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DEVELOPMENT OF AN EVALUATION METHOD FOR RIVER ENVIRONMENT

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ABSTRACT: Assessment in planning and designing process is necessary especially for nature-oriented river. The main purpose of this study is to develop an assessment method for river environment. At a workshop composed of experts on river environment, a viewpoint to identify characteristics of watershed and/or river environment was added to viewpoints of the River Council in Japan. Furthermore, the new concept of "intermediate nature" is proposed to develop a goal-oriented assessment method. In this study, the prototype of a new assessment method "EMOREK" is proposed, somewhat similar to the AMOEBA method developed in the Netherlands. A case study on the T-river in Japan was carried out to realize the capability of the assessment method through problem analysis on the river environment.

INTRODUCTION

Recently in Japan, the concept and institution of river management have been changing quickly. Two reports were delivered to the Minister of Construction in 1995 and 1996 by the River Council (The River Council 1995, 1996). In these reports, new actions and conceptual viewpoints for river environment were recommended.

According to these reports, the River Law was amended in 1997 and an environmental viewpoint was newly added to the administrative river management in order to pursue affluent nature in the river environment (Sato 1997). Before that, flood control and water use were the main purpose of river improvement in Japan. The nature-rich river project is one of the new river works that meet the concept of the law and is being carried out in some rivers. For environmentally sound river works, an evaluation of the river environment is significant at a planning stage as well as a technological assessment on a constructing approach. The evaluation technique is still at the developing stage, however, an integrated or comprehensive viewpoint is fundamental and indispensable for water management of watershed (Koga 1997).

The purpose of this study is to propose a fundamental concept for the environmental evaluation through investigating the present status and establishing indexes for pre- and post-assessment of the project. An interdisciplinary/transversal approach is necessary to examine and discuss various issues concerned with the environmental evaluation (Nakamura

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1998). For this purpose, a workshop is organized by administrators, engineers and scientists in the field of ecology, ichthyology, entomology, botany, water quality and disaster prevention.

The new concept and method of evaluation are proposed through summarizing the opinions of the experts. Finally, this method is applied to the T-river in Japan for realizing its capability.

DEFINITION OF "NATURE" IN RIVER ENVIRONMENT

The object of environmental evaluation on river works is the "nature" of a river. Consequently, a definition of "nature", viz. conceptualization of nature or terminology, is very important because it is closely related not only to methodology of the evaluation but to the setting up of the goal as well.

Through the workshop approach, nature was classified into the following types; 1) "virgin nature" (Imae 1990) without any human activities, 2) "potential nature" in the area affected by human activities (A in Fig. 1), and 3) "intermediate nature" (Imae 1990) which tends to be dynamically stable. The intermediate nature is a transitional phase that is a mature relationship between nature and human activities (B in Fig. 1).

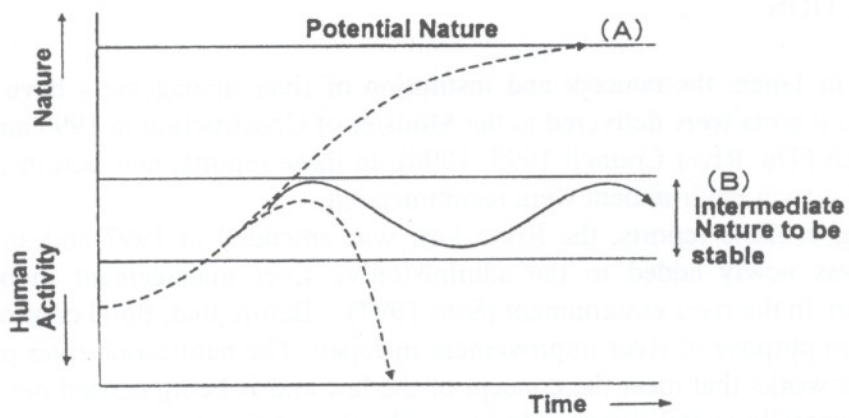

Fig. 1 Concept of nature on river works

Virgin nature is the climax depending on its climate and soil conditions which environment has reached its stable phase after a long transition. A tropical rain forest is the typical example of the virgin nature. The potential nature is a state that will appear if the artificial factors are removed off.

In case a human activity, such as river works, breaks into the potential nature, the state of nature fluctuates between the artificial climax and the potential nature. This dynamically balanced state can be called the intermediate nature. Human activities necessarily participate in a spatial environment of a river, and thus the intermediate nature is employed for the definition of nature in this study.

Based on the definition of the intermediate nature, an example on vegetation management can be shown in Fig. 2. In this figure, the first stage is the increasing period of vegetation (level of nature) due to the nature-rich river project. If this state is left as it is, weeding/felling (artificial control) may be necessary to prevent the decrease in river cross section or the increase in roughness. On the other hand, if poor vegetation occurs, superfluous

weeding/felling should be controlled to be nature rich.

The preferable management of vegetation is to keep the intermediate nature by the well-planned appropriate weeding/felling (artificial control). The second stage in Fig. 2 shows the transitionally balanced state between flood prevention works (artificial) and the power of nature. The range of the balanced level should be decided as the goal for the river project according to the river characteristics. Figure 3 shows an example of a river that landscape is (a) just after river works and (b) under well managed condition at the intermediate nature.

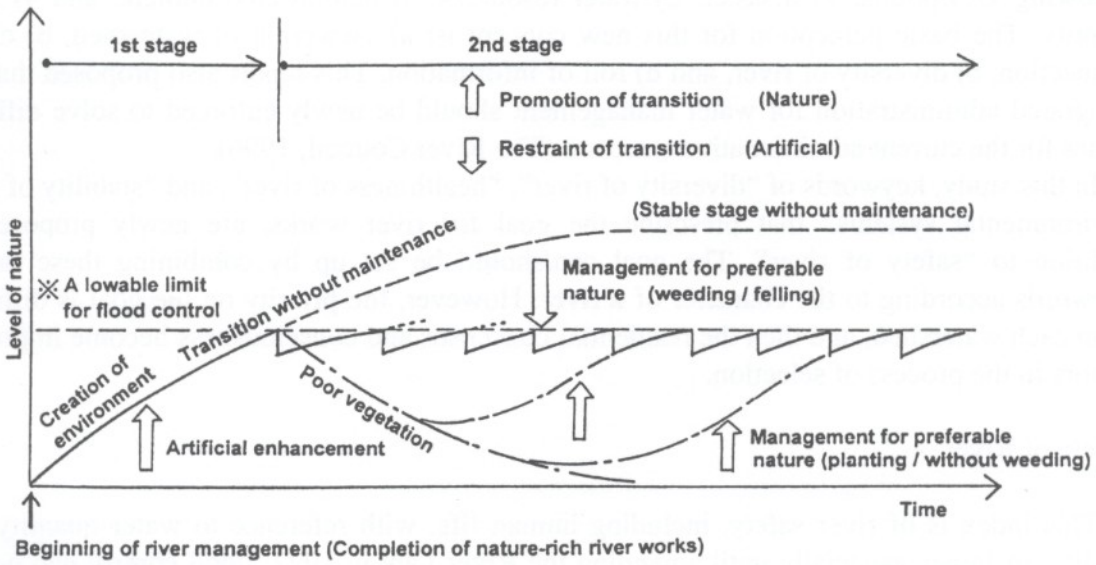

Fig. 2 Concept of the intermediate nature and transition of vegetation in flood plain

(a) Just after river works

(b) Well managed stage at the intermediate nature

Fig. 3 Example of river works and management for the intermediate nature

VIEWPOINT AND GOAL FOR RIVER ENVIRONMENT

In the report of the River Council dated March 1995 (The River Council 1995), the following viewpoints were given for river works; a) preservation of habitat diversity, b) conservation of sound water cycle, and c) restructure of the relationship between rivers and residents. Furthermore, in the next report in June 1996, an importance in restructure of the relationship between man and water from the standpoint of watershed was pointed out. Then, the relationship of society to rivers is reorganized toward the next century according to the following viewpoints; 1) disaster, 2) water resources, 3) natural environment, and 4) local identity. The basic perception for this new concept is; a) viewpoint of watershed, b) closer connection, c) diversity of river, and d) roll of information. This report also proposed that the integrated administration for water management should be newly enforced to solve difficult issues for the current administrative structure (The River Council, 1996).

In this study, keywords of "diversity of river", "healthiness of river", and "stability of river environmental systems" that prescribe the goal for river works, are newly proposed in addition to "safety of river". The goal can/should be set up by combining these proper keywords according to the character of a river. However, the priority on the goal is different from each watershed, and then the residential consensus and consciousness become important factors in the process of selection.

Safety of River

This index is of river safety, including human life, with reference to water quantity and quality. In Japan, especially until amending the River Law in 1997, flood control had been a high priority as a safety index. The new safety level should be developed based on not only water quantity such as flow capacity but also on bank protection etc. in case of implementation of nature-rich river works. The new evaluation method for the safety level is being examined through making master plans of rivers. Therefore, in this paper, the idea of the safety level for flood control is used as a tentative one according to the Former River Law.

Diversity of River

The term of diversity is commonly used in the various fields such as biological-, physical-, chemical- and environmental-diversity. Biologically, diversity of species, gene and ecosystem are considered into the index. Additionally, physical/spatial diversity of rivers and diversity of landscape are also categorized into this index to evaluate the individuality of the river environment. The diversity in the limited space of watershed is obviously different from global diversity; thus, the identity of river becomes more significant.

Some problems, such as expulsion of native species by an imported one, or crossbreed of close species, are generally pointed out in a discussion on river ecosystems (Mori 1996; Washitani 1998). However, the species that may acclimate to the river environment or not disturb the ecosystem, will be left out of consideration due to the difficulty in distinction of imported species.

Healthiness of River

This index shows a sound cycle of water and materials in a river. The characteristics of water pollution, self-purification and restoration potential of ecosystems are the examples for this indicator.

Stability of River Environmental Systems

This index describes the durability of the river environment. It means the capability that the river can be restored by itself or with minimum artificial assist. The river environmental systems consist of a river and the social systems related to the river. In this discussion, the social system means all of the human activities concerning the river, such as cleaning, utilization, recreation or good use of a dry riverbed. If these activities are sustained for a long time, they may contribute to the restoration or mitigation of the environmental impacts.

EVALUATION METHOD AND INDEX

Evaluation Method

There are several evaluation methods and indexes used in Japan (Fukuda 1996; Morioka, 1997; Morishita 1996). Kinoshita (1995) employed fish and aquatic life as indicator organisms. Baba (1996) and Tanida (1998) evaluated the river environment by using habitat such as river shape, shoal, pool, riverbed, vegetation, river depth and velocity. Hashimoto (1993) and Kohama (1994) took questionnaires to inhabitants. In the U.S., IFIM which aims to have a quantitative design of flow control and evaluation of its effect on a habitat, was developed (River Front Center 1996). CVM, which is an economic evaluation of environment, was also developed in the U.S. (Yasuda 1994). In the Netherlands, various presentation methods, such as the Score Card, the AMOEBA and the MONDRIAAN, were developed (Ministry of Transport & Public Works 1989, 1991; van Beek 1993). In all cases, the environmental evaluation technique is developing and detail discussion is still needed.

The following conditions, which are summarized through the workshop, are necessary for the environmental evaluation.

1) Various axes are necessary due to the diversity of river environment, and they should be presented intuitively and synthetically.

2) Assessment process should be easy to understand, even for residents, in order to establish a local consensus.

3) Existing data, such as the database on the national census of rivers, can be used for complement of the evaluation.

Furthermore, the environmental evaluation should be carried out within the frame of the integrated water management that includes the process of problem analysis, policy analysis, publication and public hearing. In this study, the concept of AMOEBA is referred for the policy analysis and presentation of the river environment.

Axis and Index of Evaluation

It is necessary to prepare various axes and indexes consisting with the goal of the river project in order to totally examine the character and diversity of a river. The axes and indexes obtained in the workshop are shown in Table 1.

Table 1 Axis and index of evaluation for river environment

Goal	Evaluation axis (Value axis)	Evaluation index (Measurement parameter)
• Safety	Disaster prevention system	safety for flood (whole river or partial), progress of river works, flood frequency, accidental water pollution
	Physical-/ Chemical-systems	average flow rate, high water level, water level in dry season, coefficient of river regime, flood frequency of dry riverbed, water level, roughness, water surface ratio, water temperature, water quality parameters (water quality standards)
	River structure system	shoal, pool, riverbed, roughness of aquatic plant, curvature, slope of riverbed
• Diversity	Cycle of water and material	non-point pollutant load, pollutant load from human activity, pollution level measured by bio-indicator, safety level of water supply, normal , flow rate
	Biological system	[water] aquatic plant, attached algae, benthos, fishes [land] land plant, birds, mammals, amphibian, reptiles, land insect
• Healthiness	Ecosystem	diversity, imported species ratio (naturalization ratio), valuable species, distribution of vegetation (plant colony), green coverage ratio, intermediate natural level of vegetation
	Social system	voluntary activity (cleaning action etc), number of access people (walk, recreation), number of events, bathing, fishery and fishing, environmental learning
• Stability	Cultural heritage system	monument of flood control works, facility of traditional water systems, festival, folk story, traditional fishing method, shipping, bridge, local name of place (geographical), fall, dialect of fish etc.

Process of Evaluation

The environmental problems are generally complicated, thus, the comprehensive viewpoint and local consensus should be included into the evaluation process. Figure 4 shows the flowchart of the evaluation process based on the above discussions.

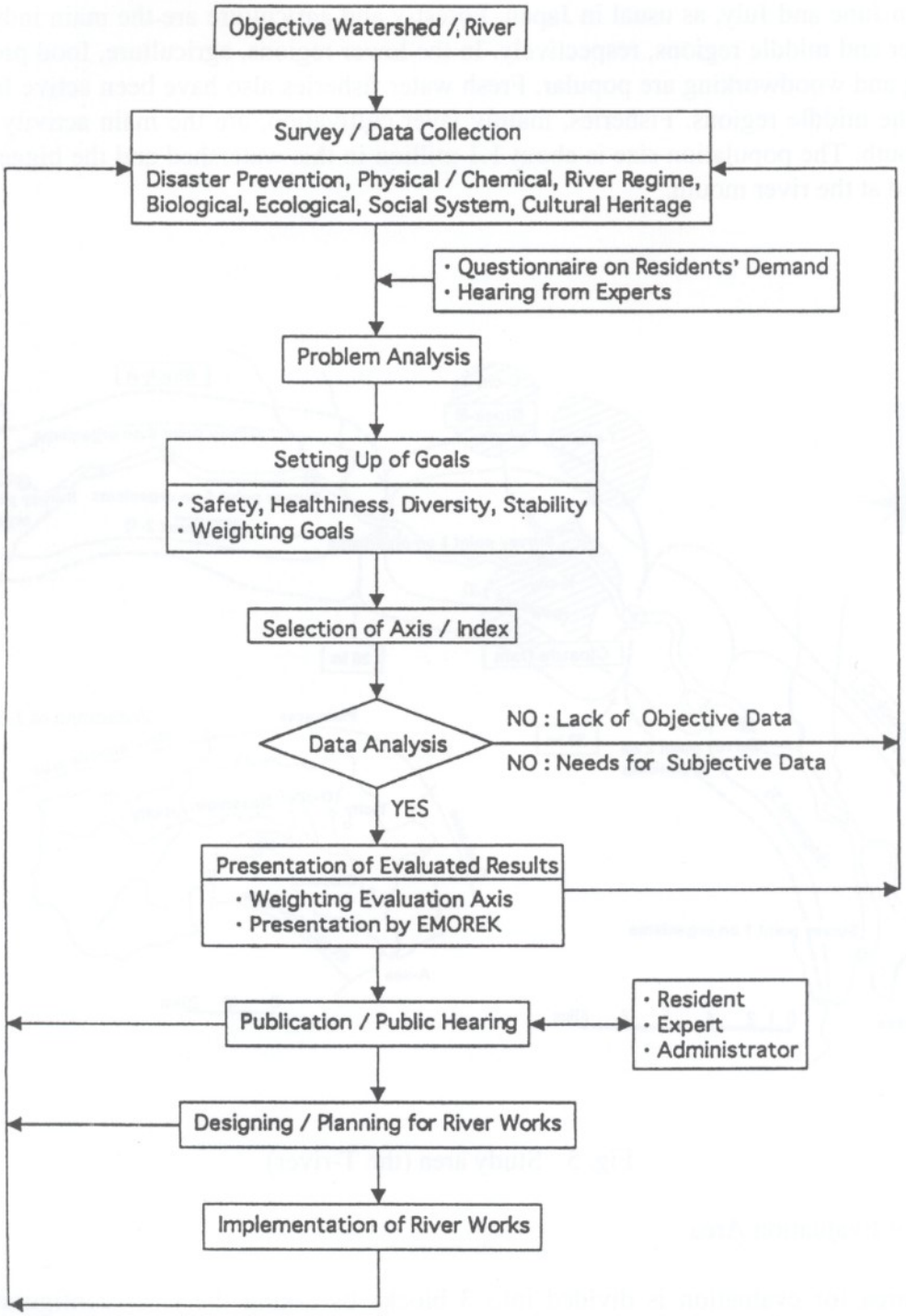

Fig. 4 Flowchart on evaluation of river environment

ENVIRONMENTAL EVALUATION OF A MODEL RIVER

Outline of the T-river

The T-river is located in northern Kyushu and has 2,900 km^2 of watershed area and 150 km of length as shown in Fig. 5. Annual precipitation is around 2,100 mm and most rainfall occurs in June and July, as usual in Japan. Forestry and agriculture are the main industries in the upper and middle regions, respectively. In the lower regions, agriculture, food processing, brewing and woodworking are popular. Fresh water fisheries also have been active from long ago in the middle regions. Fisheries, mainly laver cultivation, are the main activity near the river mouth. The population size is about 1.1 million in this watershed and the biggest K-city is located at the river mouth.

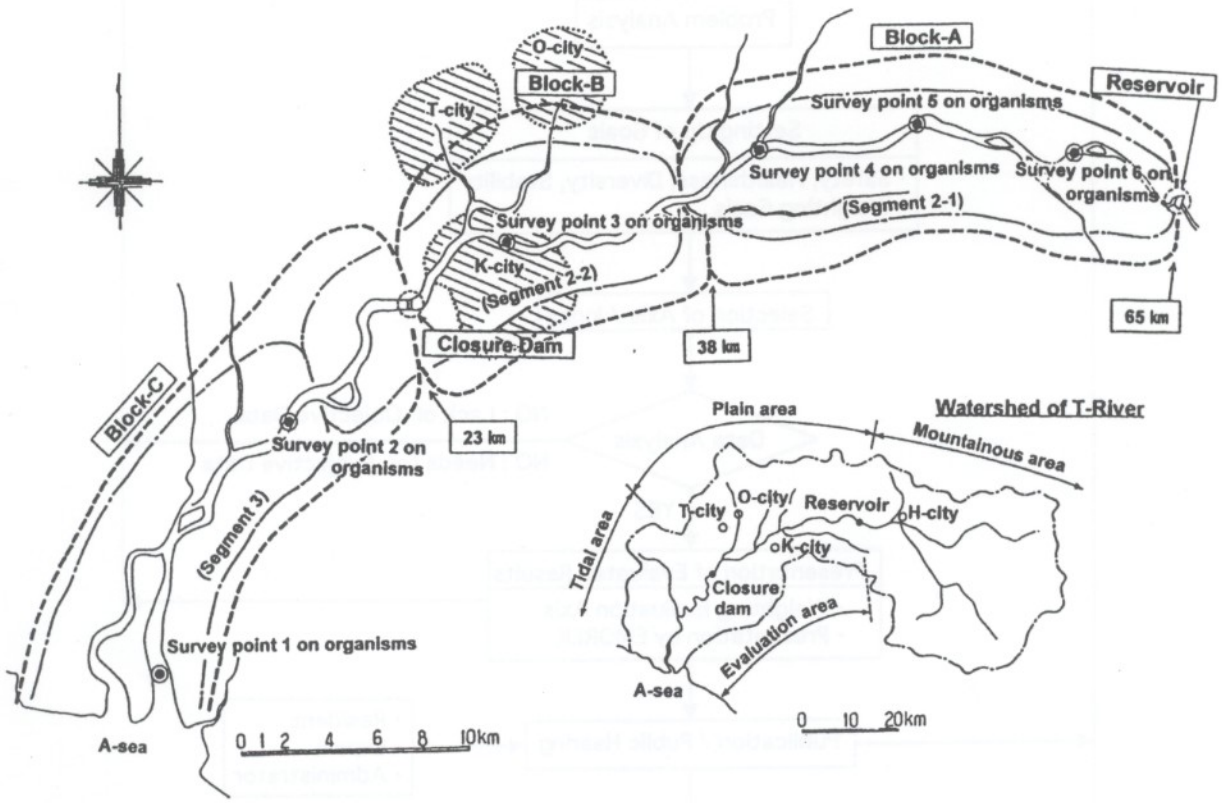

Fig. 5 Study area (the T-river)

Setting of Evaluation Area

The area for evaluation is divided into 3 blocks by taking the river configuration into account, geological characteristics, vegetation, tidal zone or hydraulic facilities, as shown in Figs. 5 and 6 (MOC 1996). The characteristics of each block are as follows:

[Block-A] Middle regions of 38 – 65 km from the river mouth. Gravel riverbed. Rural district.

[Block-B] Lower regions of 23 (dam) – 8 km. Upper area of the closure dam. Sand riverbed. Urban areas of K and T cities are located around the block.

[Block-C] Tidal area of 0 – 23 km. Delta area with clay riverbed. Farmland.

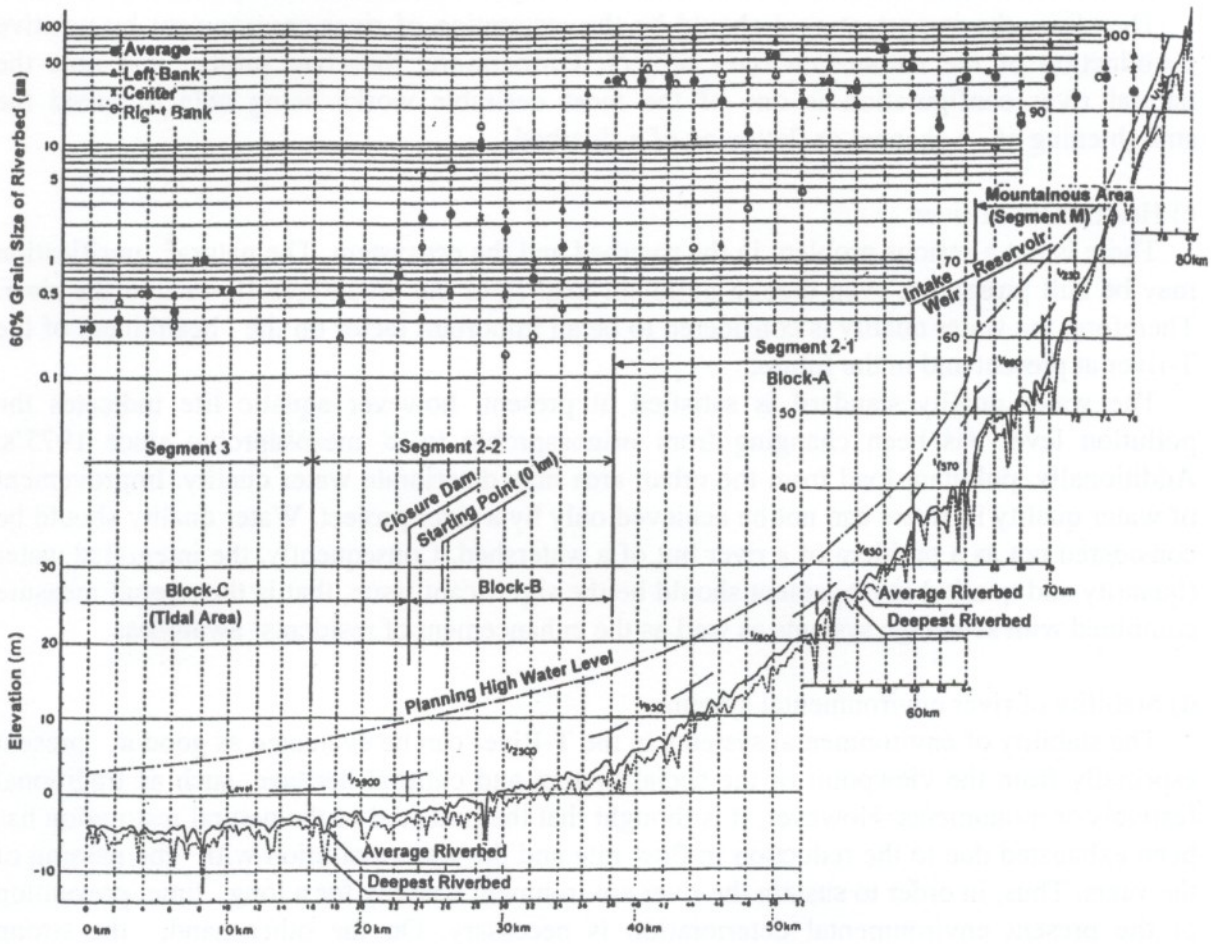

Fig. 6 Longitudinal profile of the T-river

Results of Problem Analysis and Goals for the River Works

The goals for each index are established through the problem analysis as follows.

a) Safety of river

Safety for flood control is attained in the section of 70% of the main stream if the return period is 50 years as the goal for flood control. However, inundation sometimes occurs in the branch streams due to the delay of river works. The flood prevention works that are well balanced between the main and the branch streams are an important goal for this river.

On the other hand, safety level for water supply is still low and only around 20% while the planning return period is 10 years. Drought often occurs even in these few years. Hence, the river management including water supply vested by the water rights in drought period becomes important.

b) Diversity of river

Block -A and -C are evaluated as fairly sustained, based on the goal of total number of species, while species of fish decreased in Block-B. The decrease is shown in the fisheries catch as well in all blocks. The diversity of flora is rich in Block-A where the dry riverbed is not utilized. However, the simple vegetation, such as lawn, is dominant in Block -B and -C where the river bank is walled by concrete and the dry riverbed is used for parks or golf links.

Therefore, the important goal should be the restoration of river environment by positive introduction of the nature-rich river project. Furthermore, the river project that uses the natural river configuration is one of the most desirable works being able to avoid the straightening of a channel or flattening of a riverbed.

c) Healthiness of river

There is not a serious problem in the riverbed and the ecosystem. The natural purification may be still preserved, even though pollutant load from the urban area flows into the river. Therefore, the water quality is considered to be an important factor on the healthiness of the T-river at present and in the future.

The water quality standard is satisfied at present, however aquatic life indicates the pollution level has been changing from origosaprobic to β-mesosaprobic since 1975's. Additionally, pollutant load from the urban area may deteriorate water quality. Improvement of water quality in rivers can not be achieved only by a river project. Water quality should be considered not as a problem of a river but of a watershed. Consequently, the integrated water (quantity and quality) management should be the significant issue, that is the overall measure combined with sewerage systems as well as the enhancement of residents' awareness.

d) Stability of river environmental systems

The stability of environmental systems in the T-River can be evaluated as good at present especially from the viewpoint of the social system and cultural heritage, such as traditional festivals or monuments. However, it is thought that the potential of the natural restoration has been exhausted due to the reduction in flow rate and the water pollution with the passing of the years. Thus, in order to sustain the river environment soundly for a long time, prevention of the present environmental deterioration is necessary. On the other hand, the strong demand for recreation or bathing in the river should be considered, although spatial uses of the dry riverbeds are in progress with various kinds of investment.

Results and Presentation of Evaluation

The evaluation results obtained from the flowchart shown in Fig. 4 with the preferable goal and weight for the indexes are demonstrated in Fig. 7. It is an example of Block-C. The unit circle in this figure is the goal and the envelope of each index shows a relative achievement level against the goal. This figure was made by referring to the data from the past 10 years. At the workshop (MOC, Kyushu Regional Construction Bureau 1999), the experts reached the conclusions through repeated discussions about the weighting of the goal, the selecting and weighting of evaluation axis and index, and the scaling of each index data. This newly proposed method is named "EMOREK" (Evaluation Method Of River Environment in Kyushu).

It is possible to intuitively grasp the whole image, i.e. the goal and existing situation in the T-river from this EMOREK. Finally, it is readable that; a) flood prevention works and low water management are urgent tasks, b) water quality (healthiness of river) will be more important because of a high pollutant loading, c) diversity is almost satisfactory and should be

sustained, and d) fisheries are active and needs for recreation/event are elevated.

The proposed EMOREK is useful due to; a) the flexibility in setting axes for character of watershed, b) the ability in setting and weighting the goal, c) the easiness in total and intuitive understanding of results, and d) the ability in presentation of whole processes of the evaluation in a figure.

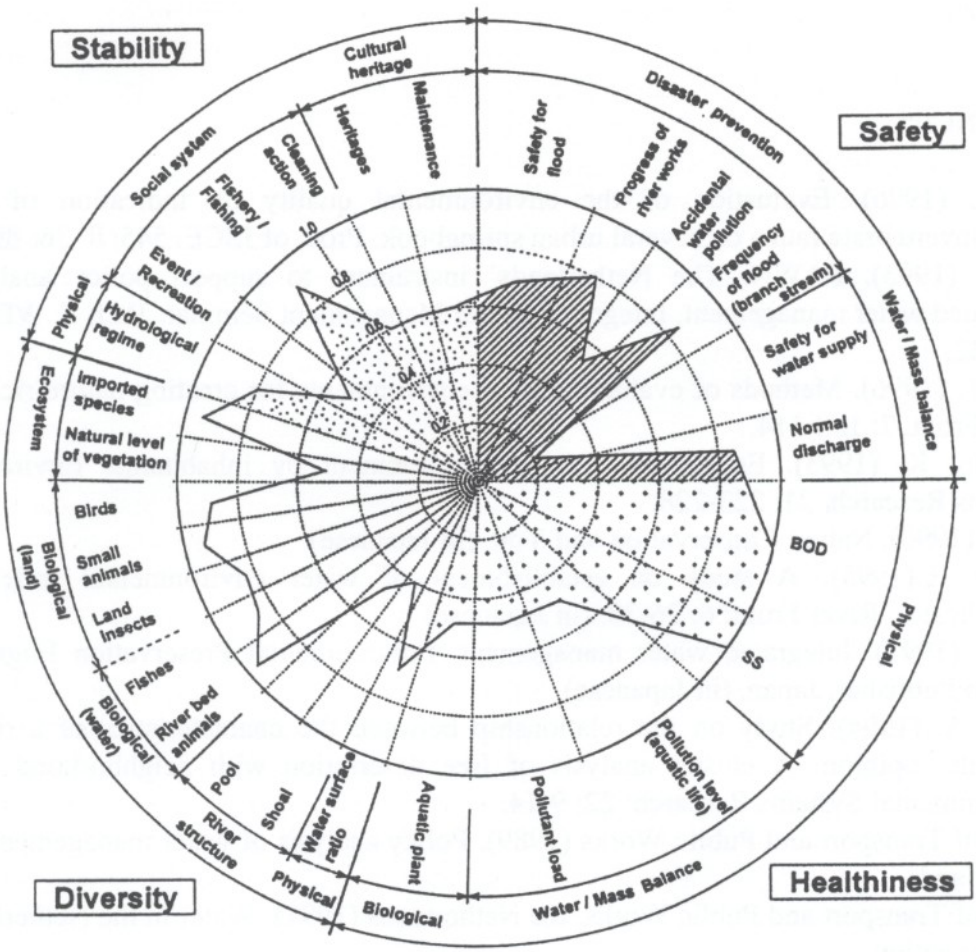

Fig. 7 EMOREK for environmental evaluation of the T-river (Block-C)

CONCLUSIONS

The concept for the river environmental evaluation and the presentation method are newly proposed. The followings are the major outcomes obtained from this study.

1. Comprehensive examination on the existing situation of the river environment makes it able to set up the goal for the river restoration project. It can be also reflected on pre- and post-assessment of river works.
2. It is expected that the proposed evaluation method can keep the diversity of the goal consistent with the identity of river or watershed.
3. The proposed presentation/publication method "EMOREK" is an effective tool for

administrators and residents to learn the goal and existing level of the river works.

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