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Lake Biwa: Have sustainable development objectives been met?

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Abstract

The need to control and manage the effects of urban, industrial and agricultural development on Lake Biwa, Japan's largest lake, led to the formation of the Lake Biwa Comprehensive Development Project (LBCDP). This article describes the nature and effects of the development, how the LBCDP was conceptualized, implemented and managed, and comments on its effectiveness. Although the basic objective of the project was to promote development of the Keihanshin region by providing additional water, other important objectives included the conservation of the natural environment, the promotion of public welfare, and the restoration of water quality. To achieve objectives on a sustainable basis, extensive political, legislative, social, technological and environmental matters needed comprehensive consideration. This article considers such matters in detail.

Key words

Lake Biwa, Lake Biwa Comprehensive Development Project, wastewater, water legislation, water management, water quality.

PART I COMPREHENSIVE DEVELOPMENT PROJECT

Introduction

Lake Biwa, the largest lake in Japan, is located in the uppermost reaches of the Yodo River Basin in central Honshu Island and occupies one sixth of the prefectural territory of Shiga (Fig. 1). In the downstream reaches of the basin are metropolises such as Kyoto, Osaka and Kobe and other small municipalities in Kyoto, Osaka and Hyogo Prefectures. The total population of this region is 13 million, for which the lake supplies water for domestic, industrial, hydroelectric and irrigation purposes.

Throughout history, there have been conflicts in water use and management between upstream Shiga and downstream areas, with respect to flood control, water resource development and more recently to water quality management.

As for flood control, the communities in the immediate surroundings of Lake Biwa had suffered many severe floodings for centuries before the central government finally agreed about 100 years ago to a major dredging of the Seta River, the only outflowing river from the lake. Seta Weir, the single artificial water flow control facility of the lake outflow, was also constructed about this time. With these and other flow control measures introduced over the past century, flooding is no longer a major threat either for Shiga or for downstream areas.

As for water resource development, the demand for lake water by the downstream megalopolises in the 1960s led to the Lake Biwa Comprehensive Development Project (LBCDP) (Nakamura 1991; Nakamura and Akiyama 1991). In this, the development of new water resources amounting to 40 m^3/s has been agreed upon by Shiga and downstream prefectural and municipal governments, as well as by the National Government.

This additional amount of water was to be made available upon completion of all originally scheduled lakeshore reinforcement works and other compensatory public works projects for Shiga Prefecture by the end of 1982. After experiencing difficulties in implementation of an array of component projects within the originally scheduled 10 year project period, the project term was extended for an additional 10 years up to the end of 1992, with integration of additional projects for environmental conservation. By the end of 1992, almost all water resource develop-

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ment projects were completed, but not all of the compensatory public works, leaving the Shiga Prefectural Government to propose the release for downstream communities of only 27 m^3/s of additional water on an 'as-needed' basis. The downstream governments reluctantly agreed to the tentative arrangement.

The LBCDP is a plan involving such project categories as nature and environmental conservation, flood control and water resources development. An array of large-scale component construction works, costing billions of dollars to the region and the nation, have been and will continue to be undertaken until the end of 1996 when the project period is due to terminate.

In the meantime, lake water quality has deteriorated over the past several decades due to population growth and various development activities within the catchment area. Some environmentalist groups have been putting blame on LBCDP itself. Shiga Prefecture is now under pressure to improve lake water quality through various wasteload reduction measures as well as in-lake restoration. The prefecture has also indicated its frustration recently by arguing that downstream governments should bear, in addition to the amount paid within the framework of LBCDP, part of the cost incurred for undertaking lake water quality improvement projects on a sustainable basis, much of the benefits of which accrue to downstream users. The proposal originally received a rather cool reception from downstream governments who claimed that the contribution to environmental conservation components of LBCDP was meant for that purpose. The Ministry of Construction facilitated the establishment of Water Quality Conservation Funds to diffuse this issue to which all neighboring prefectural governments were invited to contribute. Shiga Prefecture is currently attempting to develop a post-LBCDP scheme, the realization of which is yet unknown.

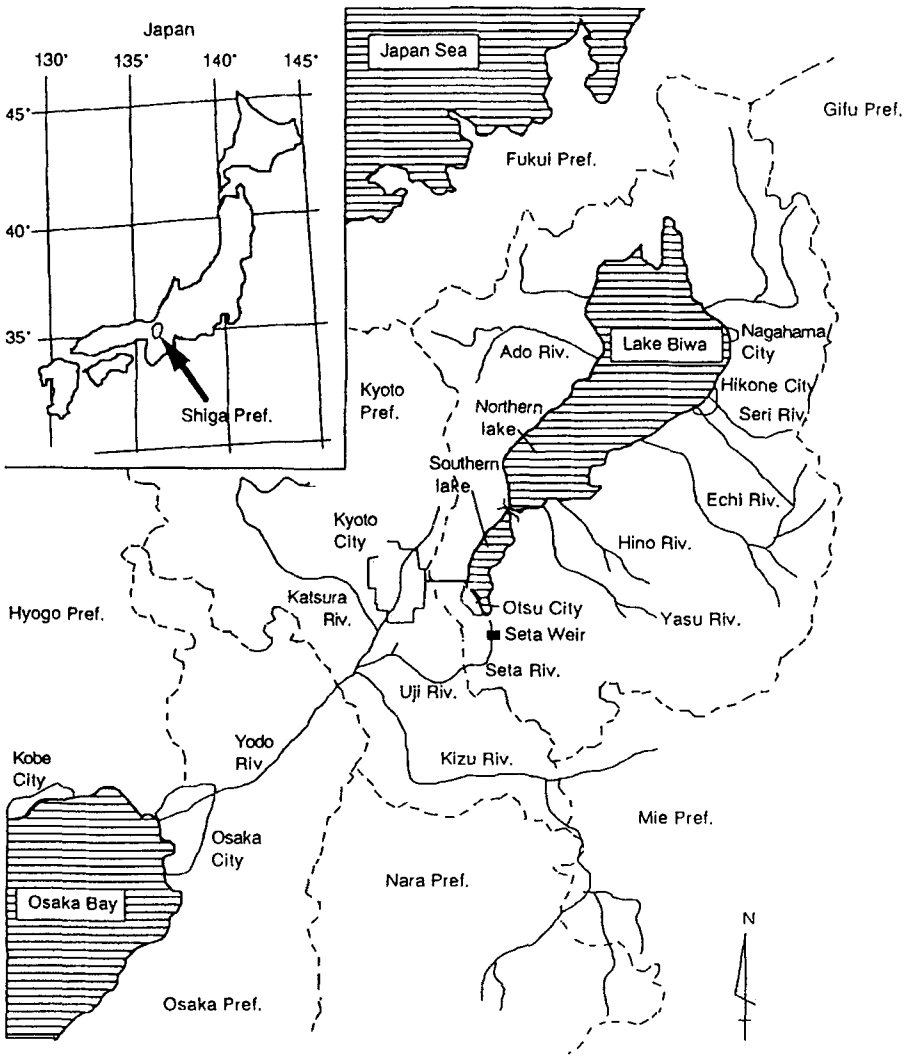

Fig. 1. Lake Biwa and the Yodo River region. Source: Anon 1991a.

Lake Biwa–Yodo River Basin

To understand the history of water resource development and water quality conservation of Lake Biwa, it is important to recognize the unique geographical feature of the Lake Biwa-Yodo River Basin and upstream-downstream relations with respect to water resource development of Lake Biwa.

The lake measures 63.5 km in a north–south direction and is divided into two sub-basins at the constriction point approximately 16 km from the southern end. It has a total surface area of 674 km^2, a volume of 27.5 billion m^3, and a shoreline length of 235 km. Its catchment area is 4.7 times the area of the lake itself, and its boundary more or less coincides with that of the prefecture, constituting 96% of prefectural land (Fig. 2). The catchment area consists of forest-covered hills and mountains (60%), paddy fields and other farmlands (25%), and urban and industrial areas. The prefectural capital, Otsu, has an approximate population of 240 000 and is located at the southern end of the lake. Some 400 rivers and streams flow into the lake, but there is only one natural water course flowing out of the lake, Seta River, and two canals passing lake water to Kyoto. The lake serves as a source of domestic and industrial water for both populations within the lake catchment area and the downstream population and industrial centres in the Keihanshin Area (Fig. 3).

It also serves for irrigation of paddy fields in the lake basin flat lands and for hydropower generation at some distance downstream of the outflowing river. Lake Biwa has been the most important natural asset for the prefecture, and Shiga residents have had a special attachment to the lake throughout history

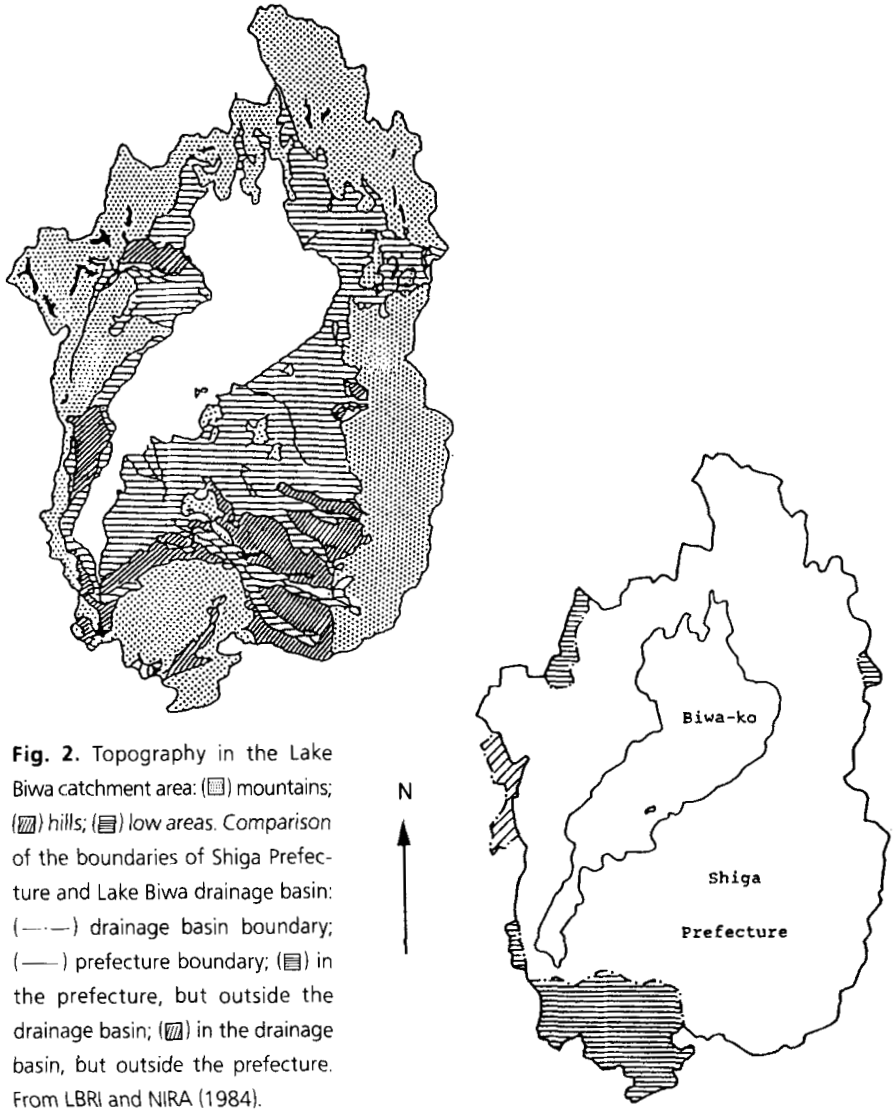

Fig. 2. Topography in the Lake Biwa catchment area: (▦) mountains; (▨) hills; (▤) low areas. Comparison of the boundaries of Shiga Prefecture and Lake Biwa drainage basin: (—·—) drainage basin boundary; (——) prefecture boundary; (▤) in the prefecture, but outside the drainage basin; (▨) in the drainage basin, but outside the prefecture. From LBRI and NIRA (1984).

because of their dependency on the lake for fishing and transportation.

In the past century or so, the water-use pattern has changed significantly due to various water resource development activities (Fig. 4, Table 1). The two canals linking the lake and Kyoto were constructed in 1890 and 1912, respectively. The City of Kyoto, therefore, has had direct access to lake water unlike other downstream metropolises. The Seta River reaches to the prefectural boundary between Shiga and Kyoto. Within Kyoto Prefecture, it is called Uji River. Uji River is met by Kizu River and Katsura River at the Kyoto-Osaka Prefectural boundary, and the downstream stretch from this point is popularly called the Yodo

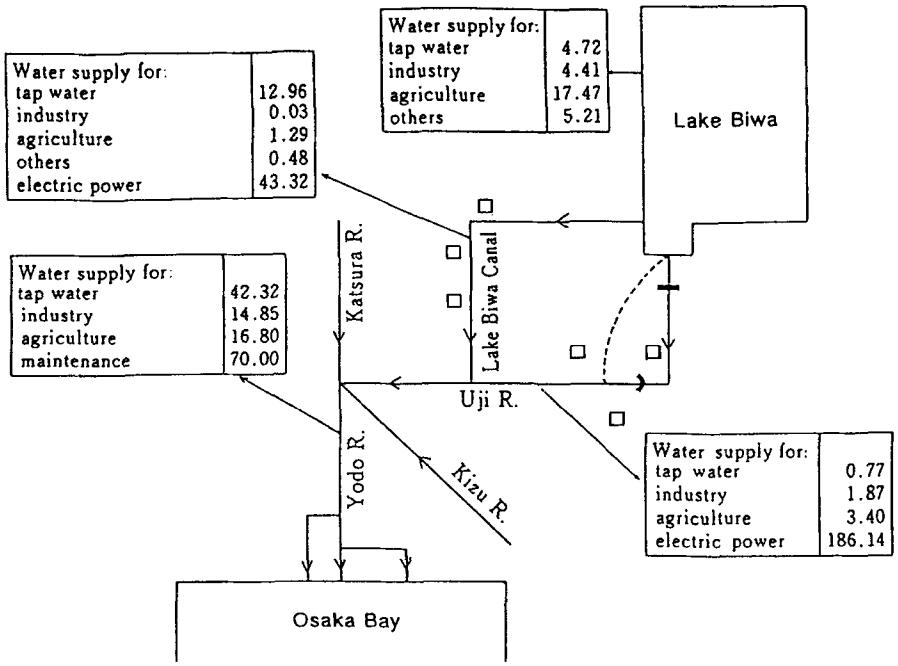

Fig. 3. Water uses in the Lake Biwa-Yodo River Basin: (—) barrage; (▮) dam; (□) generating station. Unit = m^3/s. From Anon (1991a).

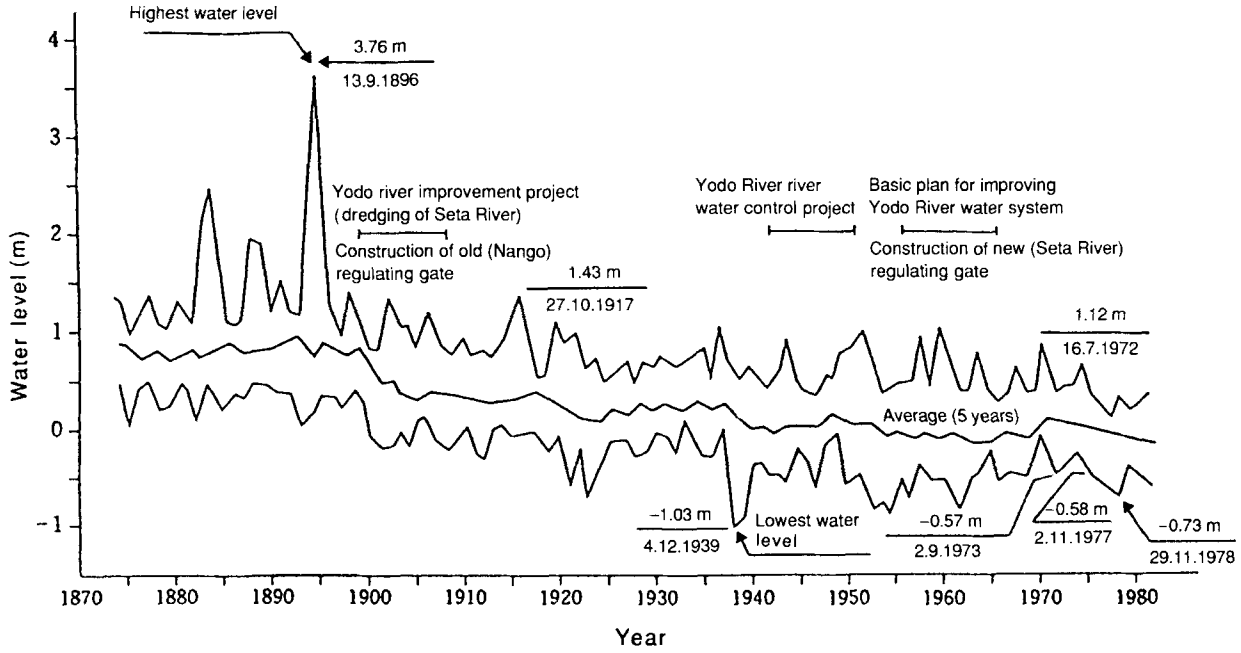

Fig. 4. Changes in the water level of Lake Biwa. From Anon (undated).

River. The flow contribution to the Yodo River of the Uji, Kizu and Katsura Rivers are, respectively, 64%, 18% and 15%.

The official designation of the whole of the Yodo-Uji and Lake Biwa water bodies is the Yodo River System. Its total catchment area, as observed at Hirakata, some 20 km upstream of the river mouth, is 7281 km^2. According to Ministry of Construction statistics, its annual average flow, high flow and low flow are, respectively, 177.6 m^3/s, 226.8 m^3/s and 117.0 m^3/s.

At present, the metropolitan regions of Osaka, Kyoto and Kobe depend almost exclusively on the Yodo River for industrial and municipal water supplies. Thus, Lake Biwa accounts for water supplies amounting to 20 billion tons per year, and serving as many as 12 million people living in the Keihanshin Area including Shiga. Lake pollution, therefore, has been of serious concern not only for those living around the lake but also for those receiving water from the Yodo River.

The history of Lake Biwa and Yodo River water management was one of a conflict of interests and the resolution between Keihanshin Area downstream, particularly the Greater Osaka Region, and the Shiga Prefecture upstream. For centuries, the communities in the immediate surroundings of Lake Biwa experienced severe flooding of their agricultural fields before the government finally agreed, about a century ago, to a major dredging of the Seta River at the outlet of the lake, in combination with the construction of Seta Weir, the only artificial water-flow control facility of the lake outflow. It is located a few kilometers downstream from the lake outlet. The weir, constructed in 1905 and renovated in 1961, controls the lake water level and discharge rate to Yodo River. The flood frequency and the flood damage in the lake catchment were drastically reduced after the weir construction. The demand for water, particularly for industrial uses, began to increase sharply as the country entered the era of economic growth a decade or so after the end of the War.

In the downstream stretch of Yodo River, the Hanshin Industrial Belt established in pre-war years began to thrive with unfulfilled demands for more water. Exploitation of groundwater soon became constrained due to competition of use among industrial establishments and to land subsidence caused by overdrafts of water. Industries were then forced to look for alternative sources of water. Domestic water supply needs also began to increase in the Yodo River areas after suburban cities joined Osaka in gaining access to Yodo River water.

Japanese economic growth gained momentum by the mid-1950s (Fig. 5), and there was significant interest in the development of a comprehensive development plan of Lake Biwa water resources by the down-

Table 1. Lake Biwa–Yodo River Basin: Water resource development activities

Year	Development activities
1874	Installation of Torii River water signpost
1885	Construction started on 1st Lake Biwa canal
1990	Construction of 1st Lake Biwa canal completed
1896	Plan for improving Yodo River drafted
1896	Large flood
1905	Construction of regulating gate completed
1912	Construction of 2nd Lake Biwa canal completed
1913	Uji Power Plant completed
1939	Severe water shortage
1943	Winter time discharge started
1953	1st river water control project completed
1954	Basic plan of improving Yodo River water system drafted
1961	New regulating gate completed
1967	Work under basic plan of improving Yodo River water system completed
1971	Basic plan of implementing constructions in Yodo River water system
1972	Special decree for LBCD Act enacted
1972	LBCD Plan drafted
1982	Special decree for LBCD Act modified
1982	LBCD Plan modified

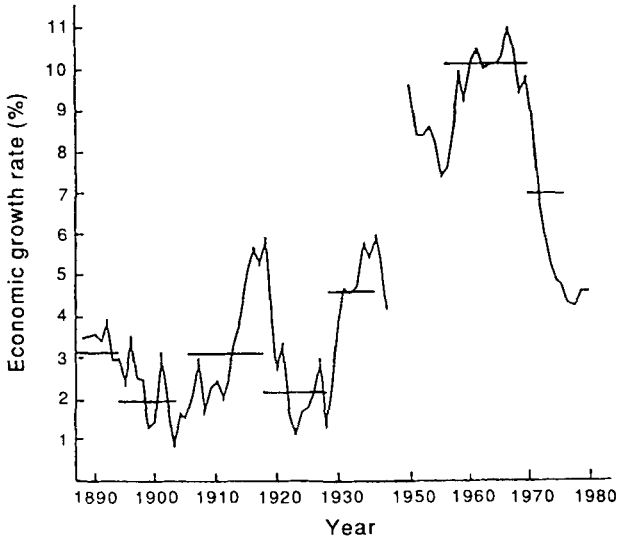

Fig. 5. Long-term growth trends of the Japanese economy: (——) average economic growth rate. From Minami and Kiyokawa (1987).

stream population and industrial centers. After nearly two decades of political pressure on Shiga Prefecture, consisting of demands by downstream interests and the initiatives by the national government ministries, Shiga Prefectural Government finally agreed to a scheme for the comprehensive development of Lake Biwa.

The concept of the LBCDP

The conceptual basis

The development of the water resources of Lake Biwa provides socio-economic benefits to the downstream Osaka and Kobe regions in the form of urban and industrial development. Shiga Prefectural residents, on the other hand, were concerned that they might simply accede to downstream demands for additional water without direct benefit from the transaction. They were more likely to suffer from additional discharge of lake water through the Seta Weir, since it would necessitate alteration of existing, or the construction of new, lakeshore facilities for coping with the lowered water level. The conceptual basis of the comprehensive development plan was, therefore, based on the following considerations:

(1) Since those living around Lake Biwa have historically made a livelihood out of the lake, the lake ought not to be considered as a mere impoundment or reservoir.

(2) The lowering of the water level ought to be kept within limits considered reasonable to those immediately affected.

(3) The development of additional water resources of Lake Biwa ought not to benefit only those who make direct use of it downstream but also those who are disadvantaged upstream due to lost opportunities.

The balance of conflicting interests of Shiga Prefecture upstream and Hanshin Region downstream required the development of a concept totally new to the water resources management policy-making institution. The consensus involved the following basic principles:

(1) The Project will comprise two major components, one being water resources development, and the other, regional infrastructure development particularly for communities around the lake.

(2) The Project will be funded predominantly by the national government and the downstream local governments.

(3) The Project, being a large scale regional development project with national implications, will be drafted by the Prefectural Governor of Shiga and be approved by the Prime Minister of Japan.

The Project was designed to consist of three categories of component projects, namely those designed to contribute to the conservation of Lake Biwa environments, to mitigate flood and coastal erosion, and to facilitate downstream municipalities and industries the use of an additional 40 m^3/s of water (Fig. 6).

Outline of LBCDP

The basic objective of this project was to promote development of the Keihanshin region by providing additional water amounting to 40 m^3/s, to compensate the Shiga residents for the possible adverse impacts of the lowered water level (assumed to reach as low as -1.5 m below the current normal level), and to improve simultaneously the socio-economic status of the Lake Biwa watershed communities. However, such a large-

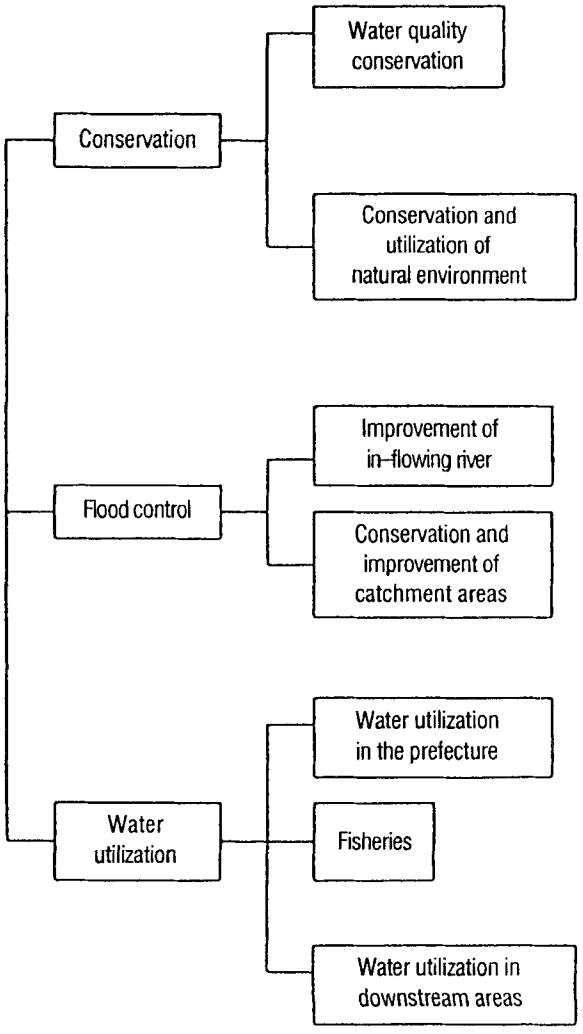

Fig. 6. Basic framework of the LBCDP.

scale development project would have not only regional implications but also national ones. In particular, there would be a need for a cost-sharing scheme involving national as well as downstream local governments so that the heavy financial burden on the upstream local governments could be lightened.

With such considerations in mind, the 'Special Measures Act for Lake Biwa Comprehensive Development' was enacted in June 1972 (Table 2). As stated in Article 3 of the Special Law, the LBCDP was drafted by the Governor of Shiga Prefecture and was approved by the Prime Minister. The particulars of this project were set in accordance with the basic policy that emphasized the importance of the preservation and development of Lake Biwa and its catchment area.

The Project also provides for administration of facilities to be constructed within each project, management of Lake Biwa and its shorelines, and operation of the Setagawa Weir. The project plan, which determines the outline of component projects, sets forth the purpose, volume and particulars of each of the 21 projects for local area improvements. These are to be carried out mainly by municipalities in Shiga, Osaka and Hyogo prefectures and by the prefectural governments themselves pursuant to three major guidelines of the basic policy. The water resources development projects and the Lake Biwa flood control projects are to be conducted mainly by the Water Resources Development Public Corporation.

Extension of the terms of the Special Measures Act and revision of the Project plan

This act, enacted 1972, had a limited validity period of 10 years and was to be terminated in March 1982.

Table 2. Basic structure of the Special Measures Act for the LBCDP

Article	Description
1	Purpose of this law
2	Particulars of development and conservation projects
3	Procedures to be used for decisions and revision of the plan
4	Preparation of a yearly plan for individual projects
5	Responsible agencies
6	Co-operation among the concerned bodies
7	Measures for restoring the living conditions of local people
8,9,10	Involvement of the national government
11	Proposed scheme for cost sharing
12	Establishment of the Lake Biwa Administrative Fund

However, due to the rapid change in social and economic conditions of the nation during the ten year period, the Lake Biwa environment and the situation surrounding the LBCDP also changed, resulting in the emergence of various problems not adequately taken into consideration at the time of enactment.

In particular, because of the decreased growth of the Japanese economy since the first oil crisis in 1974 (Fig. 5), public investment was severely curtailed, and the LBCDP had achieved only 40% of the goals stated in the Project plan by the end of March 1982. In addition, the trend in the demand for water, which decreased soon after the oil crisis in 1973, had cast some doubt on the validity of the very basis of the project scheme (Fig. 7).

Furthermore, the water quality of Lake Biwa deteriorated more rapidly than earlier anticipated, necessitating the implementation of remedial measures by revision of the original component projects. The major incidents of significance during this period may be listed chronologically.

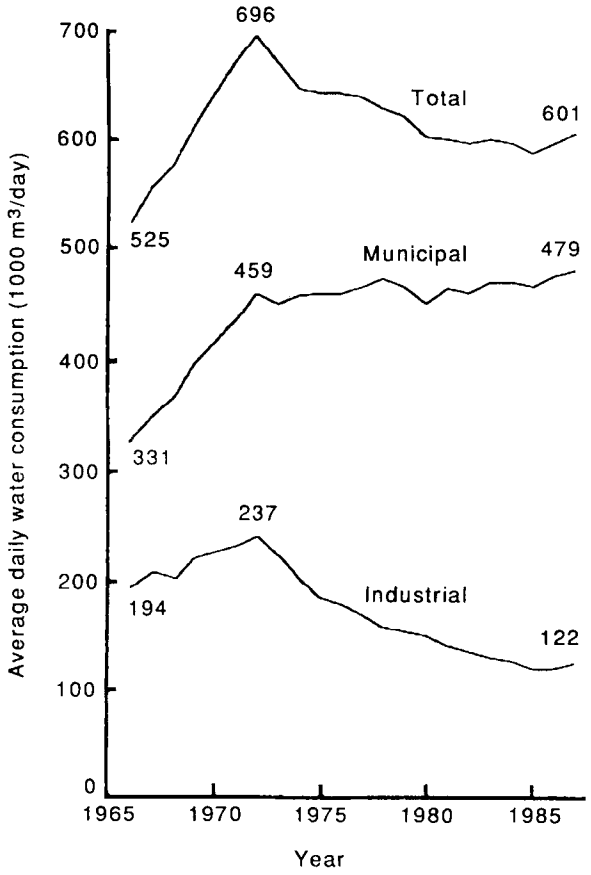

Fig. 7. Water consumption trends in the lower reaches of the Yodo River. Source: Shimazu 1989.

1973 The sudden increase in international petroleum prices (the first oil crisis) and its severe impacts on the Japanese economy.

1976 The environmental impact study conducted on the construction of an artificial island in the southern end of Lake Biwa as a wastewater treatment plant.

Litigation against the implementation of LBCDP submitted to Otsu District Court House.

1977 The first sighting of a freshwater 'red tide' (confirmed annually since).

1979 The Eutrophication Control Ordinance enacted for the first time in Japan by Shiga Prefecture.

1981 Taste and odour problems associated with Lake Biwa water became highly noticeable.

The Shiga Prefectural Government thus consulted with concerned national government agencies for an

Table 3. Component projects in LBCDP and costs

Projects Component	Planned Cost (1971 price)	1972–81 Cost (price of year)	1982–91 Cost (1981 price)	1972–92 Cost (unadjusted sum)
A. Conservation				
A–1. Water quality				
Sewerage system	59000	99633	257940	357573
Nightsoil system	2938	9268	4262	13530
Stockbreeding waste management	—	—	2163	2163
Rural sewerage	—	—	20000	20000
Refuse disposal	—	—	16423	16423
Lake surveillance system	—	—	841	841
A–2. Conservation				
City parks	2775	686	7400	8086
Natural parks	4832	505	1621	2126
Acquisition of conservation areas	3650	566	1632	2198
Roads	62863	60575	111331	171906
Ports and harbors	7193	35	4321	4356
A–3. Conservation total	143251	171268	427934	599202
B. Flood control				
B–1. River-related				
Rivers	47330	46649	68975	115624
Dams	20200	10424	71090	81514
Erosion control	22509	15793	35347	51140
B–2. Catchment-related				
Afforestation	14393	25875	27131	53006
Mountain management	20320	20118	18947	39065
B–3. Flood control total	124752	118859	221490	340349
C. Water utilization				
C–1. In-prefecture use				
Water supply	20446	63650	15379	79029
Indust. water supply	5920	10447	7978	18425
Land improvement	54117	74755	143080	217835
C–2. Fishery				
Fishery	5118	3254	5046	8300
Fishing ports	1033	1455	255	1710
C–3. Water utilization total	86634	153561	171738	325299
D. Downstream use				
Flow control and water management	72000	118305	141695	260000
Grand total	426637	561993	962857	1524850

Costs in ¥ million. Source: Shiga Prefecture.

extension of the validity period of the Act and the revisions of the plan as follows:

(1) To extend the validity period of the special act for an additional ten years to allow for the completion of the initially planned projects.

(2) To revise the Project by adding projects dedicated specifically to water quality management.

(3) To maintain the current special financing measures for project implementation.

At the national assembly in December 1981, the requests by the Shiga Prefectural Government as stated above were approved almost wholly, and the 'Partially Revised Special Measures Act for Lake Biwa Comprehensive Development' was enacted, promulgated and put into force in March 1982. Four additional categories of projects were added to the original 18 categories. They included construction of agricultural dairy waste management facilities, rural community wastewater treatment systems, solid waste management systems, and water quality surveillance and monitoring systems. The total expenditure swelled from the original ¥426.637 billion to ¥1524.85 billion. Table 3 provides details of the costs of component projects.

In addition, there arose a need for renewed efforts for co-ordination between upstream and downstream local governments, and a consensus reached in May 1982 stipulated the following basic agreements.

(1) To establish a forum of joint study by the concerned local governments on the management of water quality of Lake Biwa–Yodo River Basin.

(2) The joint financial obligation of the downstream governments was determined as ¥36.0 billion.

(3) To extend the pay-back period for the ¥5.0 billion left over from the previous years for an additional 10 years.

(4) The actual release of the additional flow of lake water, amounting to 40 m^3/s, would begin only after the compensatory works have been completed.

The emerging issues

The terminal year of LBCDP as specified within the special act was 1992, and the component projects were then at various stages of completion. Table 4 indicates completion rates in 1988, as an example. Those projects concerned with increasing the flow through the Seta Weir down through the Seta, Uji and Yodo Rivers were reasonably close to being completed in time. The progress of compensatory public works projects for infrastructure development, however, had been less than satisfactory. A great deal of effort is needed for implementation of the remaining portion of the projects, and for instituting transitional measures such as extending further the project period. Shiga Prefectural Government, the downstream governments and the national government are reported to have agreed to extend the term of LBCDP till the end of 1996, in order to complete remaining projects.

In the meantime, the court case on the 1976 litigation concluded, allowing LBCDP to continue as planned, and water demand began to increase again, particularly domestic consumption, due in part to the changing lifestyle of the people. The Shiga Prefectural Government will take transitional measures to release,

Table 4. Project completion rates of LBCDP in 1988

Name of project	Completion rates (%)
Conservation	
Sewerage system	64.1
Nightsoil treatment facilities	87.7
Stockbreeding environmental improvement facilities	78.3
Rural sewerage system	61.6
Refusal disposal facilities	36.5
Water quality monitoring facilities	40.1
City parks	29.5
Natural parks	40.9
Public ownership natural conservation	52.2
Roads	70.7
Ports and harbors	19.0
Total (for conservation)	65.0
Flood control	
Rivers	64.2
Dams	30.7
Sabo works	62.8
Afforestation and forestry paths	75.4
Mountain management	98.0
Total (for flood control)	62.8
Water utilization	
Water works	93.4
Industrial water works	80.0
Land improvement for agriculture	70.8
Fisheries	89.1
Fishing ports	96.2
Total (for water utilization)	77.8
Lake Biwa flood control and water resources development	91.8
Grand total	71.9

From Imai *et al.* (1989).

steadily, 27 m^3/s of lake water down through the Seta River and hence to the Yodo River. Thus, the original and the most important aspiration of LBCDP, that is, the management of lake water for flood and erosion control and for flow augmentation to satisfy downstream demands, is about to be realized.

As the facility construction phase of LBCDP comes to an end, there emerged new issues of importance such as: (i) the proper operation and maintenance of facilities constructed in connection with the Project; (ii) management of the lakeshore fronts uncovered due to lowered water levels (up to 1.5 m); (iii) the establishment of new operational rules for the Seta Weir; and (iv) the acquisition of necessary funds for various undertakings of a managerial nature hitherto not accounted for in project funds.

The conservation of the Lake Biwa environment at the completion of LBCDP would not be adequate with only those provisions stated above. The management of the aquatic environment of Lake Biwa has entered a new era. Concern for the conservation of water quality has become more serious today than in the earlier days of LBCDP. There is an emerging realization that there would be a need for a more comprehensive concept of management of Lake Biwa and Yodo River system, particularly for countering the deterioration of water quality of the lake at a rate which seems to be much greater than before. Concentrations of total nitrogen and phosphorus in the lake, as measures of water quality trends, are indicated in Fig. 8.

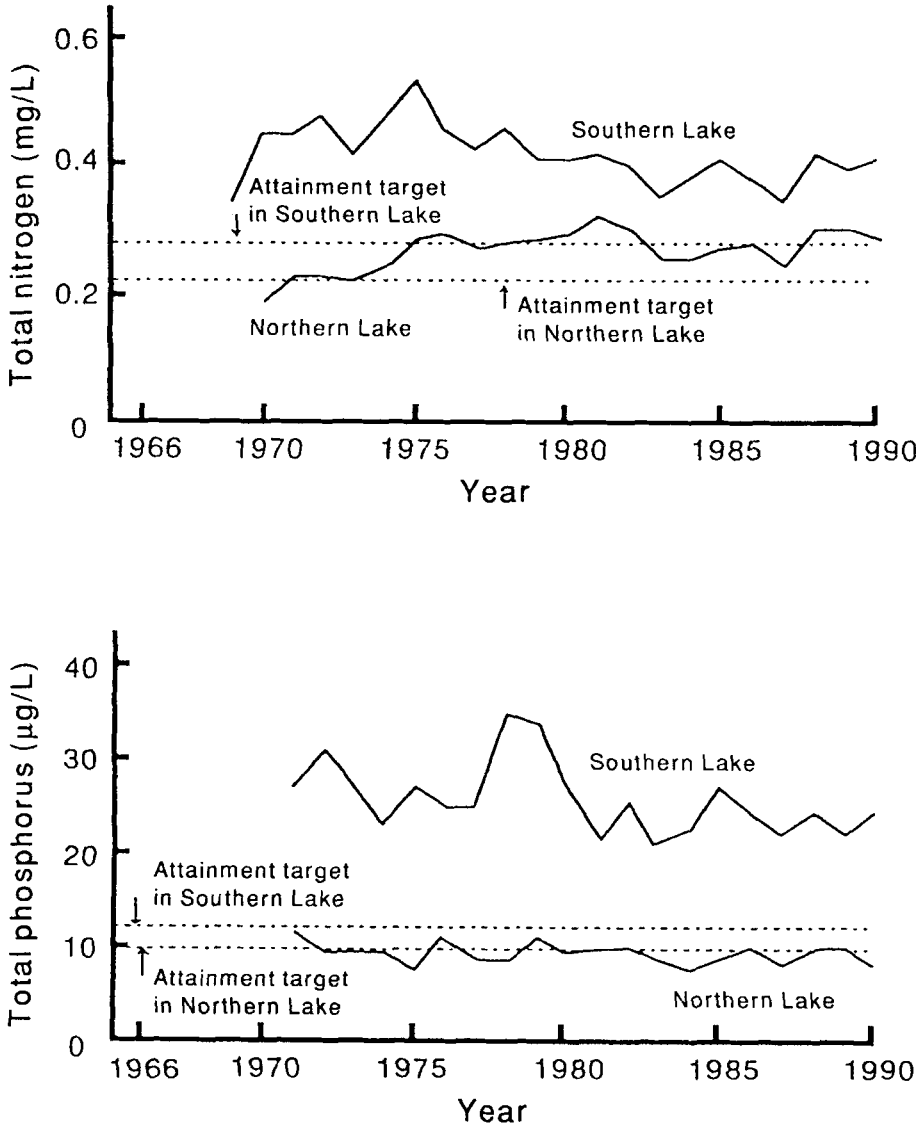

Fig. 8. Water quality trends in Lake Biwa, as indicated by concentrations of total nitrogen and phosphorus. Data are mean annual values for 48 stations. Source: Anon. 1991b.

Implication of LBCDP

One can make many observations on the implications of this large development project, keeping in mind that the approach taken to realize this project and many of the issues raised in the process of implementation will have significant bearings on the conceptualization of similar developmental projects undertaken in other (particularly developing) countries in future.

Historical timing of conceptualization and implementation of the Project

LBCDP was conceptualized at a time when Japan was undergoing considerable economic growth. There was significant development pressure and momentum building up in the nation for greater access to water resources, and at the same time the mobilization of financial resources for such a massive project appeared feasible. Given the pressing needs for water resources by the downstream population and industrial centers then, the issue at that time was when to launch the project and how could politically satisfying arrangements be arranged between upstream, downstream and national interests.

It would probably not have been possible to realize this project in Japan at any other time than in the early 1970s and in any other form than the current form, balancing downstream interest in water resources with upstream interest in regional development, and balancing resource development with environmental conservation.

The implication is that the present generation will enjoy the satisfaction of having accomplished the project, but at the same time it will have to bear the responsibility for the consequences of the decision, be they newly generated economic benefits, costs for restoring disturbed ecological integrity, or any other consequences not properly accounted for at present.

Long duration of the project implementation

A complex development project such as LBCDP often takes decades to complete. As the social and economic situations change over the project duration, sometimes drastically, the nature of the project will have to be modified with additional costs of adjustments. In the case of LBCDP, they were incrementally reassessed and readjusted, while maintaining the basic framework of the development project. The societal needs for water have changed, the environment and the ecology of the lake have changed, and the level of awareness of the public of the value of the lake has also changed. Facilitation had to be made, more for some and less for others, to accommodate these changes.

The implication is that projects with long implementation duration will require timely re-evaluation and necessary modification, and the facilitation of such modifications will require substantial additional financial commitments. Sometimes such re-evaluation may call for fundamental change in the original concept of the plan.

The concept of basin-wide water management

One of the subjects attracting growing interest among water management specialists is an approach called 'basin-wide water management'. In the case of Lake Biwa, it would be the management of the whole of the Lake Biwa–Yodo River Basin as a single unit. How does LBCDP fare in this respect?

Simply stated, the upstream and downstream jurisdictional entities in the Lake Biwa–Yodo River Basin have conflicting interests in the management of water quantity on the one hand, and non-conflicting interests in the management of water quality on the other. As for water quantity, the conflicts are softened through monetary transactions for undertaking compensatory public works, the very basis of LBCDP. For water quality, the conflicts do not exist in the sense that everyone wants lake water quality improved, and it costs money to do so. The problem is that we do not know how much it will cost and who will have to bear this cost. Parts of the expenditures on water quality improvement are defrayed through the natural and environmental conservation component of LBCDP. Although the original expectation was that the amount of investment under this category would be sufficient for realizing significant improvement in Lake Biwa water quality, it has not yet proven so.

In addition to the environmental conservation component of LBCDP, the prefectural government of Shiga has always wanted governments downstream to join in creating water quality conservation funds specifically aimed at accelerating the improvement of water quality of Lake Biwa through such activities as controlling nutrient run-off into the lake. Let us consider this issue given discussion of similar issues elsewhere.

If we confine the scope of water quality improvement just to water supply, the justification for the need for such conservation funds may prove difficult. Downstream communities may be able to get clean water by resorting to improved treatment technology for much less than what they may have to contribute to funds to improve the lake water quality itself. If, on the other

hand, the lake has been sustaining growing development pressure of all kinds coming from downstream communities as well as the entire nation, and a broad spectrum of intangible benefits has to be passed on to the entire population in the basin over many generations to follow, then it would not be unreasonable to ask downstream governments to bear the burden of enhanced clean-up efforts upstream.

How convincing such an argument would be depends not only on the willingness of the population to pay for such long-term objectives, having full understanding of the value of protecting the lake, but also on its capability to pay.

The implication is that the emerging structure of the basin-wide water resource management would be dictated by the capability of the people and governments to adjust to emerging factors in water quantity and quality, many unknown at the time of project inception.

Assessment of benefits and costs of the Project accruing to future generations

Since LBCDP is such a massive project and has trans-generational implications, the full benefits and costs accruing to future generations in the Lake Biwa Basin have yet to be assessed. It is not known if society would mature enough to accept the concept of environmental and water resource sustainability to the extent of making further efforts to reduce water consumption and waste production activities on land, or if it would simply let supply dictate the demand for more water and production of more wastes.

Would future generations hail this generation for having implemented the plan? Would they lament the disturbed ecological integrity of the Lake Biwa environment? Would they say that they would have done the same to develop Lake Biwa, or would they say that they would have done otherwise?

The implication is that the lake, watershed, socio-economy of the region and the whole environment surrounding the lake should be carefully monitored to enable future generations not only to assess the Project in retrospect, but also to take whatever measures they deem appropriate and necessary then to develop and conserve Lake Biwa and its environment.

PART II EVOLVING ISSUES IN LAKE BIWA WATER QUALITY MANAGEMENT

Framework of Analysis

Few lakes in the world possess the intricate history of human–nature interaction, which characterizes that of Lake Biwa, the largest and, in virtually all possible aspects, the most important lake in Japan. To understand the lake, its limnology, ecology and environment, socio-economic implications, resource values and all other features, one would almost have to live at the lake and sense the weight of its history. Lake Biwa today reflects humanity's unique interaction with the lake over centuries, and it also reflects, of course, what it will bequeath to future generations.

Important subjects requiring analysis for a thorough understanding of evolving issues in Lake Biwa water quality management include:

(1) National, regional and local legislation, which provide the basis for economic development, land use and land development, and water quantity and quality management.

(2) Legal framework for land-use control and its relationship with the development of major water pollution control programmes.

(3) Water use trends and the development of locally appropriate water management systems, particularly for the agricultural use of water and run-off control.

(4) Major water quality conservation measures for the control of domestic, industrial and agricultural pollution loads.

(5) Development of eutrophication control ordinances, particularly with respect to initial driving movements, legal, social and policy implications, impacts generated both in terms of actual control of eutrophication and socio-political significance.

(6) Intricate mechanisms of interaction between local government agencies and prefectural residents in dealing with lake water pollution incidents.

(7) LBCDP development process, contents, progress, and its implications and impacts.

The development of interactions between these subjects is the most important feature about Lake Biwa. It may be summarized as follows:

(1) Lake Biwa is the largest Japanese lake both in area and volume and has been the single most important water source in the western part of Japan throughout modern history.

(2) For its irreplaceable tangible, as well as intangible, natural resource values, the prefectural residents have historically shown extreme attachment, to an extent perhaps unparalleled in any other lake in Japan.

(3) It has only been a century or so since construction of major control facilities for water resource development and flood control have been undertaken, and it has only been a little more than a few decades since

the prefectural government began to engage in serious and systematic pollution control activities.

(4) The history of the development and conservation of the lake catchment area reflects extremely intricate policy decisions, sometimes resulting from severe conflicts of interest among various national, regional and local entities at various levels of the decision hierarchy.

(5) There emerge, therefore, many complex structures of interaction among major decision-making bodies, such as governments, industries, citizens, and others, both with respect to development and conservation policies involving the lake and the catchment.

Legislative basis for development and conservation

Regional development

Japan is a nation with a highly hierarchical decision-making structure and the central government sets the basic policy direction in most issues of general national concern. Setting national and regional development policy, of course, falls within this category of hierarchical decision-making. Legislative measures concerning regional development are many; they are classified according to their designated objectives (Fig. 9). The seven classes of legislation are: general, development-block, special region, land-related, individual project, long-term planning, and other types of legislation.

Development plans for regions and prefectures will have to be prepared closely in response to the framework established within long-term national development plans. The National Land-use Planning Law of 1974, which sets the basic framework for the planning of national lands, includes, for example, stipulations on prevention of uncontrolled development and speculative activities. The national land-use plan in Shiga Prefecture was prepared in 1977 pursuant to the framework established in this law. The revised prefectural plan was prepared in 1986 also in accordance with the Revised National Land-use Planning Law of 1985.

The national government also took very strong initiatives in the development of the overall plan of national reconstruction and economic development throughout the post-war period. The regional development plan of the Kinki Region, which encompasses Shiga Prefecture and five other downstream prefectures including the Keihanshin Industrial Zone, has been developed and implemented according to the overall framework established in the national plans such as the National Comprehensive Development Plan of 1962 and the New National Comprehensive Develop-

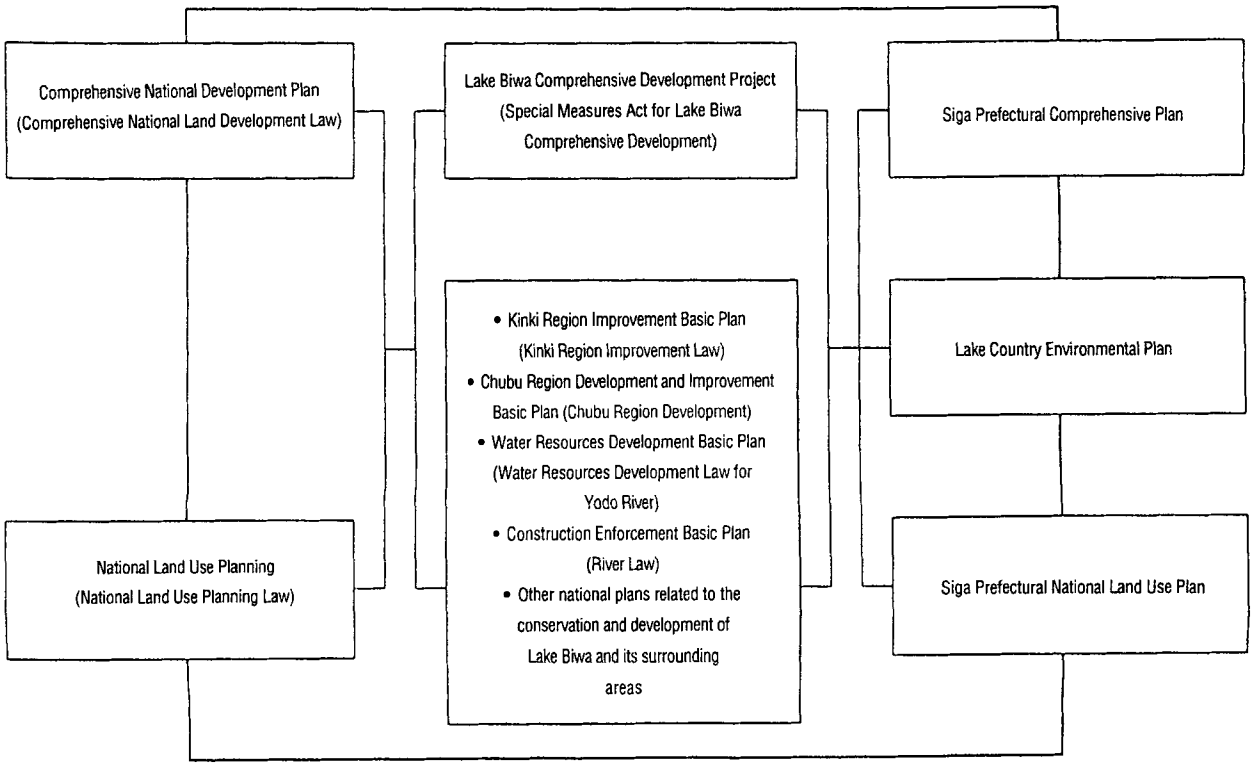

Fig. 9. LBCDP and regional development plans. From Imai *et al.* (1989).

ment Plan of 1969. The intense industrialization and urbanization through the 1960s and the major part of the 1970s in downstream prefectures, together with Shiga's own comprehensive development plans of 1963 and 1967, had great impacts on the profile of the Lake Biwa catchment area. The quality of lake water began to show signs of deterioration about this period for the first time in the long history of the lake.

Water management and water allocation

Water legislation may be categorized into those dealing with river management, forests, sea-shores, land-slide and flood control, water resources and utilization, and water quality conservation. Among these categories, those concerned with water quality conservation are dealt with below in order to highlight their slightly different orientation from the others. The remaining two categories of water legislation exhibit, as in the case of legislation concerning regional development, a very strong degree of centralization of management authority. Rivers of any significant size are under total control of the Ministry of Construction. Hydroelectric power generation is the responsibility of the Water Resources Development Agency, a semi-governmental body closely affiliated with the Ministry of Construction. And water supply is the responsibility of the Ministry of Health and Welfare. All except a few were enacted prior to 1965; they have not been revised to any significant extent since. In effect, it is reasonable to state that water is a national rather than local matter in Japan.

The legislation specially enacted for facilitating the development of Lake Biwa, the Special Measures Act on Comprehensive Development of Lake Biwa, may be regarded as one such water legislation. The act stipulates the undertaking of a number of facility construction and development projects concerning the conservation of the lake and its catchment area, together with an agreed formula to mobilize financial resources. These projects are to be undertaken as compensation for lowering the lake water level by a maximum of 1.5 m below the officially recognized water level. The additional water withdrawn from the lake through the Seta River is for use by downstream metropolises and industrial complexes. The special measures act, however, is not exclusive in that it is to be applied with other relevant legislation, particularly for regional and prefectural development plans, already in existence.

Water quality conservation

The hierarchical structure of government activities also dictates the way in which other issues of national concern including environmental conservation are dealt with. The national government, for example, has taken initiatives in providing the broad framework on pollution control by enacting required legislation on the protection of water, air and other environmental resources. Of a series of laws concerning the environment, the ones of greatest importance are the Basic Laws of Pollution Control (1967, revised in 1970) and the Water Pollution Control Law (1970). Together these laws marked the beginning of the era of environmental conservation after decades of near total disregard of environmental conservation in the name of post-war reconstruction and extensive national growth by means of industrialization. Many local laws on environmental conservation were enacted following these two key laws. The Revised Shiga Prefecture Anti-Pollution Ordinance of 1972, for example, has its basis in the Revised National Basic Law of Pollution Control of 1970.

Note, however, that there has been a significant number of cases involving environmental issues where local governments took an initiative in establishing the basic framework of legislative action. The first step in post-war anti-pollution legislation was not a national legislation but the ordinance on the control of industrial pollution enacted by the Tokyo Metropolitan Government. The Eutrophication Control Ordinance of Shiga Prefectural Government, enacted in 1979, was also one of the most outstanding examples of this kind. The ordinance was designed specifically to combat eutrophication of Lake Biwa and it stipulated regulations on the control of phosphate-containing synthetic detergents and the control of discharge of industrial effluents containing nitrogen and phosphorus.

Facilitating the development pressure: Altered land and water uses

Before commenting on the development and conservation dynamics to be discussed below, it would be appropriate to review the relationship between the impetus of economic development and the resultant changes in water quality, as well as the process of fulfillment of water quality and quantity requirements for development activities. The discussion will centre around two basic issues: land and water uses.

Land use

As indicated, the basic framework for the use of national land is dictated by the National Land Use Planning Law of 1974 (Fig. 10). To overcome the shortcoming of land use planning practices prior to the enactment of this law, the law stipulates the need for determining overall land-use schemes, superseding, if necessary, any existing plans established within the framework of sectoral legislation. In effect, the law empowered the governor of a prefectural government to set five land-use areas, that is urban, agricultural, forest, natural park and natural reserve areas. The closer determination of land-use categories will take place as needed based on established procedure.

As for the Lake Biwa catchment area, a major part of the flat lands surrounding the lake has for many years been dedicated to rice growing crop lands. The land-use patterns first began to undergo noticeable change in the 1940s. Filling of lagoons around Lake Biwa took place just before the Second World War and immediately afterwards, primarily for the purpose of increasing rice production, though they were never really made use of for that purpose. Filling parts of the south basin of the lake itself took place in the 1960s, basically for converting wet lands into arable and/or habitable lands. What appears to be gross mismanagement of land began at about this time, principally due to the introduction of a new set of transportation routes enabling the south-eastern part of the lake to be included in the marketing networks of the Keihanshin industrial region. The outcome of this change was haphazard exploitation of the then prevailing agricultural farm lands. Many projects, which involved the conversion of farm land into industrial estates and residential establishments, took place in a rather piecemeal fashion during the periods of intensive industrialization and urbanization between the early 1960s to mid-1970s.

The urbanization of the Lake Biwa catchment area, particularly in the south-eastern portion under the strong influence from the Keihanshin economic zone, testifies to the unique land-use problems of the region. The area stretching northwards had long been covered by extensive paddy fields until an almost sudden influx of industrial activities and associated population migration brought about change in the late 1960s (Fig. 11). However the urbanization occurred in a piecemeal fashion because of the reluctance of land

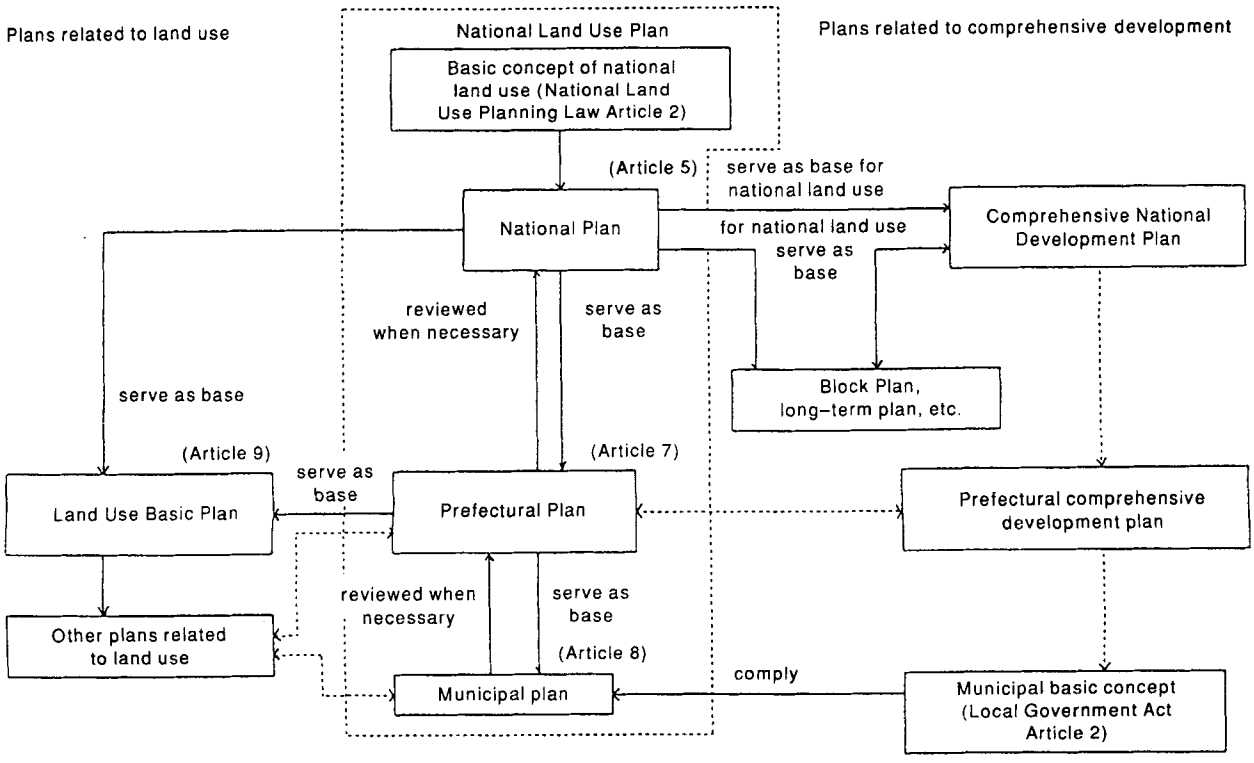

Fig. 10. Relationships among land use and development plans. From Imai *et al.* (1989).

owners to succumb to developmental pressure all at once and the ad hoc siting of industries and housing estates due to topographical variability of the paddy fields. In addition, the traditional agricultural lifestyle of the region had to be altered to adjust to this industrial and urban invasion. In effect, the changes involved four events. First, the region, which for centuries had been dedicated to paddy field agricultural lifestyles, had to be changed to accommodate for the demand for an industrial labour force. Second, multiple crop production became less and less popular because of unstable markets for non-rice crops. This resulted in the gradual polarization of farmers; some would grow only rice crops, but others would totally give up farming. Third, the exclusion of lowlands from zoned priority urban development districts resulted in haphazard delineation, spurring further piecemeal urbanization. And fourth, land value appreciation was phenomenal and could no longer sustain intact land use for farming alone.

The combined effect of these changes in the context of the internal agricultural structure was the uniquely Japanese urbanization of land which had once been dedicated to paddy-field cultivation. The impacts of urbanization are many, but some typical problems, aside from those of water quality mentioned in sections to follow, include: (i) rainwater drainage at newly converted industrial and housing development sites (previously absorbed by paddy fields); (ii) groundwater inflow and infiltration problems in lowlands; and (iii) facilitation and accommodation for previously urbanized areas, with appropriate legislative provisions so as to achieve reasonably consistent land use.

The description of land use within the Lake Biwa catchment area would not be complete without discussion of forestry management. The present forest area covers a little more than half of the entire prefectural land. In the past, typical problems associated with forest management included deforestation. For example, the Tanakami mountain range in the southern region of the basin has long been extensively cleared by timber logging operations used for constructing temples and shrines in Nara and Kyoto centuries ago. More recently, growing population pressure and the demand for firewood has resulted in the exhaustion of deciduous forests, particularly during the period when Japan was almost totally isolated from the rest of the world (1639–1854). These exploitative activities contributed to the denudation of forests and the resultant severe flooding and siltation problems of many of the Lake Biwa river systems.

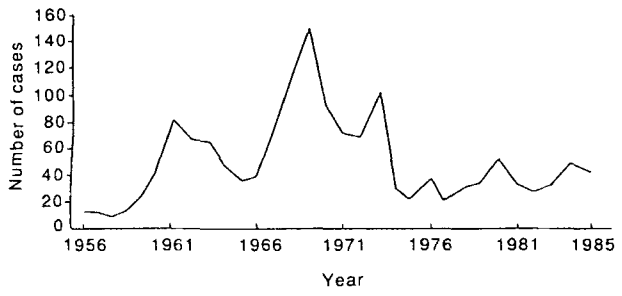

Fig. 11. Trends in industrial siting in Shiga Prefecture. From Imai *et al.* (1989).

In recent decades, the problems associated with the use of forested land have become more subtle. As in the case of agricultural lands (paddy fields and other croplands), the forest edges have slowly but steadily been cleared and graded for various developmental purposes including housing and industrial estate development. In the process, the forest has slowly lost its capability to function as a reservoir of precipitated rain and snowmelt, and contributes also to run-off into nearby streams of nutrients contained in the precipitation. It is claimed that the amount of nutrients discharged from forested land today amounts to almost as much as that discharged from agricultural fields. The major difference between agricultural and forest run-off is that, in the former the nutrients originate from fertilizers, but in the latter mostly from rainwater and soil and are difficult to control without properly maintaining forests.

Upon introduction of the National Land Use Planning Law, the prefectural government was given the opportunity to correct the situation and realign fragmented land parcels dedicated to many different uses. But the lands once allocated for different uses have been difficult to convert back to uses consistent with the desired planning framework. The development of land-use schemes consistent with existing land uses and appropriate future development goals of the prefectural government will continue to be a challenge for the prefecture.

Water use

One of the most outstanding modern features of Lake Biwa water use and allocation is that the agricultural sector has the biggest share (amounting to 93% of the total) of the water withdrawn from the lake, despite the fact that the prefecture has undergone significant industrialization and urbanization in recent decades. Throughout history also, the agricultural sector has

had the oldest and most complex water-use practices and well-established customary rules of withdrawal. Industrial and municipal demands, which began to increase in the 1960s, had to compete against agricultural demand. The resulting impacts were twofold: (i) the establishment of a new rule to supersede the current destabilized and ad hoc water use and allocation rules; and (ii) the need for serious efforts to control of point as well as non-point pollution. It became clear also that there was a need to balance water uses where they competed for scarce water supplies. The variety of sources serving to supply Shiga communities is indicated in Fig. 12.

Agricultural water use. Agricultural waters have been obtained throughout history in one of three ways. At or near the foothills, particularly on the eastern side of the lake where there is a large number of irrigation ponds. The ponds were the only source of water for centuries in the high altitude fields or fields distant from the lake. They are still used today, but in combination with other means of water supply and basically for auxiliary purposes. Irrigation in the flatlands, however, depends on either or both groundwater pumping and water withdrawal from the lake, the latter being particularly prevalent in the delta regions of major river systems. Irrigation from the lake has evolved over centuries of agricultural practice. For a long time before electricity became available, creek water was pumped or scooped by manual labor. In the Meiji era (1868–1912), lowered lake water levels necessitated direct withdrawal by electric pumps.

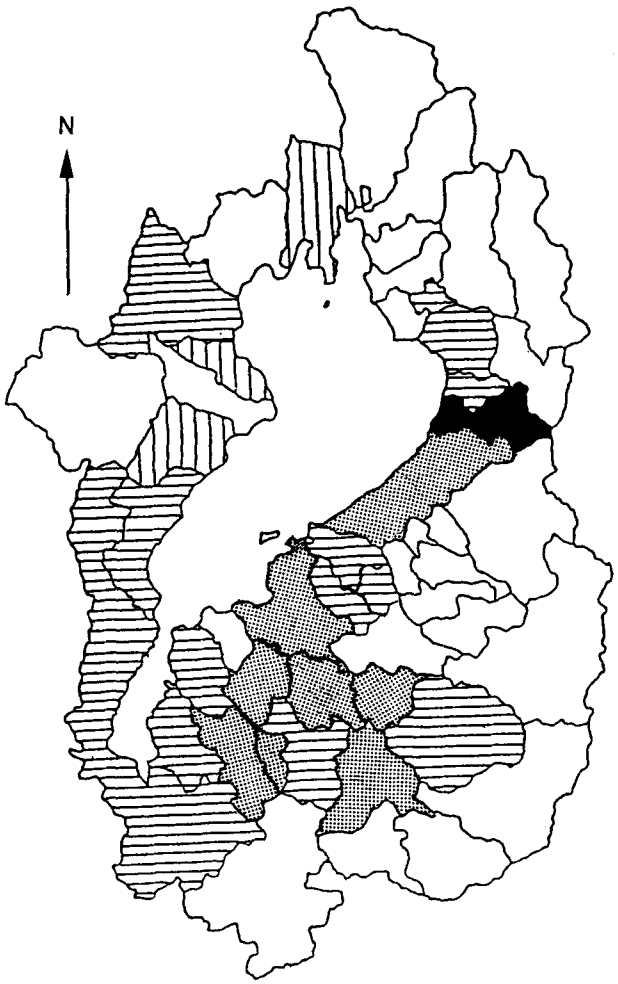

Fig. 12. Sources of water supplies serving communities in Shiga: (▤) all or more than $^2/_3$ from lake water; (▣) lake water and underground water; (▥) lake water and surface water; (□) all or more than $^2/_3$ from underground water; (■) underground water and surface water. Source: Shiga Prefecture.

As agricultural water demand increased after the Second World War, it became necessary to ease severe water allocation conflicts between upstream and downstream communities in the lake catchment area. Many dams of significant scale were constructed along rivers. At the same time, the use of lake water for irrigation became possible even in regions distant from the lake as extensive irrigation network systems were constructed. In effect, the network created flows in the reverse direction. As a result, areas previously irrigated by groundwater began to shrink. The combined effect of the expansion of lake water irrigation areas upstream and of river water irrigation areas downstream was significant lake water pollution, and this phased out previous repetitive water use through dendritic or cascade channels.

Industrial water use. As for industrial waters, water use has been very much dependent on industrial types and sizes. The early days of industrialization in Shiga were very much dictated by textile industries, particularly of synthetic silk-thread, rayon. Today, major industrial categories in the prefecture are assembly industries such as electronics and light machinery which require water in only limited quantities. The amount of water used by all categories of industry is 1.36×10^6 m^3 per day, of which the manufacture of textiles, chemicals (pharmaceuticals), plastics, pottery, electro-machinery and vehicular machinery are the major consumers. With respect to water-use pattern by industrial size, those with employees numbering between 100 and 300 use the greatest amounts of water. Many of these industries do not have the financial resources to invest in water recycling, particularly because they are not large enough to enjoy economies of scale. They are also the most likely sources of point-source pollution, so that the effective control

of waste discharges from these industries will become the key to achieving significant reduction in water pollution. There is a very important linkage between agricultural water and industrial uses in that the implementation of large-scale irrigation systems has greatly increased the opportunity for groundwater contamination, resulting in serious damage to the operations of textile industries requiring uncontaminated groundwater. On the other hand, groundwater users have been avoiding direct confrontation with surface water users who pollute groundwater by continuing to extend well depths to deeper and cleaner aquifers.

Domestic water use. The supply of drinking water has its own history. Prior to the introduction of piped supplies, a major portion of drinking water was extracted from nearby streams and wells. Today, approximately 60% of water supplied by domestic water supply systems originates from Lake Biwa. The single most important factor affecting the increase in domestic water supply in recent times has been the population migration from Keihanshin region into the prefectural jurisdiction. The provision of water to these new migrants was a precondition for housing development activities, an unavoidable consequence of industrialization and urbanization of the prefecture. Today there are six municipalities, twenty-six townships, one water-utility agency, and one association engaged in the provision of water supplies, and 97.5% of prefectural residents are supplied with piped water.

As the population continued to increase, it became more and more difficult to develop dependable water-supply systems and to find suitable water sources. This resulted in the regionalization of water-supply systems. Currently, there are two regional water-supply systems both of which withdraw water from Lake Biwa (except that one draws water in part from a dam located upstream of Yasu River).

Traditional water usage in lake-front communities was quite efficient in that there were self-regulatory efforts preventing the direct discharge of used water to streams flowing into the lake; waters were held for a period in a small holding pit prior to discharge to the receiving stream. In addition, the amount of used water generated by households was much less when there were no water-supply systems, as most washing was done directly at water fronts. When piped water-supply systems were introduced in the agricultural and/or fishery communities, they effectively destroyed the traditional style of water management. Now that a large percentage of the population depends on lake water through piped water supply systems, lake conservation and lake water use have become synonymous to many Shiga residents. This has brought about an interesting situation with respect to Shiga residents and the residents of downstream prefectures in that they now share a common concern and sentiment about the future of lake water quality. This has never been the case before. At the same time, those engaged in agricultural and industrial activities have been placed in the situation where they will have to face the consequences of degraded water quality resulting from their own actions.

Land and water use interactions

Several important observations may be made on land/water interactions, particularly with respect to the deterioration of water quality, both of rivers (streams, paddy-field channels and household ditches) and the lake. Including some events already mentioned briefly, they are:

(1) Agricultural run-off problems due to: (i) conversion of semi-natural intake and drainage channels to large-scale irrigation networks; and (ii) expanded irrigation areas resulting in increases in fertilizer and pesticide run-off.

(2) Impacts from the siting of industry resulting in: (i) discharge of inadequately treated wastewater from small to marginal industries; (ii) discharge or release into the environment of previously unregulated chlorinated hydrocarbon contaminants such as trichloroethylene and tetrachloroethylene; and (iii) high groundwater levels of newly prepared industrial sites causing infiltration problems and making industries vulnerable to inadvertent failures of manufacturing and/or wastewater treatment operations.

(3) Problems created by household wastewater especially: (i) discharge into drainage canals leading to contamination of irrigation waters; (ii) coverage by the regional sewerage system is still confined to limited areas, so that most houses resort to on-site treatment systems for only toilet wastewater, excluding kitchen and bathroom wastewater.

(4) Impacts of forest clearing over decades/centuries; though limited in scale today this has resulted in topographical features clearly responsible for nutrient run-off.

Further information is necessary before a more thorough analysis of land and water use interactions in the Lake Biwa catchment area can be attempted. Some of the major factors already known to have contributed to the intricacy of the interaction are

described above, but there are many others still to be clearly identified. The structure of land and water uses within the catchment area is now subject to more complex sets of dynamic forces than at any other time in history.

Coping with environmental stress: An assortment of conservation efforts

As stated, the Lake Biwa catchment saw significant changes taking place following insurmountable development pressure exerted by the national development policy and which resulted in intensification of development activities downstream of the lake system (Imai *et al.* 1988, 1989). The most obvious outcome was an almost sudden surge of environmental stress on the lake, particularly its southern basin (the Southern Lake). To illustrate this, Fig. 13 indicates the long term decrease in lake transparency and Table 5 documents major events attributed to lake pollution. For centuries, Lake Biwa has had no large aquaculture farms such as fish pens and fish cages and most nutrients accumulated in the lake originated on land and were transported to the lake in rivers and streams. Thus, for an extended period the lake as a whole maintained a fairly stable ecological balance, a consequence of its large self-purification capacity. Being a confined body of water, despite the large water volume, the deterioration of water quality, and hence a disturbed ecological balance, was sudden once pollution load inputs exceeded a threshold. In terms of geological time, it was almost instantaneous. It was not much earlier than the late 1960s that this became a reality. The balance sheet of pollution, therefore, was of prime interest to those concerned. Who is (was) responsible? What actually happened?

Studying the state of the lake

Surprisingly, these questions have still not been answered scientifically and precisely. In terms of organic pollution loads generated on land, the deterior-

Table 5. Calendar of pollution episodes

Year	Pollution
1955–59	Disturbance at the filtration plant was noted for the first time
1960–64	Sudden change in zoobenthos began *Elodea nuttalli* overspread the lake
1965–69	*Corbicula sandai* began to decrease Thick growth of *Elodea nuttalli* attained its peak Musty odor of tap water was noted for the first time, and has been noted intermittently since
1970–74	*Egeria densa* invaded the lake Water quality further deteriorated *Elodea nuttalli* declined and was replaced by *Egeria densa* Some bathing resorts in the Southern Lake closed
1975–79	*Corbicula sandai* nearly died out and was replaced by *Corbicula japonica* *Egeria densa* was dominant in the Southern Lake Freshwater red tide occurred, and continued to be noted every year till 1984 Ordinance Concerning the Prevention of Eutrophication of Lake Biwa was promulgated
1980–84	*Egeria densa* decreased sharply Both *Egeria densa* and *Elodea nuttalli* began to revive Water bloom was noted in a part of the Southern Lake

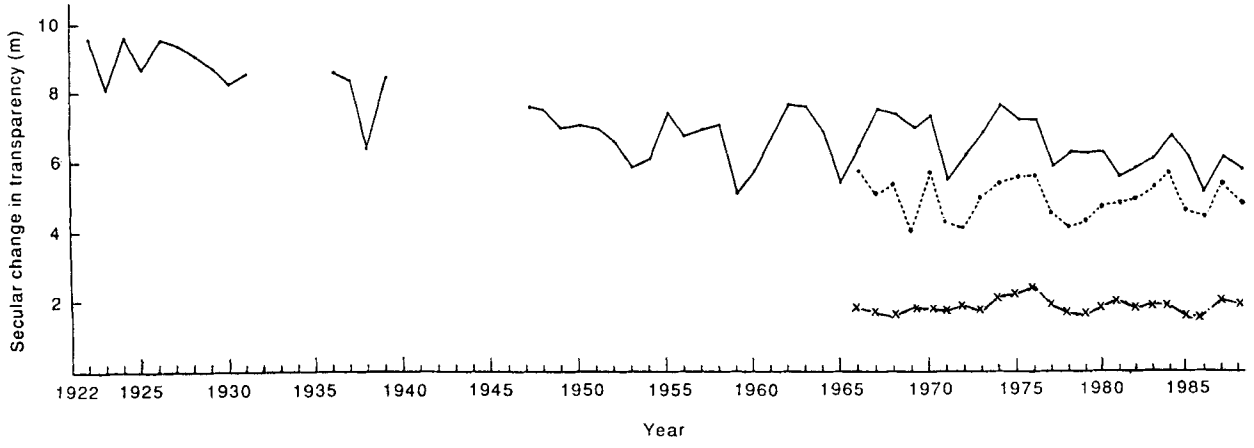

Fig. 13. Secular trends in transparency: (⟵⟶) center of the Northern Lake; (·····) mean over the Northern Lake; (x—·—x) mean over the Southern Lake. Source: Shiga Prefecture.

ating water quality could be attributed approximately equally to domestic, agricultural and natural sources. However, exactly what events trigger physical, biological and chemical interaction of natural and human-made substances to bring about eutrophication is still uncertain.

Furthermore, the dynamics of pollutant generation on land have undergone significant changes over the past decades, making it still more difficult to be scientifically accurate. There is now a greater number of people and industries, resulting in the generation of greater amounts of pollutants. Industrial point sources such as discharges of toxic substances have been controlled, thanks to the introduction of stringent regulations and rather severe enforcement efforts since the 1970s. But discharges from small to marginal industries and from households have been on the increase.

Today, discharges of gray waters from individual households (due to the absence of sewerage systems) are said to be major contributors to lake pollution. There have also been changes in agricultural practices. A great majority of paddy-field farmers today are weekend farmers, resorting to highly mechanized production practices and generous use of fertilizers and pesticides. This was not the case 30 years ago. Then, individual paddy fields had semi-natural channels connecting individual fields in which a significant degree of trapping of outflowing nutrients took place. But after the institution of the paddy field land reform project, highly streamlined inflow and outflow control channels were constructed and are thought to be in part responsible for nutrient run-off in larger quantities than before.

Today there are concerted efforts to study and monitor the state of the lake and the process of eutrophication. Lake Biwa Research Institute, a research institute dedicated to basic and applied multi-disciplinary research on Lake Biwa, was established in 1981. It is unique in Japan and is also regarded as unique internationally. Routine monitoring of the state of the lake is conducted by another centre also under the management of the prefectural government. The center conducts water quality monitoring for 25 major rivers and takes regular samples of lake water from 47 sampling points located in the lake. Automatic monitoring is conducted also at six sampling stations in the lake and four river stations.

In all, an assortment of conservation measures had to be introduced to cope with the rapidly deteriorating environment subjected to extreme development pressure on a large portion of the catchment area. A brief outline of these pollution control measures is presented below for domestic, industrial and agricultural wastewater, together with a discussion on water quality monitoring and the Eutrophication Control Ordinance.

Management of wastewaters

Of the three categories of wastewater most easily recognizable, domestic wastewater has attracted greatest publicity in the recent past because Shiga residents realized that the planned construction of sewerage systems around the lake will take considerable time and by the time they are complete the lake may already have been irreversibly eutrophied. According to the latest statistics, only some 30% of the population have been connected to public sewerage systems.

There are four regional wastewater collection and treatment systems (Fig. 14). Two are partially completed and in use. They will eventually collect a major portion of domestic wastewater and some non-toxic industrial wastewater. The remaining population must be served by one of several wastewater management systems, including nightsoil collection and treatment systems and on-site household treatment systems of various kinds. For example, the city of Otsu has its own sewerage system, but its service area is confined to the western side of the lake. The rest of the population is served by one of two regional systems partially in operation, but with areas in the outskirts of the city which the regional systems will not service in the near future. Households in these areas resort to on-site treatment units. Most household systems marketed in the past treat only toilet wastewater, and gray water, that is, kitchen and bathroom wastes, are discharged into ditches, streams and eventually reach the lake through river systems.

Industrial wastewaters are generally regarded as having been brought under tight control, particularly after the institution of the Water Pollution Control Law. There has not been serious violation of the law as in the past, due to stringent enforcement, awareness of the public media, reports by citizens of any sort of spill incidents, and the realization by industry that illegal discharge of pollutants involves high penalties. Discharge of substances potentially harmful to the environment and public health is regulated by the Water Pollution Control Law; discharge of nutrients that cause lake eutrophication is controlled by the Eutrophication Control Ordinance and the Clean Lake Act.

Aside from the established effluent standards under these legislation, there are permit systems for indus-

trial operations. Industries engaged in activities with the potential for inadvertent discharge of toxic materials are subject to a permit system. Similarly, those industries or premises discharging wastewater in quantity are also subject to a permit system, together with annual surveillance and imposed self-monitoring of discharge wastewater quality.

Agricultural wastewater, including dairy wastewater, is also regarded as a serious pollutant of the lake. The approaches for pollution control of this type of wastewater differ from such point sources as domestic and industrial discharger. As for paddy-field cultivation, pesticides and fertilizer use is of greatest concern. The recent changes to agricultural practices for improving productivity have yet to provide the solution to improving the efficiency of pollution control.

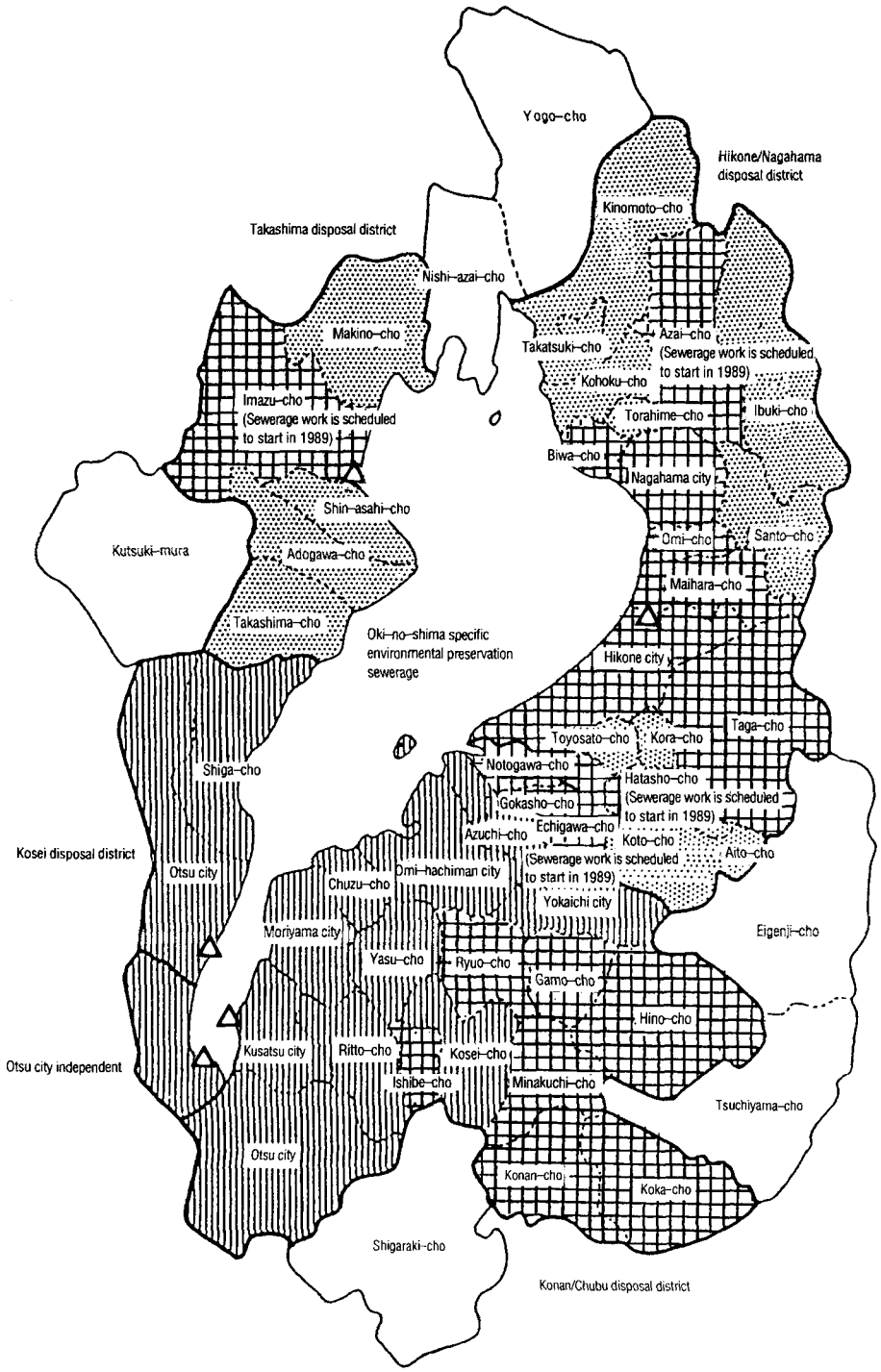

Fig. 14. Map of sewerage services, as of 1989: (□) planned district map; (▥) municipalities where operation has already started; (▦) municipalities where sewerage work was already laid out; (▨) municipalities where sewerage work not yet laid out; (△) sewerage disposal center. Source: Shiga Prefecture.

Various measures to improve the efficacy of pesticide and fertilizer application are being made, both in terms of management practice and technological innovations. Point injection of fertilizer at the root of the rice seedlings is being tested and is gradually being accepted by farmers. Recycling of irrigation water, drawn into the irrigation network by large pumps, is also proposed and under investigation for technical and economic feasibility. In addition, the environmental monitoring center conducts paddy-field discharge monitoring at the time of spring cultivation and fertilizer application to check for incidents of gross pollution.

Eutrophication control ordinance

These pollution control efforts are not by any means unique to Shiga Prefecture. If anything is unique about pollution control in the Lake Biwa catchment area, it must be the spirit and symbolism reflected in the Eutrophication Control Ordinance enacted after the first 'red tide' occurred in 1977. Perhaps the most important aspect of the whole sequence of events, leading to the enactment of the ordinance and its implementation afterwards, were public initiatives in refraining from the use of synthetic detergent containing phosphorus. At the height of the movement and immediately after the enactment of the ordinance, almost 90% of households surveyed were willing to collaborate and not use phosphorus-containing detergents. With an assortment of provisions in the ordinance, including regulations on industrial discharges of phosphorus- and nitrogen-containing wastewaters, the water quality of the lake seemed to show slight improvement within the first few years. However, lake water quality has since remained more or less the same. Various land development activities and continuing inflow of non-point sources of pollution are blamed as the major contributing factors.

Water quality component of LBCDP

With respect to water quality management, what does the LBCDP imply? The Special Measures Act for Lake Biwa Comprehensive Development was enacted in March 1972 as a 10 year time-limit legislation. Its overall aim was to undertake construction of water resource development facilities to allow for the lake water level to be sufficiently lowered to meet the then rapidly growing downstream water demands. The act stipulated the following as its intended basic objectives: (i) utilization of water resources; (ii) conservation of the natural environment; (iii) general welfare of the concerned public; and (iv) restoration of water quality.

Specific projects were to be prepared by the prefectural government, presented at public hearings, and submitted by the Governor of Shiga Prefecture to the Prime Minister through the Secretary General of the National Land Agency. The LBCDP, as stipulated in the act, came into effect in December 1972.

Objective (i) was the primary objective, as the name of the Project indicates, and needs little elaboration. Objectives (ii) and (iii) were more a reflection of the desire of the prefectural government to share in development benefits, and they were approved by the National Government. Objective (iv) had not been heavily weighed in the original bill. In the process of deliberation, however, concern was expressed by various quarters—including scientific and environmental groups—over exploitation of the environment. This concern was responded to. The tone of the final bill, therefore, was much more sympathetic to environmental conservation than the original bill. In fact, when the time limit was extended for an additional ten years in 1982, substantial addition was made to the projects categorized under objective (iv) to reflect an inclination toward environmental conservation than compared to ten years before. In summary, the LBCDP is:

(1) A large-scale development project for water resources development with trans-generational implications.

(2) A highly political undertaking, like other projects of this nature, with respect to its design and implementation.

(3) A project which had to meet changing needs over the time between its conceptualization and realization, and which will have to be responsive to the needs of future generations, on both development and conservation accounts.

It is not, however, a project dedicated, by any means, exclusively to environmental conservation.

Development and conservation dynamics

Dynamics of development efforts

The dynamics of development efforts in the past several decades could be described in many ways. However, one of the most obvious and most important forcing functions has been, of course, major policy decisions of the national government. Throughout its modern history, the Shiga Prefectural Government, like all other prefectural governments, has been subjected to

strategic regional development programmes under the national umbrella development policy framework which have collectively underpinned national economic achievements in the post-war decades. Regional development efforts are facilitated through appropriate legislation, the principal legislation being the National Comprehensive Development Law of 1950. In the course of nearly 40 years after enactment, four national comprehensive development plans were prepared. In Shiga Prefecture, six prefectural development plans of major significance were prepared, the current plan in 1987. A series of development activities took place in the forty year period, the most important being the completion of major transportation arteries, such as Route No. 1 Highway, New Tokaido Railway Express Line, Meishin Express Highway, Biwako Oohashi Bridge, and Oomioohashi Bridge. In addition, industrial estates of varying sizes either moved in from Keihanshin Region or were newly established, particularly along the south-eastern edge of the lake. In effect, the dynamics of development efforts have reflected historical events, that is, local development efforts had to be responsive to national and regional development needs as well as local inclinations.

Another important observation on the dynamics of development is that development efforts result, of course, in a variety of impacts on all phases of development activities. These include industrial structuring, social and demographic alterations, land and water use changes, and increasing environmental stresses. The industrial structure has changed over the past four or five decades, allowing secondary and tertiary industries to overtake primary industry in terms of output. The social and demographic alterations, such as changes in lifestyle, community structure, labour force structure, and even cultural and educational opportunities and facilities, are of great significance in characterizing societal dynamics. Land and water use changes have already been discussed, but the fact that the changes took place, in terms of development history of the catchment area in so short a span of time, should be recognized explicitly.

Of course, the LBCDP constitutes an important element of development dynamics. It is in part closely linked to the framework of regional development, but it could well be regarded historically and nationally as a unique undertaking to consolidate the overall social capital specially focused on an unsurpassable natural resource of the nation, Lake Biwa. How it fares in the formula of the dynamics of development efforts is not a simple analysis because of difficulties in assessing socio-political implications in addition to difficulties in quantifying economic and social benefits.

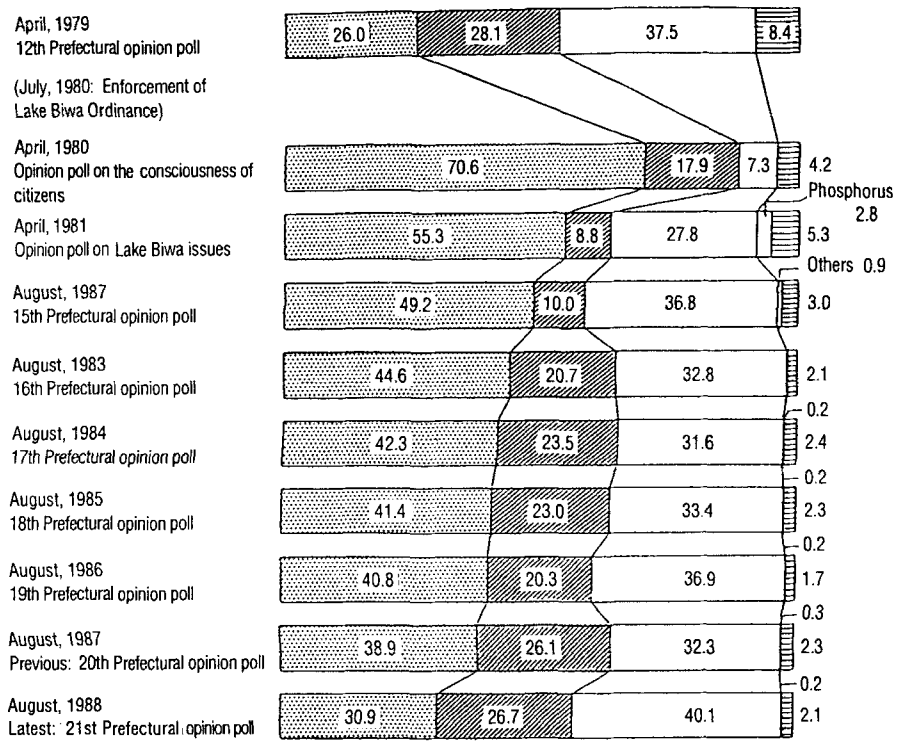

Fig. 15. Trends in public awareness in the use of soap: (▩) use only soap powder; (▨) mostly use soap powder or soap powder and non-phosphorous synthetic detergent; (□) use little soap powder or only non-phosphorous synthetic detergent; (▤) have no idea. From JICA/ILEC (1991).

Table 6. Sequence of environmental events, 1973–80 and 1981 to the present

Years	Sequence of environmental events
1973–80	(1) Causes of environmental disturbance:
	Intensification of industrial activities
	Increased population migration
	Development activities including those specified in LBCDP
	(2) Apparent deterioration of environmental integrity:
	Disturbance of plankton life-cycles resulting in large-scale red tides
	Large-scale marginal filling of the lake and reduction in natural lake fronts
	(3) Impact and damage to basic public facilities:
	Clogging of water treatment filter-beds
	(4) Enhancement of citizens' awareness of environment:
	Sense of alarm on the deteriorating quality of drinking water
	Loss of opportunities for water-front activities
	(5) Message from environment to citizens:
	Taste and odor problems
	(6) Citizens' demand on government:
	Banning of phosphorus-containing detergents
	Regulation of discharges of nutrients from industries
	Moratorium on development activities
	(7) Citizens' initiatives:
	'Use-soap' movement (see Fig. 15)
	In-house reduction of pollution loads
	(8) Message from environment to government:
	High N and P concentration in lake waters
	Algal blooms
	(9) Government action:
	Regulatory actions on phosphorus-containing detergents
	Monitoring of industrial wastewater discharges
	Control of agricultural run-off
	Instruction of environmental impact assessment
1981 to date	(1) Causes of environmental disturbance:
	Non-point, non-specific sources of pollution
	Development activities including those specified in the revised LBCDP
	(2) Apparent deterioration of environmental integrity:
	Continuing incidents of algal blooms including by *Uroglena americana* and *Microcystis*
	(3) Impacts and damage to basic public facilities:
	Pollution of local streams
	Disappearance of certain invertebrates and 'ayu', an indigenous fish species
	(4) Enhancement of citizens' awareness on environment:
	Strong sense of loss of 'good old days' of clean streams and drinking water free of taste and odor
	(5) Message from environment to citizens:
	Continuing taste and odor problems
	(6) Citizens' demand on government:
	Non-point source pollution control measures
	Intensification of litigation against LBCDP
	(7) Citizens' initiatives:
	Establishment of 'environmental co-operatives'
	(8) Message from environment to government:
	N and P concentration at standstill
	(9) Government action:
	Development of an overall environmental management plan
	Initiation of environmental education and planning assessment

The interactions of these nine events are indicated in Fig. 16. From Imai *et al.* 1989.

Dynamics of conservation efforts

The dynamics of conservation efforts in the Lake Biwa case are unique on the one hand and typical on the other. It is unique because Lake Biwa has unique features with respect to its geography, hydrology and socio-economy. The conservation measures had to be responsive to this uniqueness. It is typical also in that many of the conservation measures introduced have been representative of a particular time in Japan and typical of the manner in which the government and the citizens dealt with the emerging issues.

One of the most important features of Lake Biwa is that the lake and its catchment area and the prefectural jurisdictional area almost totally coincide. Thus, people living within the catchment area are directly reminded that they have their own role to play in whatever endeavours for achieving environmental integrity operate. Figure 15, which shows trends in the public awareness of the effects of using soap powder, is indicative. It is this coincidence that has brought about the unintended partnership, as it were, between government and residents.

Two periods may be distinguished as far as the dynamics of conservation efforts are concerned, 1973–80 and 1981 to the present (Fig. 16). The sequence of events and responses is summarized in Table 6.

While factors contributing to the dynamics of conservation efforts change over time, the basic structure and substance of the dynamics remain fairly intact. Nevertheless, new initiatives and developments continue to be introduced in the government–citizen partnership. The future trend appears to be a greater involvement of citizens with genuine concern, and the development of mechanisms to facilitate their involvement. This may be further supported by the increasing ease by which information is disseminated and transmitted through various means at all levels.

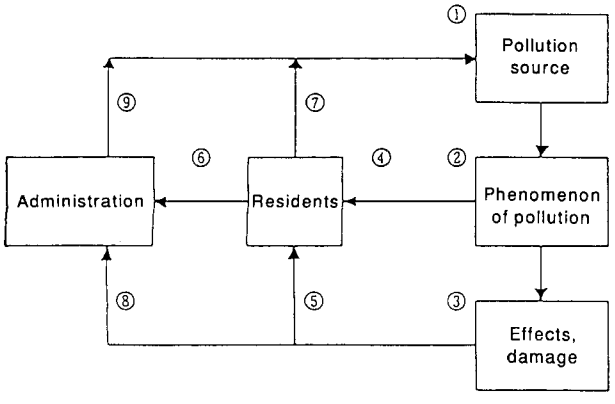

Fig. 16. Diagram illustrating cause–effect interactions between pollution, public reaction and local government response. See Table 6 for explanation of numbers. From Imai *et al.* (1989).

Policy organs and instruments as constituents of the dynamics

Lake Biwa development and conservation policies have been formulated in response to various national and regional initiatives and requirements. Thus, a wide array of policy organs has participated in some manner in their formulation. These organs could be categorized according to their position in the governmental hierarchy such as: national government *vs* local governments; governmental sectors of responsibility such as agriculture *vs* industry; regional economy and intra-region political positions such as Shiga *vs* downstream prefectures; economic zones such as Keihanshin *vs* concentrated industrial establishments within prefectures; or forms of political influence, such as bureaucracy *vs* citizens. Each such organ has played its role in pursuit of specific objectives.

The intricate dynamics of both development and conservation and the involvement of a variety of policy organs are the result of many centuries of a rich history of human–nature interactions in an area which has been very important socially, economically and politically. While interactions of policy organs of the type described for Lake Biwa may seem typical for cases involving important water resources elsewhere, the Lake Biwa case is unique in many respects; the long history of human–lake interaction has created indigenous institutions and management practices, aroused particular sentiments in opposing viewpoints, and provided a unique sense of balance among concerned policy organs. Thus, a complex mixture of practices, sentiments and a sense of balance has resulted in what appears to be the unique Lake Biwa experience.

A wide array of policy instruments has been introduced in the process of achieving individual policy goals. Legal instruments, of course, have been the most powerful, and some attempts have been made earlier to clarify the maze of laws, regulations and ordinances for land and water management. Economic and financial instruments have been introduced in various forms at several levels of economic policy decisions, many in direct response to national development plans. Both public and private sector investments have had great impacts on the shaping of regional welfare in the Lake Biwa area. Information, more often in the area of environmental conservation than

other areas, has played a critical role in the political dynamics in the handling of Lake Biwa issues. A typical example is provided by events which followed the enactment of the eutrophication control ordinance.

Policy assessment perspectives

The basic objective of this paper was to illustrate events associated with change in Lake Biwa in terms of increasing socio-economic development pressure over time and shifting emphasis on resource values, impending lake management issues, and policy measures and their intricate relationships. However, the paper does not fully assess objectively many important questions pertaining to the evolution of management policies of Lake Biwa and its catchment area. No comprehensive literature on this subject is currently available, although there is some on confined areas of analysis. Extrapolation of such analyses to understand the evolutionary whole of intricate policy interactions would be meaningless. No literature exists, perhaps, because there has been no neutral perspective when Lake Biwa is brought to the arena of objective analysis. This study will also fail the test of neutrality because it too represents a particular perspective. However, attempts to assess the overall evolution of Lake Biwa management policies are worthwhile and there are ongoing attempts to shed some light on other important questions as:

(1) Have there been adequate coherency and consistency in the legal instruments introduced and implemented?

(2) Has there been sufficient facilitation in the allocation of natural as well as economic resources within the context of achieving sound management of Lake Biwa environments?

(3) Have we succeeded in maintaining regional integrity in terms of economic development and environmental conservation, perhaps at the expense of deterioration of water quality in Lake Biwa?

(4) Have we succeeded in attaining a satisfactory level of local autonomy as well as local initiatives both in terms of mobilization of national, regional and local resources, and of having prefectural residents sufficiently involved in critical policy decisions for the sound management of Lake Biwa and its catchment areas?

This paper attempted to highlight certain aspects of the above questions. It is hoped that these attempts will open avenues of future analysis and assessment which cumulatively will lead to better understanding of the value of Lake Biwa and the ways in which it could be preserved better for future generations.

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