 15 municipal governments in the watershed, *Chiba* Prefectural Government, and national government.

1.3 Establishment of Emergency Action Plan

In arguments in the committee, the status of the water cycle system was revealed through our monitoring and computer model analysis. We had drawn up Emergency Action Plan in February, 2004 after our minute arguments in the committee. Now, we are implementing various types of measures provided in the plan, for example, measures for domestic water, installation of rainwater infiltration and storage facilities, and environmental conservation agriculture. The committee continues to follow up the plan.

In this paper, we introduce the contents of the plan and actions of Lake *Inba-numa* as an advanced example of a watershed in a water-enclosed area with bad water quality.

2. Emergency Action Plan

2.1 Emergency Action Plan

The plan calls for doing both effectively and intensively what can be first done with watershed-wide cooperation (e.g. citizens, government, business organizations, etc.). It also describes measures to be taken by 2010, identifying the definition of roles for all the measures. We introduced the characteristics and main outline of the plan as follows.

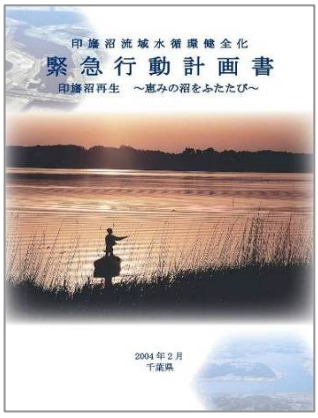


Figure 2　Emergency Action Plan

2.2 Lake *Inba-numa* Approach

In the aforementioned plan, Lake *Inba-numa* Approach was adapted as a basic principal (Table 2). We implemented the plan along this approach.

Table 2　Lake *Inba-numa* Approach

- Plan for solving problems from viewpoints of the watershed management
- Plan adapted to the characteristics of Lake *Inba-numa*
- *Mitameshi** plan … reviewed and modified on an as-needed basis

  **Mitameshi* is an old Japanese word and it means " see and try ". Farmers used this word when they tried to balance distribution of their irrigation water.
- Plan with citizens' participation
- Plan through the cooperation of government agencies

2.3 Goals and Evaluation Indexes

The plan has set "Restoring the life-sustaining lake" as a future vision by target year 2030. The vision is being embodied with four goals - water quality (Enjoyable and swimmable), amenity (Attracting and coexisting with people), ecosystem (Fostering the local ecosystem), and flood control (Not dangerous even after heavy rain) in accordance with the notion of integrated watershed management (Figure 3).

In order to check the achievement of the goals, we provided eight evaluation indexes, and also gave their target values at 2010 to each index. For example, as for "water

quality (COD)," we have to fulfill COD 8mg/L.

With a viewpoint of adaptive management, the state of the goal achievement will be checked by monitoring, and the plan will be reviewed and modified on an as-needed basis.

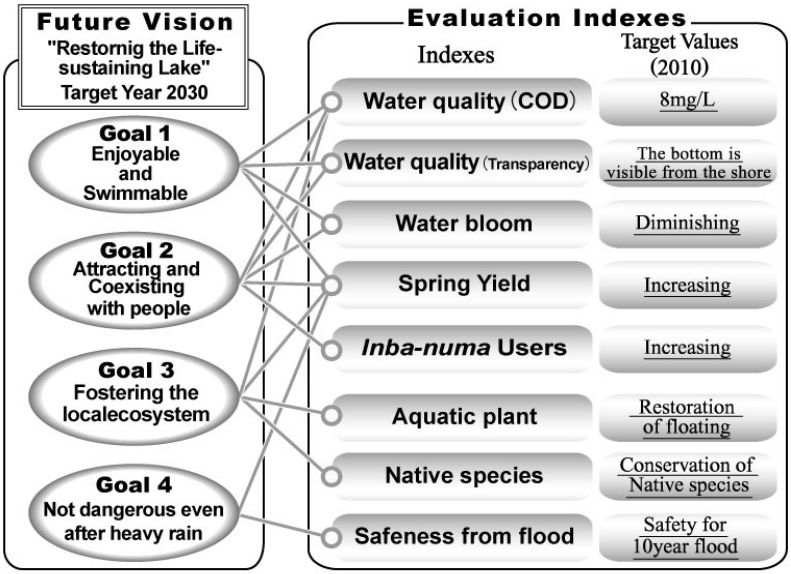


Figure 3 Goals and evaluation indexes

2.4 Measures and allocation of the roles

To achieve the goals, the plan described 63 concrete measures to be taken by 2010, identifying clearly who, when, where, and how much for all the measures. Thus, we selected important measures among 63 measures, and sorted them into five priority categories (Table 3). For example, the first category - "Making rainwater infiltrate into the ground" - consists of measures on the detention and infiltration of rainwater. The plan also described quantity to be taken of each measure: installation of 63,400 units of rainwater infiltration inlets; 183,000 m^2 of permeable pavement; 107,000 m^3 of stormwater detention facilities with an infiltration function, etc.

Table 3 Five priority categories of the measures

priority categories	Examples of the measures	Planned Number (2003–2010)
1) Making rainwater infiltrate into the ground	Providing houses with rainwater infiltration inlets	Increase of 63,400 units
	Paving roads with permeable materials	Increase of 183,000 m^2
	Adding an infiltration function to the facilities designed for stormwater retention (e.g., detention facilities using school playgrounds)	Increase of 107,000 m^3
2) Reducing the domestic pollution loads	Constructing or improving sewerage systems	Sewered population increase of 123,000
	Constructing or improving rural drainage systems	Treatment population increase of 2,000
	Promoting the installation of on-site advanced wastewater treatment systems	–

priority categories	Examples of the measures	Planned Number (2003–2010)
	Promoting pollution control measures related to domestic gray water	–
3) Promoting environmentally friendly agriculture	Reducing fertilizer and pesticide Increasing fertilization effectiveness Promoting "*Chiba* Eco Agriculture (Eco-oriented agriculture)"	–
	Promoting the utilization of spring water for irrigation	–
	Constructing circulating irrigation systems	–
4) Fostering the local ecosystem	Conserving and restoring community forests, *Yatu* (valley bottoms) and springs	–
	Conserving and restoring biotopes and wetlands	–
	Greening of urban area; Conserving farmland	–
	Promoting nature-oriented river works	Length=13.3km
	Controlling exotic species	–
	Strengthening the monitoring of illegal dumping of wastes	–
5) Protecting communities and public transportation systems from floods	Repairing Lake *Inba-numa* bank	Length=24km
	River improvement	Length=8.3km
	Constructing or improving drainage pump station	–
	Promoting the installation of stormwater control facilities in the watershed	Same as 1)

3. Post-planning effort: *Mitameshi* actions

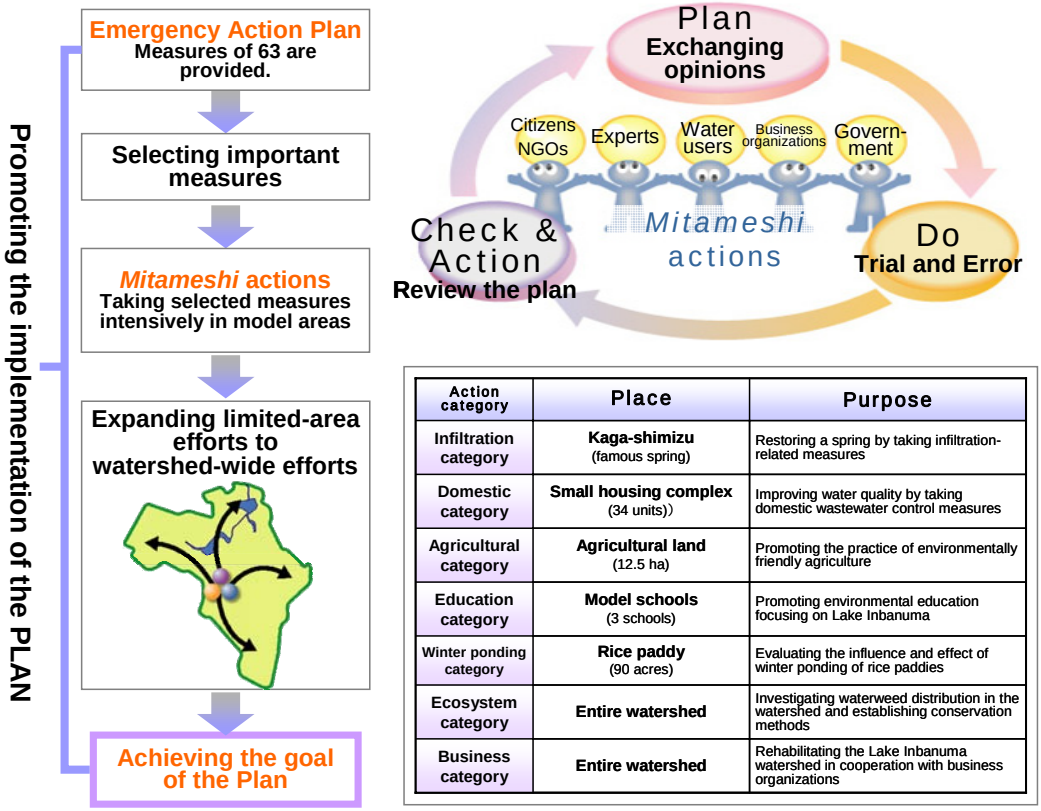
3.1 What are *Mitameshi* actions?

We had a concern that the spread of the plan and its effect would take time since Lake *Inba-numa* watershed was so broad as 541km^2 and watershed population was so large as 700,000. Therefore, to promote the implementation of the plan, we planed to take "trial and error" actions of seven categories such as infiltration, domestic, agriculture, winter ponding, ecosystem, and business (Figure 4). In these actions, at first, we selected model areas and measures to be taken in the actions, and then we take the selected measures intensively and adoptively with the residents in the area. Finally, we expand the limited area efforts to the watershed-wide efforts.

We have been taking these actions with the notion of adaptive management and Plan-Do-Check-Action cycles. These are corresponding with the word "*Mitameshi*", one of the Lake *Inba-numa* approaches (see 2.2), so we call these actions "*Mitameshi* Actions." In this paper, we introduce the *Mitameshi* actions of the infiltration category as follows.

3.2 Infiltration action category

Infiltration action category has been implemented at a famous historic spring "*Kaga-shimizu*" (Figure 5) and its recharged area (16.3ha). *Kaga-shimizu* spring yield has decreased lately and dried up occasionally. On the contrary, in heavy rain times, floods occurred frequently in the area. Therefore, we decided to promote the installation of rainwater infiltration inlets at the house, permeable pavement, and stormwater infiltration inlets with separate ducts at the causeway to increase the *Kaga-shimizu* yield and to reduce flood damage.



Action category	Place	Purpose
Infiltration category	**Kaga-shimizu** (famous spring)	Restoring a spring by taking infiltration-related measures
Domestic category	**Small housing complex** (34 units)	Improving water quality by taking domestic wastewater control measures
Agricultural category	**Agricultural land** (12.5 ha)	Promoting the practice of environmentally friendly agriculture
Education category	**Model schools** (3 schools)	Promoting environmental education focusing on Lake Inbanuma
Winter ponding category	**Rice paddy** (90 acres)	Evaluating the influence and effect of winter ponding of rice paddies
Ecosystem category	**Entire watershed**	Investigating waterweed distribution in the watershed and establishing conservation methods
Business category	**Entire watershed**	Rehabilitating the Lake Inbanuma watershed in cooperation with business organizations

Figure 4 *Mitameshi* actions

Figure 5 *Kaga-shimizu* spring (Left: Mar. 29, 1999; Right: Feb. 24, 1999 (dried-up))

3.3 Measures implemented in the action

Table 4 is the list of the measures implemented in the area. The residents installed 144 units of rainwater infiltration inlets, capitalizing on *Sakura* City's and *Chiba* Prefecture's subsidies. To encourage the installation of inlets, we distributed brochures, explaining the importance of rainwater infiltration and promoting participation in the *Mitameshi* action to the residents. Originally, the City of *Sakura* had promoted the installation of inlets in this area since 1997. Our *Mitameshi* action succeeded and developed *Sakura* city's approach. Road stormwater treatment system contains trenches, infiltration inlets with separate ducts, and permeable pavement (Figure 6).

The separate ducts separate dirt such as fallen leaves, suspended solids, and besides oil. The separated water is infiltrated to the ground by the infiltration inlets (Figure 7). So far 389m of the road stormwater treatment facilities (36-unit inlets, 778m trenches, and 1,561m^2 permeable pavement) were installed by *Chiba* Prefecture.

Table 4 Implemented measures

Measures		Before FY2005	Planed in FY2006
Rainwater infiltration inlets		144units	100units
Infiltration trenches		350m	
Road stormwater treatment facilities	Length	389m	125m
	Infiltration inlets with separate duct	36units	10units
	Trenches	778m	250m
	Permeable pavement	1,561m^2	550m^2
Stormwater detention and infiltration facilities		—	At *Ino-cho* Community Center

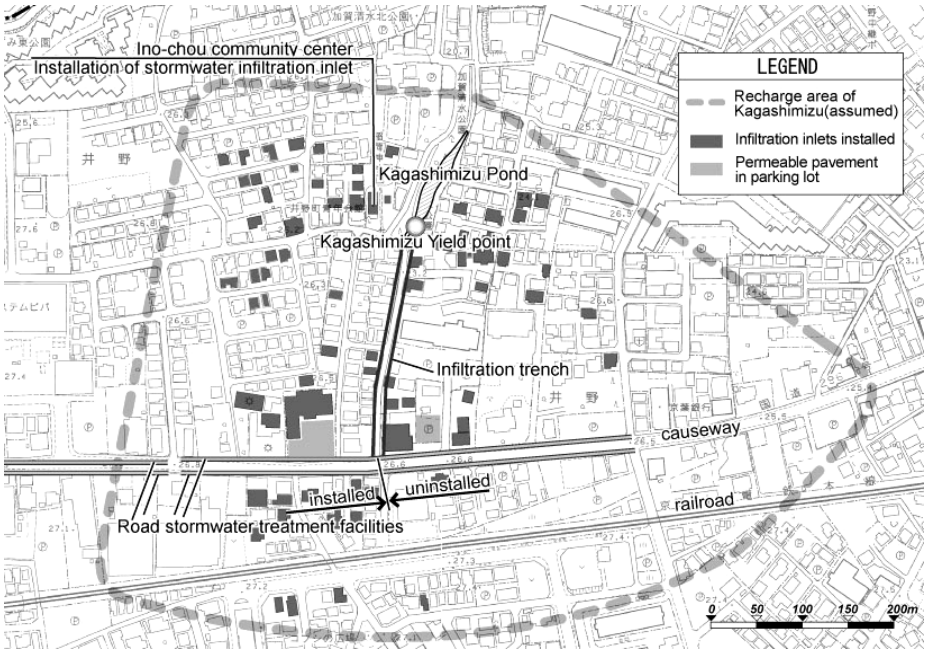


Figure 6 Infiltration action category: location and implemented measures

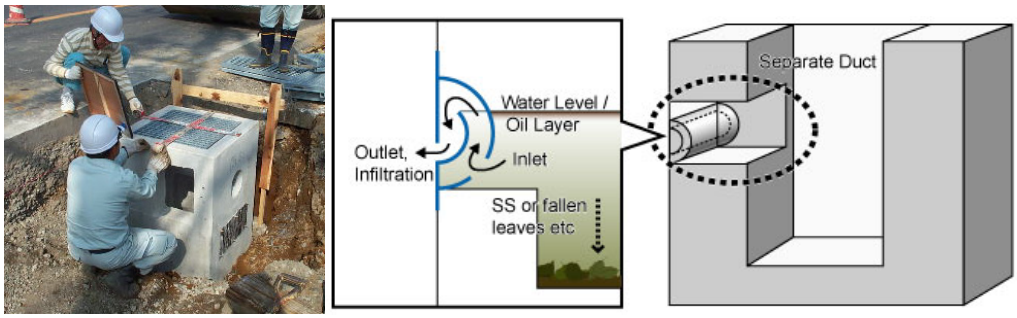
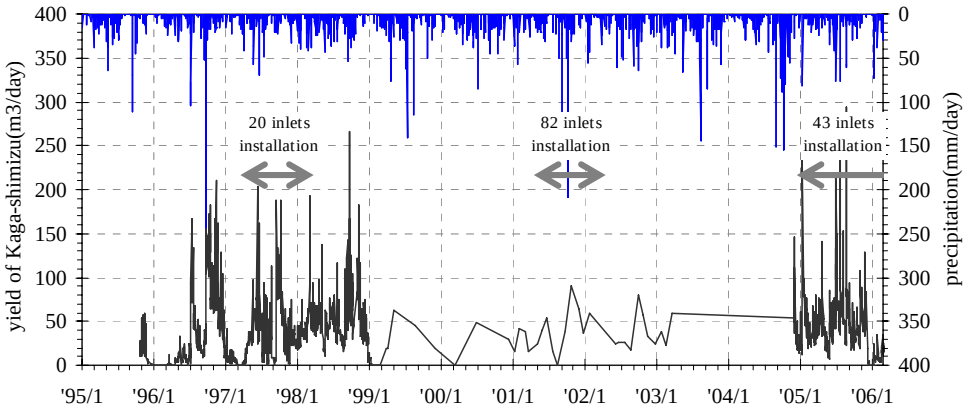


Figure 7 Road stormwater infiltration inlet with a separate duct (Left: installation, Right: internal structure of the inlet and duct)

3.4 Effect of the infiltration category action

To estimate the effect of the action, we have been surveying the yield of *Kaga-shimizu* continuously (Figure 8). The monitoring results show that the yield, except for rain times, amounts 70m^3/day (50L/min), and it becomes zero during winter rainless time, especially in January. The observation data also indicates that the dried-up frequency or period would have been reduced significantly if the rainwater infiltration inlets were installed in 1997.



Yield is observed by the City of *Sakura* (Oct. 1995 - Mar. 2003) and *Chiba* Pref. (Apr. 2004). Observation frequency is one hour (except for Jan. 1999 - Jan. 2003; once a month). Precipitation is observed at the City of *Sakura* by the Meteorological Agency (the AMeDAS data).

Figure 8 Monitoring results: yield of *Kaga-shimizu*

To confirm this, we compared the correlation between the minimum yield of each month with the precipitation of the previous month before the facilities installation (before 1996) and with the ones after the installation (after 1997) (Figure 9). This figure indicates that the monthly minimum yield after the installation clearly increases as compared with that before the installation. Thus, *Kaga-shimizu* dried-up occurred when the precipitation of the previous month is less than 150mm before the installation, but it didn't occur not less than 50mm/month after the installation. Incidentally, the reason why we use the precipitation of the "previous" month is that it has a higher correlation efficient with *Kaga-shimizu* yield than that of the same month or two months before. This indicates that *Kaga-shimizu* yield affects the precipitation for the month just past strongly.

According to these points we have considered, we could confirm the effectiveness of the rainwater infiltration inlets. We have opened the monitoring results to the residents. This follows that they manage to work on further actions, confirming and understanding the effect that they bring. Now, we start an observation of the surface run-off. We will evaluate effects on floods and the first flush load control after the accumulation of monitoring data.

We will continue to promote the action, and furthermore, we will have to expand the limited-area efforts to the watershed-wide efforts.

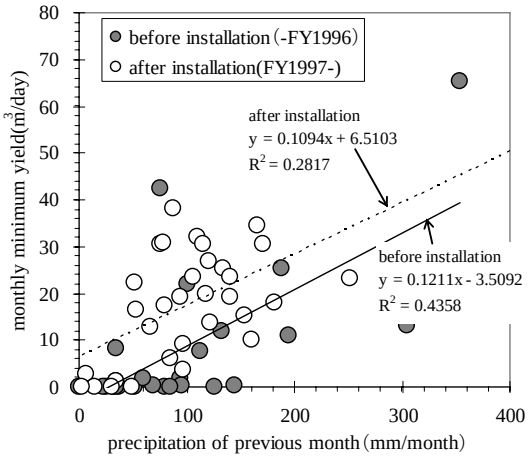


Figure 9 *Kaga-shimizu* yield increase by the installation of the rainwater inlets

4. Conclusion

We introduced the outline of Emergency Action Plan and actions in Lake *Inba-numa* watershed. It is difficult to improve water quality at an enclosed water body as *Inba-numa* only by a conventional means of pipe treatments like constructing sewage treatment system. Therefore, we set four goals toward "Restoring Life-sustaining Lake," identifying the allocation of the roles of all the stakeholders in the watershed. Thus, to promote the implantation of the plan, we planed to take the *Mitameshi* actions of seven categories. However, our plan and actions do not still prevail all over the watershed. It's important that the citizens in the watershed think and take actions pontaneously. We strongly hope that our future vision - "Restoring Life-Sustaining Lake" - will be incarnated in 2030.

Acknowledgement

The authors would like to appreciate the other members of the Committee for Lake *Inba-numa* Watershed Management for their thorough and helpful comments. We also appreciate the stakeholders in the *Inba-numa* watershed for their assistance and corporation. In the "*Mitameshi*" Actions, residents in the area, associated specialists, and local governments are to be acknowledged for their participation and corporation. Especially, the infiltration action category we have introduced in this paper was originally launched by the City of *Sakura*, and we succeeded their efforts integratedly. Thanks are due to the members of secretariat of the committee, officers of *Chiba* Prefecture, and staff of Pacific Consultants, without whom this effort would not have been fruitful.

Abstract

Lake *Inba-numa* is located in the northwestern part of *Chiba* Prefecture. Its water quality has been deteriorating rapidly since around the mid-1960s mainly because of the urbanization in the watershed. Lake *Inba-numa* has been ranked as a lake with the worst water quality among lakes which are being used as water supply sources in Japan.

Chiba Prefectural Government and other organizations concerned have drawn up and implemented a number of plans for the lake's sewerage system construction and lake water quality conservation. Despite various measures taken under those plans, water quality has not yet improved significantly. *Chiba* Prefecture Government, therefore, has drawn up Emergency Action Plan in February, 2004 after a series of debates among conflicting stakeholders for 2 years.

This plan sets its goals on water quality, water amenity, ecosystem, and flood control in accordance with the notion of integrated watershed management, which have to be achieved to restore Lake *Inba-numa* and its watershed in 30 years. With a view point of adaptive management, the state of the goal achievement will be checked by monitoring, and the plan will be reviewed and modified on an as-needed basis.

Now, we are implementing various types of measures, for example, measures for domestic wastewater, installation of rainfall infiltration and storage facilities, and environmental conservation agriculture. To promote implementation of the plan, we are taking "*Mitameshi* (or Trial and Error)" actions in model areas, and organize "*Inba-numa Waiwai Kaigi* (Conference with citizens)," where we can exchange opinions with the citizens.

In "*Mitameshi*" actions, we selected important measures provided in the plan at first, and then we take the selected measures intensively and adoptively with the residents in model areas. Finally, we expand the limited-area efforts to the watershed-wide efforts. We can review the effect of "*Mitameshi*" actions by several monitoring, and open the monitoring results to the residents in model areas. They manage to work on further actions, confirming and understanding the effect that they bring themselves.

We would like to introduce the plan and actions of Lake *Inba-numa* as an advanced example of a watershed approach of an enclosed water area with bad water quality. We would appreciate it if this case would be a clue to solve the similar problems of watersheds in the Asia-Pacific region.

Keywords: *integrated watershed management, adaptive management, water quality conservation, enclosed water body*