A BASIC STUDY ON EVALUATION SYSTEM FOR PUBLIC RIVERWORKS
- Analytic Hierarchy Process Application to Riverworks Planning -

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1. INTRODUCTION

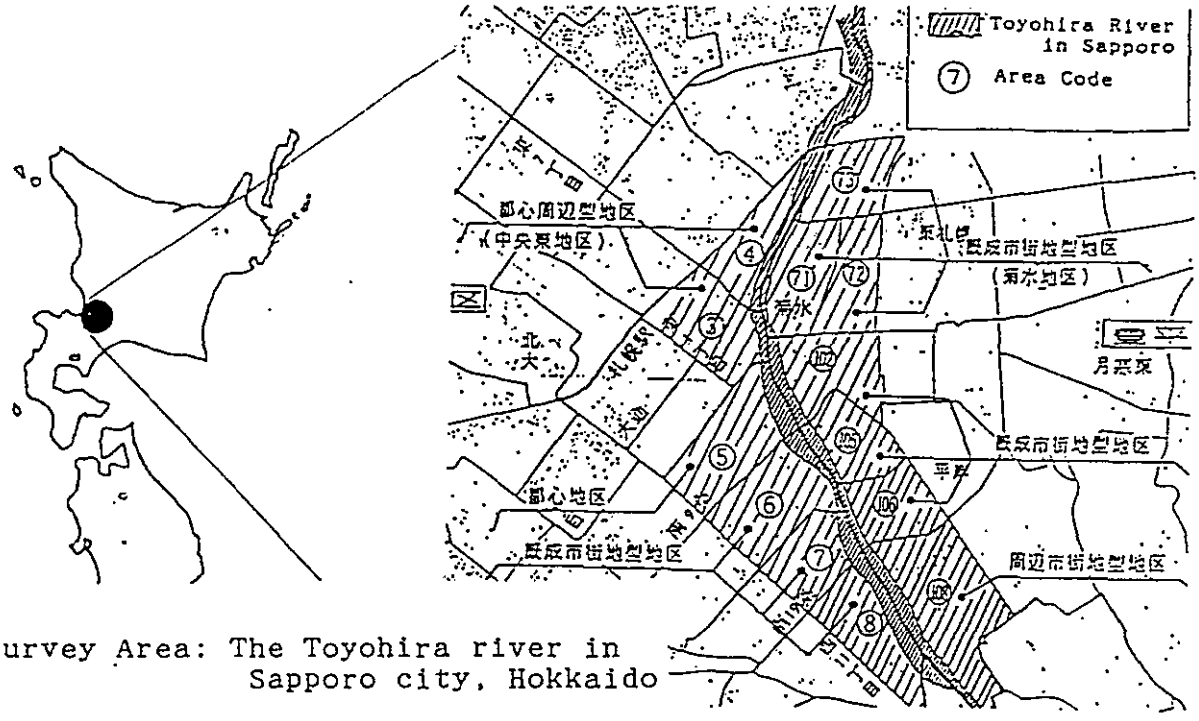
Traditionally, public riverworks in Japan have been designed for two major functions ; floodwater control and the supply of water for basically domestic and industrial uses among others. An expansion of the functions of such riverworks are considered necessary to promote and maintain the attractiveness of river sides.

This is because the quality of life in Japan is rapidly changing with an anticipated increase in demand for access to riversides for recreational and other uses. The government of Japan has also initiated plans to promote the quality of life of the people toward the 21st century.

As part of the government's envirnomental program, particularly for rivers in urban areas, access to the riversides is to be encouraged, notably for recreation and fishing among other uses. Consequently, a comprehensive restructuring of public river works has begun, to make them provide the additional functions.

There are, however, uncertainties about the compatibility as well as the impact relations of recreational uses and the traditional functions of public river works. There is, therefore, the urgent need for research to clarify the situation and to provide the requisite basic data for a comprehensive criteria for the design of comprehensive river works programs. This study is intended to make a contribution in this direction.

In this paper, we assume that citizens perception and evaluation of the practical uses of riversides can be classified into hierarchies. The first objective is, then, to examine and classify the responses of the citizens, relating to the three functions of river works, flood control, water supply and recreation, into hierarchy. The second objective is to weight and analyze the results of interactions between traditional and new functions of river works so that the performance of river works can be evaluated. We will be able to reveal the similarities and differences between the people and the policy makers by the evaluation of item weights generated by AHP.



Survey Area: The Toyohira river in Sapporo city, Hokkaido

2. FUNCTIONS OF RIVERWORKS IN URBAN AREAS AND IDENTIFICATION OF CRITERIA

The function of riverwork in an urban area consists of many categories. At least, we can list up three major functions; floodwater control, the supply of water, and recreational uses. The performance of riverworks can be evaluated with respect to the three major functions which may be broken down into many subfunctions, We then have to identify criteria corresponding to the subfunctions to obtain the accurate performance evaluation of the benefits generated by the riverworks.

Each subfunction, may further be broken down into smaller or lower level subfunctions, thus developing into a high degree of complexity. Consequently, it may not be easy to find the hierarchical structure which corresponds to the functions of the riverworks in urban areas.

Working together with residents on the Toyohira river in Sapporo and managers of the floodwater control division attached to the Ministry of Construction, we went through several free wheeling brainstorming sessions to list all concepts which may have relevance to the functions without regard to relation or order. And then we arranged these in groups according to dominance among the groups by paying careful attention to the three major functions.

There were some problems relating to the three major functions with respect to the hierarchy. In Japan it has been said that floodwater control is the most basic function among them. If floodwater control is not effective, the others can not be facilitated.

This implies that the two functions depend, to a certain extent, on floodwater control. We may then have to set these two

functions at the lower level. We,however, ignored this problem of dependence. Because in reality floodwater contorl is often effectively achieved. As long as this can be realized, the other twwo functions can possibly be considered independent of floodwater control. We have consequently set these three function major functions on the same level.

3. HIERARCHICAL STRUCTURE OF THE CRITERIA AND EVALUATION

3.1 HIERARCHICAL STRUCTURE

After dividing the major functions into seven big categories(level3) and several tentative outputs in structuring the hierarchy were carried out, we obtained Figure 1 which is an illustration of the resultant hierarchy of the functions(criteria) of a riverworks project in an urban area. This consists of seven levels including an alternative set of possible future scenarios as mentioned later.

In Figure 1 the first level in the hierarchy has a single objective; improvement of the riversides in an urban area. The second hierarchical level has three objectives, floodwater control, the supply of water, and access to riversides for recreational and other uses. Their priorities are derived from a matrix of pairwise comparisons with respect to the objective of the first level. The fourth, fifth, sixth, and seventh hierarchical levels have respective objectives as shown in Figure 1.

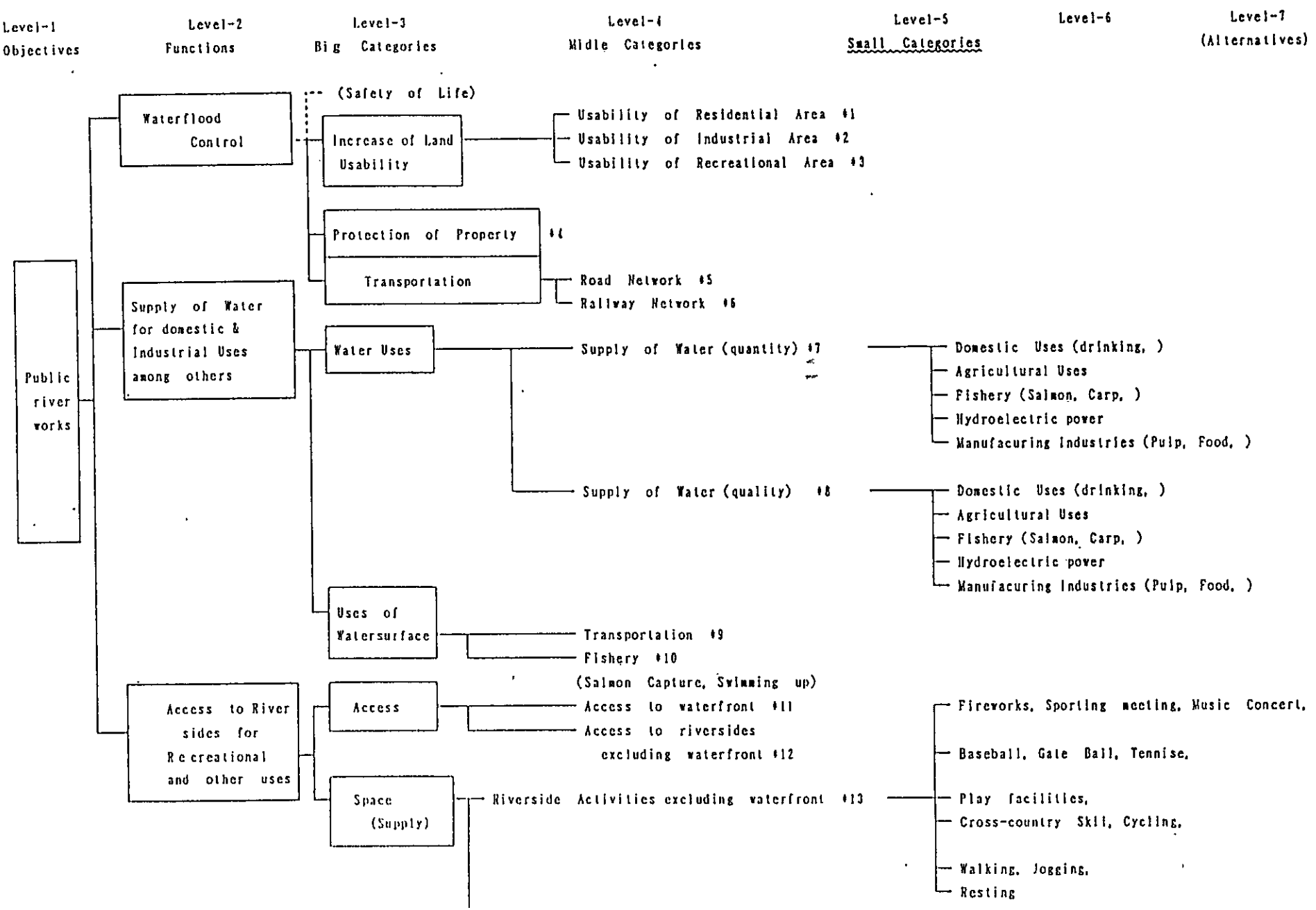
The object is to determine the priorities of future possible measurements of the overall benefit of the improvement of the riversides through 22 criteria at the intermediate levels, especially at the fifth hierarchical level.

Thus their priorities, with respect to each alternative in the lowest level, are obtained from a pairwise comparison matrix with respect to that objective, and the resulting four priorities vectors are then weighted by the priorities vector of the fifth level to obtain the desired composite vector of priorities of the alternatives. In order to obtain the priorities, We totally have to compute the forty pairwise comparison matrixes which consit of 212 judgement questions on pair.

3.2 FEATURES AND GENERATION OF ALTERNATIVES

We arranged a set of alternatives, A, B, C, and D with respect to 22 criteria at level 5 as shown *number at Figure 1, which has been generated by careful discussion focusing on increasing amenity in the region as a result of access to the riversides and "designed nature"(alternative D).

As the possible alternatives for the riversides improvement in the near future, the following four scenarios have been drawn up by combining the aforementioned three major functions. Therefore, the four scenarios, which are different qualitatively


Level-1 Objectives
Level-2 Functions
Level-3 Big Categories
Level-4 Midle Categories
Level-5 Small Categories
Level-6
Level-7 (Alternatives)
Public river works
Waterflood Control
(Safety of Life)
Increase of Land Usability
Usability of Residential Area #1
Usability of Industrial Area #2
Usability of Recreational Area #3
Protection of Property #4
Transportation
Road Network #5
Railway Network #6
Supply of Water for domestic & Industrial Uses among others
Water Uses
Supply of Water (quantity) #7
Domestic Uses (drinking,)
Agricultural Uses
Fishery (Salmon, Carp,)
Hydroelectric power
Manufacuring Industries (Pulp, Food,)
Supply of Water (quality) #8
Domestic Uses (drinking,)
Agricultural Uses
Fishery (Salmon, Carp,)
Hydroelectric power
Manufacuring Industries (Pulp, Food,)
Uses of Watersurface
Transportation #9
Fishery #10
(Salmon Capture, Swimming up)
Access to River sides for Recreational and other uses
Access
Access to waterfront #11
Access to riversides excluding waterfront #12
Space (Supply)
Riverside Activities excluding waterfront #13
Fireworks, Sporting meeting, Music Concert,
Baseball, Gate Ball, Tennise,
Play facilities,
Cross-country Skii, Cycling,
Walking, Jogging,
Resting

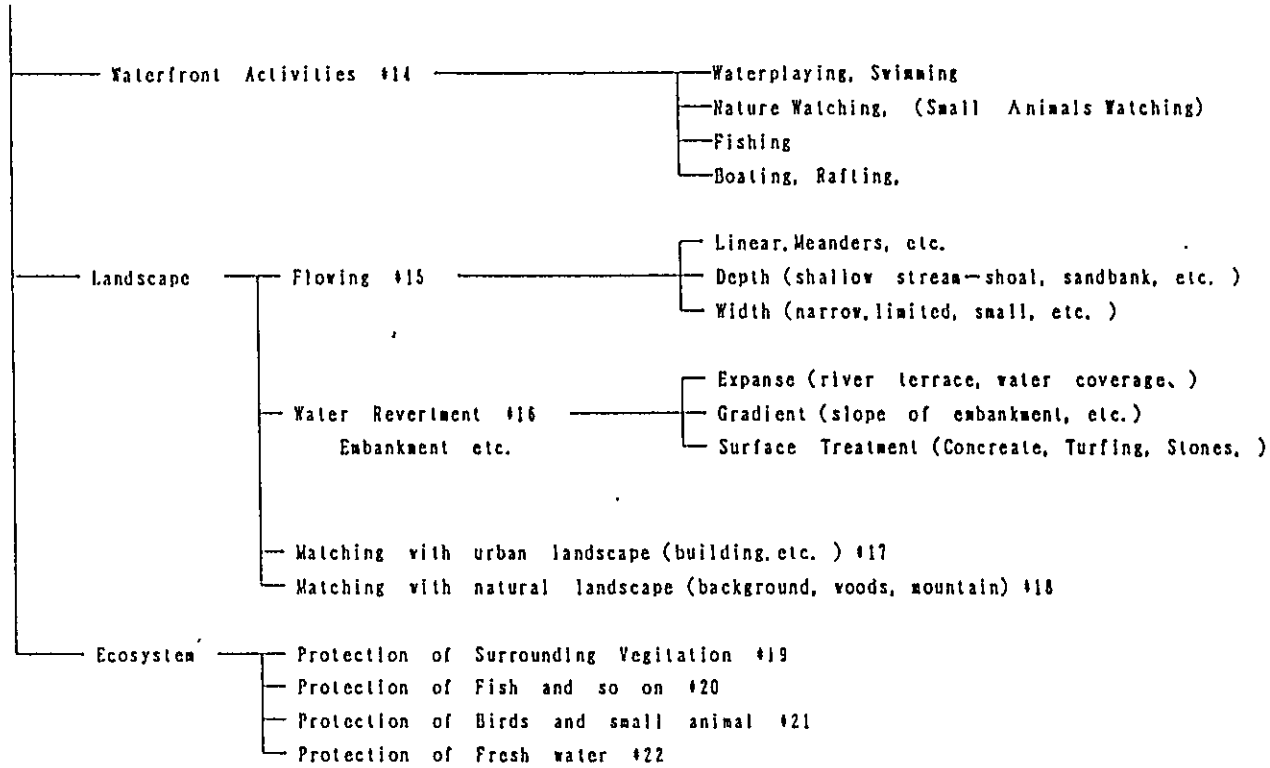
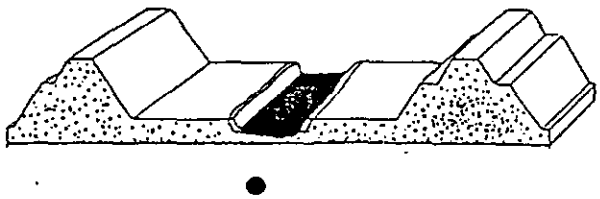


Figure 1 A hierarchy for priorities of improvements with respect to riverworks

*number means characteristics with respect to priorities of alternatives

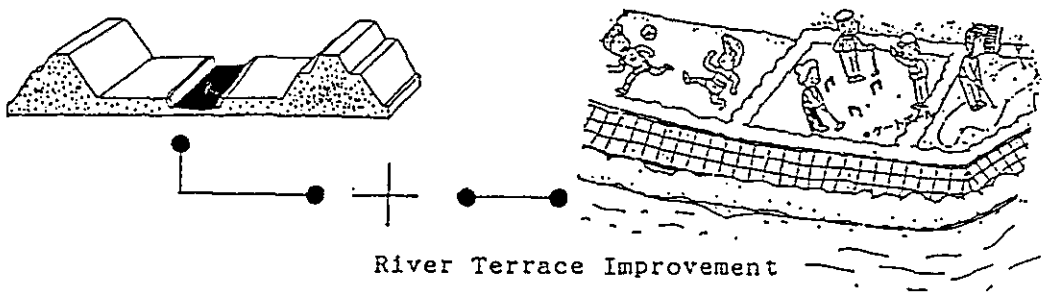
Therefore, the four scenarios, which are different qualitatively from each other,are directly concerned with the feature of riversides improvement corresponding with each function, as follows.

1) Scenario A:Improvement laying stress on floodwater control only , excluding other major functions.



Embankment Only

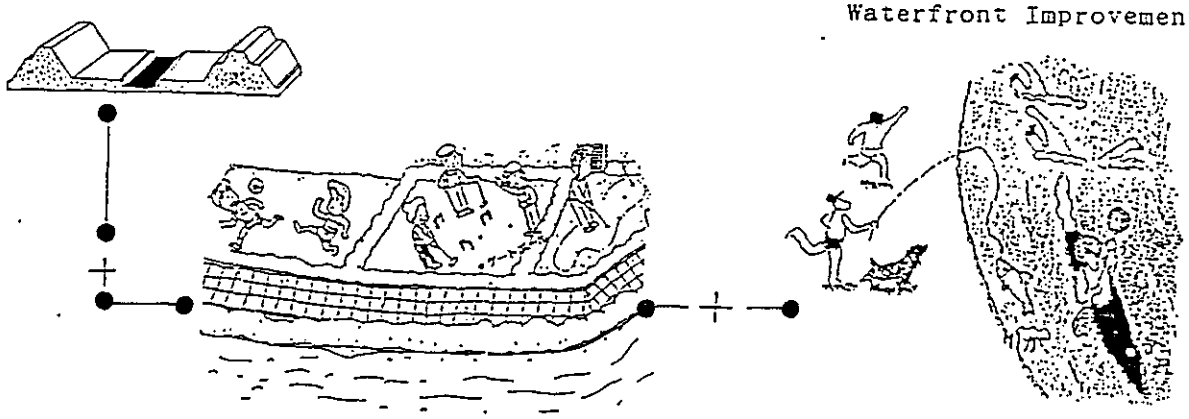
2) Scenario B(=Scenario A + 1):Improvement which, in addition to the function in Scenario A, lays stress on the function of recreational use of river terrace excluding waterfront,especially criterion *13.



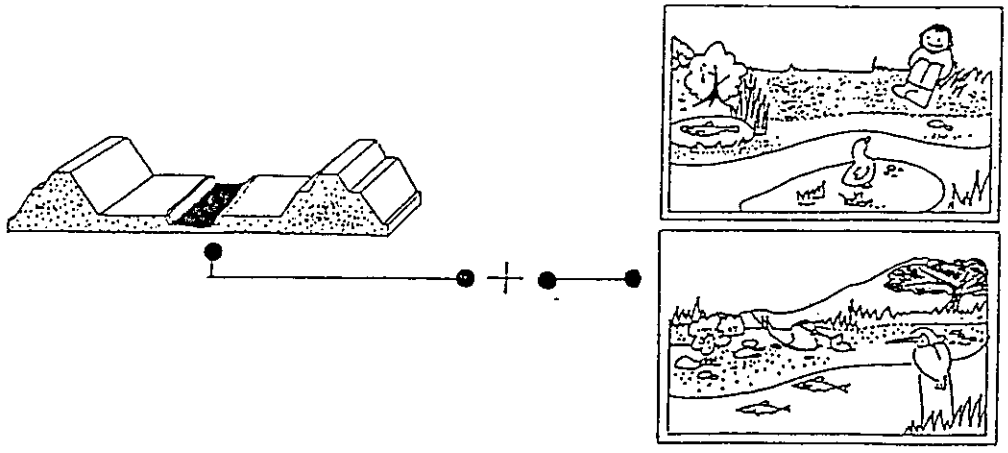
River Terrace Improvement

3) Scenario C(=Scenario A + 2):Improvement which, in addition to the function in Scenario A, lays stress on the function of recreational use of river terrace including waterfront, especially criterion *13 and *14. That means residents can swim and play a boat.

Waterfront Improvement



4) Scenario D(=Scenario A+3):Improvement which, in addition to the function in Scenario A, lays stress on the function of nature protection on the river,precluding recreational uses.



3.3 PRIORITIZATION OF ALTERNATIVES

In this we are concerned with finding priority weights for several alternatives for improvement of riversides. Alternatives were analyzed from the standpoint of the representative of the people(RL:region leader) and project managers(PM:policy maker) according to their desirability through 22 characteristics(Level 5),shown in Table 1, which were selected for the comparison.

(1) Evaluation from the standpoint of RL

This yields the following composite priority vector of the hierarchical level 5 for the alternatives A,B,C, and D,[0.2883, 0.2376,0.1752,0.2989] as shown in Table 1. Thus the overall priority of alternative A is 0.2883, that of B is 0.2376, C is 0.1752, and D is 0.2989. We have now ranked the alternatives on a ration scale according to his overall impact.

The highest priority is alternative D which lays stress on the improvement for nature protection of the river excluding water front(wet place).

(2) Evaluation from the standpoint of PM

This yields the following composite priority vector of the hierarchical level 5 with respect to the alternatives A,B,C, and D, [0.2572,0.3226,0.2692,0.1510] as shown in Table 2. Thus the overall priotity of alternative A is 0.2572, that of B is 0.3226, C is 0.2692, and D is 0.1510. We have now ranked the alternatives on a ration scale according to his overall impact.

The highest priority is alternative B which lays stress on the improvement for recreational use of river terrace excluding waterfront.

(3) Evaluation by 22 criteria

The priorities of the alternatives depend on the value of the 22 criteria in the fifth hierarchical level. Let us see the results of the criteria from the standpoint of RL and PM as shown in Tables 1 and 2. As shown in Table 1, composite priorties of the criteria are 0.2230(No.4 in Table 1), 0.1946(No.12), 0.1109(No.7), 0.0649(No.11), and 0.0581(No.13) in that order.

And as shown in Table 2, the other results are 0.1597(No.4 in Table 2), 0.1540(No.3), 0.1457(No.5), 0.1224(No.13), and 0.0720(No.1) in that order. These constitute of the critera with respect to the function floodwater control.

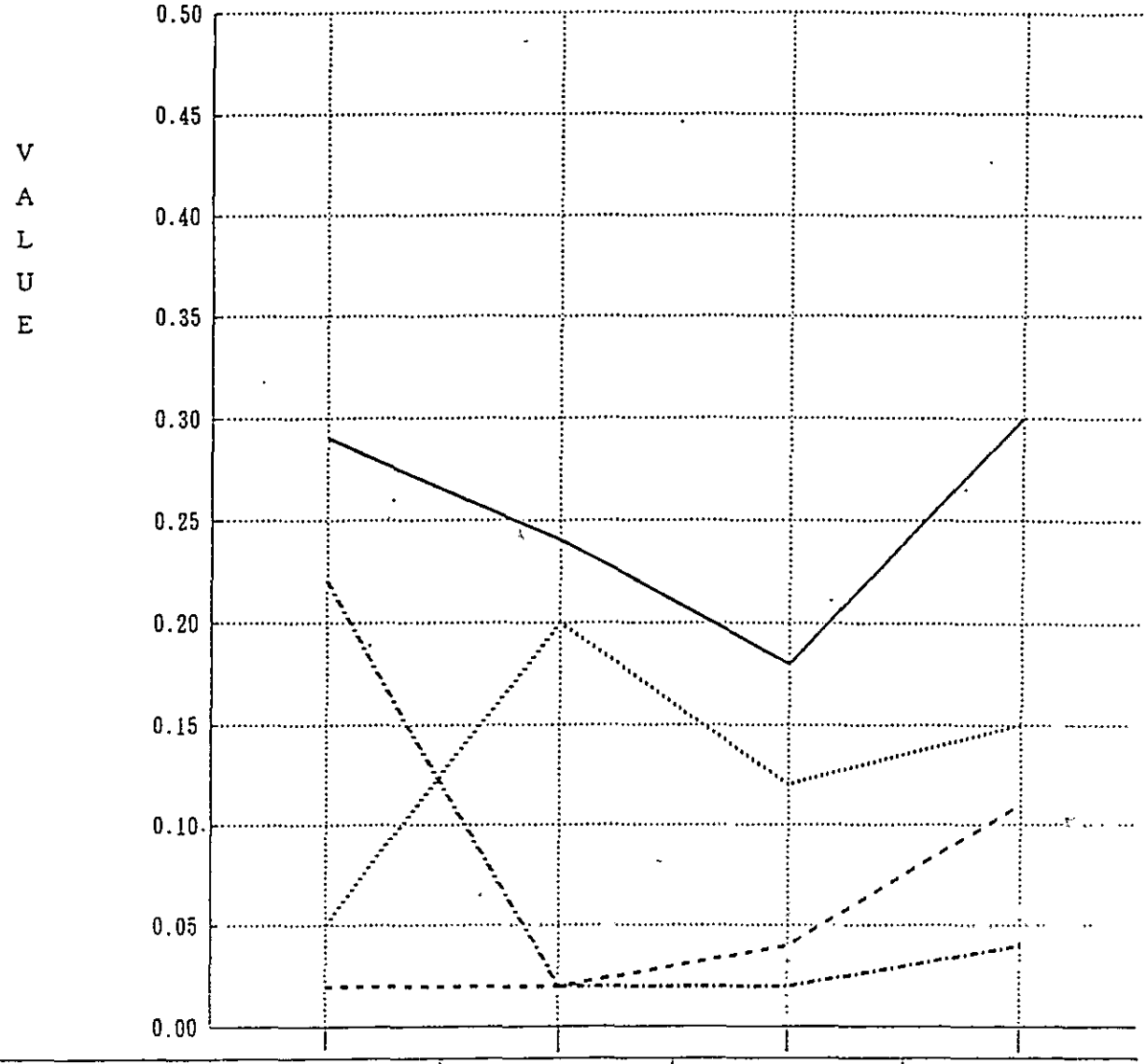
Table 1 Copmarison of alternatives with respect to the characteristics
- Results from the standpoint of R1 -

Level 5		Alternatives				
Characteristics (22)	Rank) Value	A	B	C	D	C. I.
1. Usability of Residential Area	0.0285	0.7292	0.0494	0.0494	0.1720	0.1136
2. Usability of Industrial Area	0.0057	0.7405	0.0598	0.0598	0.1399	0.0514
3. Usability of Recreational Area	0.0285	0.7096	0.0353	0.0788	0.1763	0.2277
4. Protection of Property	1) 0.2230	0.7405	0.0823	0.0641	0.1131	0.0514
5. Network of Transportation (Road)	0.0147	0.7000	0.1000	0.1000	0.1000	0.0000
6. Network of Transportation (Railway)	0.0029	0.7003	0.1000	0.1000	0.1000	0.0000
7. Supply of Water(quantity)	3) 0.1109	0.1199	0.0836	0.1969	0.5996	0.1132
8. Supply of Water(quality)	0.0370	0.0369	0.0806	0.2375	0.6450	0.2842
9. Transportation (Watersurface)	0.0049	0.1182	0.4875	0.2762	0.1181	0.0514
10. Fishery (Watersurface)	0.0247	0.0353	0.0788	0.1763	0.7096	0.2277
11. Access to waterfront	4) 0.0649	0.0565	0.1720	0.5996	0.1719	0.1131
12. Access to riversides excluding waterfront	2) 0.1946	0.1686	0.6132	0.1226	0.0956	0.0514
13. Riverside Activities excluding waterfront	5) 0.0581	0.0730	0.5994	0.2546	0.0730	0.1135
14. Waterfront Activities	0.0213	0.0377	0.0603	0.1898	0.7122	0.2124
15. Flowing	0.0089	0.0484	0.1819	0.1819	0.5878	0.1686
16. Water Revertment/ Embankment	0.0026	0.0544	0.2367	0.5250	0.1839	0.0425
17. Matching with urban landscape(building.etc.)	0.0082	0.0565	0.4052	0.4052	0.1331	0.1131
18. Matching with natural landscape (background.woods.)	0.0246	0.0543	0.4098	0.3107	0.2252	0.1621
19. Protection of Surrounding Vegitation	0.0160	0.0382	0.1162	0.1162	0.7294	0.1131
20. Protection of Fish and so on	0.0385	0.0382	0.1162	0.1162	0.7294	0.1131
21. Protection of Birds and small animals	0.0612	0.0353	0.1123	0.1283	0.7241	0.1434
22. Protection of Fresh water	0.0203	0.0656	0.1295	0.4450	0.3599	0.1940
	(1.0000)					
Composite Priorities		0.2883	0.2376	0.1752	0.2990	1.0000
(rank)		(2)	(3)	(4)	(1)	

Table 2 Copmarison of alternatives with respect to the characteristics
- Results from the standpoint of PM -

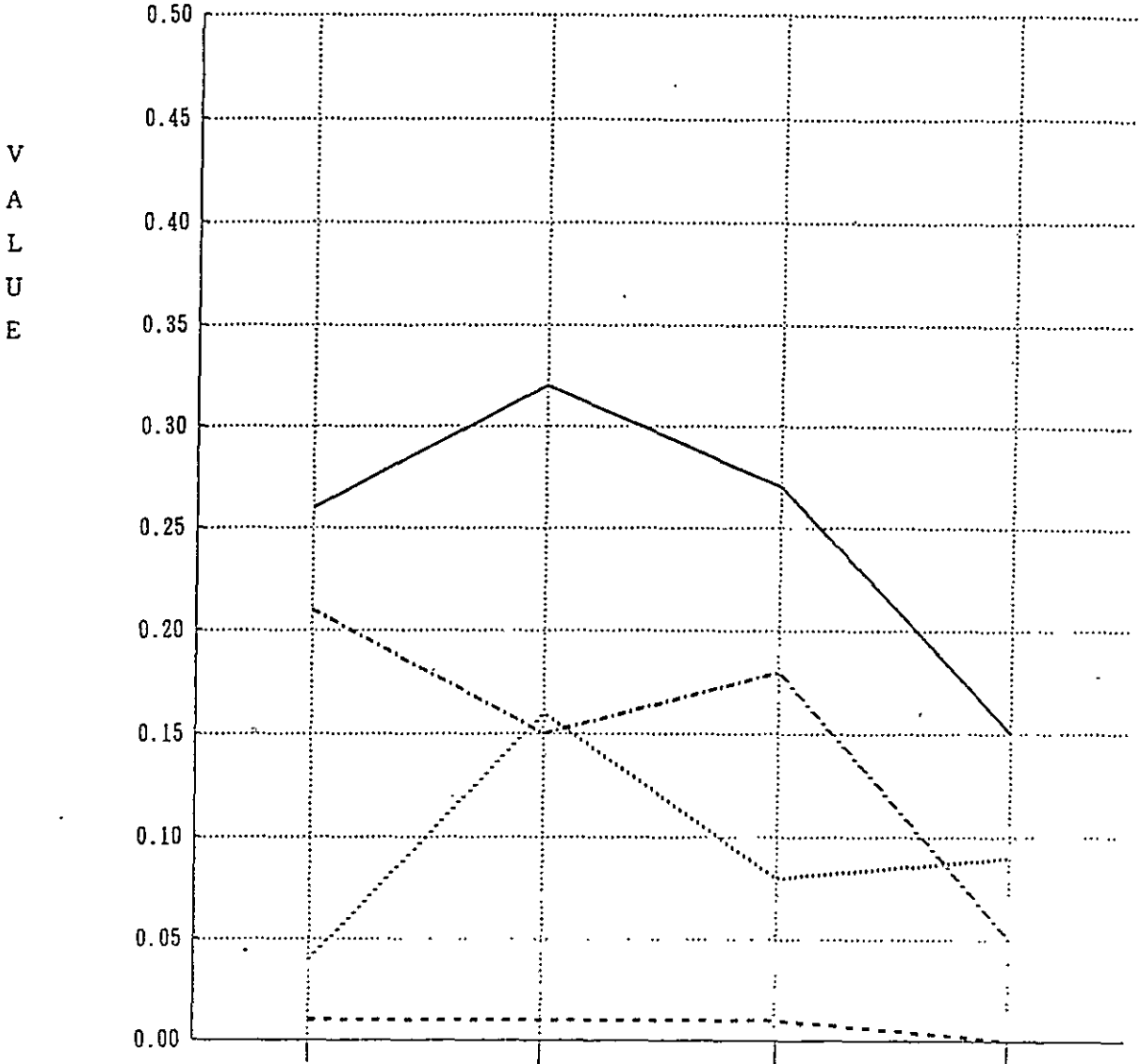
Level 5 Characteristics	Rank)	Value	Alternatives A	B	C	D	C. I.
1. Usability of Residential Area	5)	0.0720	0.0523	0.2908	0.5244	0.1325	0.0238
2. Usability of Industrial Area		0.0330	0.6631	0.2059	0.0802	0.0508	0.1101
3. Usability of Recreational Area	2)	0.1540	0.0735	0.2665	0.5149	0.1451	0.0373
4. Protection of Property	1)	0.1597	0.3081	0.3081	0.3081	0.0757	0.3567
5. Network of Transportation (Road)	3)	0.1457	0.7196	0.1944	0.0430	0.0430	0.1686
6. Network of Transportation (Railway)		0.0211	0.7501	0.0833	0.0833	0.0833	0.0000
7. Supply of Water(quantity)		0.0291	0.4608	0.3113	0.1765	0.0514	0.1163
8. Supply of Water(quality)		0.0010	0.0573	0.0903	0.2212	0.6312	0.1295
9. Transportation (Watersurface)		0.0032	0.1431	0.2876	0.5048	0.0645	0.0660
10. Fishery (Watersurface)		0.0029	0.1125	0.2158	0.5325	0.1392	0.0520
11. Access to waterfront		0.0153	0.0680	0.6492	0.2004	0.0824	0.0552
12. Access to riversides excluding waterfront		0.0458	0.0590	0.6470	0.1908	0.1032	0.0760
13. Riversides Activities excluding waterfront	4)	0.1224	0.1125	0.5325	0.2158	0.1392	0.0520
14. Waterfront Activities		0.0242	0.0738	0.1925	0.4393	0.2944	0.0188
15. Flowing		0.0108	0.0319	0.3227	0.3227	0.3227	0.1286
16. Water Revertment/ Embankment		0.0112	0.0771	0.4403	0.3100	0.1726	0.0222
17. Matching with urban landscape (buildings.)		0.0462	0.0595	0.3552	0.2088	0.3765	0.1556
18. Matching with natural landscape (background.woods.)		0.0131	0.0374	0.2618	0.1879	0.5129	0.0718
19. Protection of Surrounding Vegitation		0.0434	0.1884	0.4623	0.1444	0.2049	0.0271
20. Protection of Fish and so on		0.0097	0.0180	0.1929	0.1879	0.6012	0.9896
21. Protection of Birds and small animals		0.0097	0.0376	0.0727	0.1647	0.7250	0.1379
22. Protection of Fresh water		0.0265	0.1364	0.1364	0.2322	0.4950	0.0201
		(1.0000)					
Composite Priorities			0.2572	0.3226	0.2692	0.1510	1.0000

Figure 2 Priorities of alternatives at the level 5
- From the standpoint of RL -



	A	B	C	D
--- Floodwater	0.2227	0.0229	0.0200	0.0377
-- Water Supply	0.0162	0.0166	0.0364	0.1083
···· Access to W	0.0494	0.1981	0.1188	0.1529
— Composite P	0.2883	0.2376	0.1752	0.2989

Figure 3 Priorities of alternatives at the level 5
- From the standpoint of PM -



	A	B	C	D
··· Floodwater	0.2068	0.1480	0.1770	0.0538
-- Water Supply	0.0143	0.0107	0.0084	0.0028
···· Access to W	0.0361	0.1639	0.0838	0.0944
— Composite P	0.2572	0.3226	0.2692	0.1510

The protection of property from floodwater as the first priority among them is selected by common consent of the two, RL & PM. The value, 0.2230, of RL is rather bigger than the value, 0.1597, of PM.

4. CONCLUSION

We may summarize the results of the foregoing discussions on the priorities of the alternatives. We obtained the results from the standpoint of the representatives, RL and PM. There are several differences between the judgment of RL and PM. One of them is that while RL rates alternative D very high, PM rates alternative D very low. This may imply that RL prefers landscaping and maintenance of the riverside ecosystem to improvement riversides for recreational use.

We can infer that both lay stress on either the function of floodwater control or the function of access to the recreational use and both rate the function, the supply of water, low compared with the other major functions.

We can select the alternative efficiently, though we have to coordinate the differences between RL and PM. But before we can coordinate the alternatives(A,B,C, and D) as possible improvement of riverworks from the judgments, a lot of discussion should be made including group judgments with respect to the alternatives. After further examination we will be able to get a better and wider understanding of decisions concerning riverside improvement from the judgments.

Thus, it is anticipated that the results of this study can make a useful contribution towards the restructuring of public river works to make them attractive to the people and also it can also contribute to performance evaluation of such schemes.

It must be remarked that other studies similar to the present one are necessary in the planning of riverworks projects, particularly studies on the utility of such schemes. This can possibly be the direction of future research.

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Reference: Thomas L. Saaty:"The Analytic Hierarchy Process Planing, Priority Setting, Resource Allocation ,"McGraw-Hill,New York,1980.