Methodological Study on the Evaluation of the Conservation-Utilized Potential of Second-class River on the Urban Fringe Area : A Case Study in the Southern Osaka Prefecture

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Methodological Study on the Evaluation of the Conservation-Utilized Potential of Second-class River on the Urban Fringe Area —A Case Study in the Southern Osaka Prefecture—

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Abstract

This research is a case study focusing on a second-class river on the urban fringe area. Evaluation axes corresponding to each riverine function were established from the viewpoint of conserving and utilizing of the numerous functions possessed by river spaces. A concrete evaluation method was then devised through an examination of evaluation elements and ranks. Then the numerous functions possessed by river spaces were evaluated according to corresponding evaluation elements and ranks from the viewpoint of conservation of the natural environment and utilization to human beings. Through a process of synthesis, a method of evaluating the comprehensive conservation and utilized potential of river spaces was devised.

Purpose of Research

The numerous functions possessed by river spaces have been noted in recent years, and the necessity of consolidation these spaces is now being widely discussed. As a result, there is a pressing need for an accurate method of evaluating riverine functions. This research is a case study of a second-class river on the urban fringe area. Evaluation axes corresponding to each riverine function were established from the viewpoint of conserving and utilizing of the numerous functions possessed by river spaces. A concrete evaluation method was then devised through an examination of evaluation elements and ranks.

Research Method

The subject river in this case study was a second-class river in southern Osaka Prefecture (see Figure 1). Analytic units were set by establishing a 1×1 km mesh over an area that included the subject river. Step 1 in this research consisted of reviewing past literature and research in order to select 22 elements by which to evaluate the numerous functions possessed by river spaces. Ranks were assigned to each element and their validity was tested through a case study. Step 2 consisted of establishing evaluation axes from the viewpoint of conservation and utilization. Then the evaluation elements tested in Step 1 were grouped according to each function that corresponded to an evaluation axis.

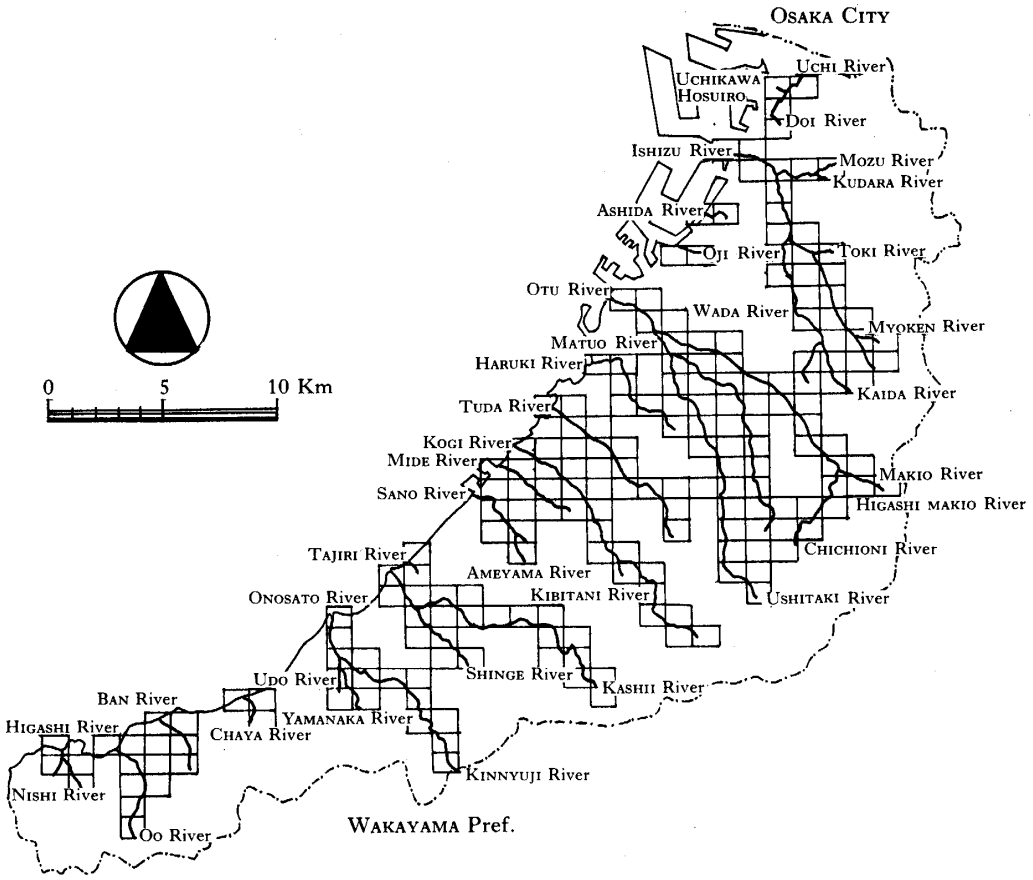

Fig. 1 Location of Subject River

Mesh data from the subject river were used on each grouped evaluation axis in order to quantify evaluation elements as "items" and evaluation ranks as "categories" through application of Type III Mathematical Quantification Theory. The evaluation elements and ranks that make up each evaluation axis were clarified by the arrangement of range values assigned to evaluation ranks. Some problematic evaluation elements were disposed of, and evaluation ranks were restructured. In Step 3 of this research, the evaluation elements and ranks that were restructured in Step 2 were used on the mesh data from the subject river. From the comprehensive viewpoint of conservation and utilization, the data were analyzed using Type III Mathematical Quantification Theory. The validity of this method for evaluating conservation and utilized potential was considered.

Results of Analysis and Discussion

1) Establishment of Evaluation Elements and Evaluation Ranks

(1) *Selection of evaluation elements*

Past literature and research[1-5] were reviewed, and the 22 evaluation elements shown in Table 1 were adopted as means of evaluating the following points: accessibility of river spaces, spatial volume of river spaces, demand for park-use of river spaces, landscape value of river spaces, ecosystem in the vicinity of river, ecosystem of river spaces, and possibility of habitation by wildlife.

Table 1 Evaluation Elements and Ranks

Evaluation Elements	Evaluation Ranks				
Riverside roads	Roads on both sides	Road on one side only	Absence of road		
Direct-route roads	Presence of bus route	Absence of bus route	Absence of road		
Distance from railway station	Less than 1 km	1～2 km	2～5 km	More than 5 km	
River width	More than 60 m	60～40 m	40～20 m	Less than 20 m	
Presence or absence of floodplain	More than 10 m	Less than 10 m	Absence of floodplain		
Distribution of nearby parks	Absence of park (in urban area)	Presence of neighborhood park (in urban area)	Presence of community park (in urban area)	Presence of regional park (in urban area)	Absence of park (in nonurban area)
Population (persons/ha)	More than 40	Less than 40			
Legal status	Urban area	Urbanarea＞nonurbanarea	Urbanarea＜nonurbanarea	nonurban area	
Pleasantness	Highest	Higher	Normal	Lower	Lowest
Openness	Highest	Higher	Normal	Lower	Lowest
Naturalness	Highest	Higher	Normal	Lower	Lowest
Harmony with background	Highest	Higher	Normal	Lower	Lowest
Land use nearby	Natural forest	Artificial forest	Agricultural land	Built up area	
Valuable plants	Presence	Absence			
Animal that are normally present	7 species	6～4 species	3～1 species	Absence	
Valuable animals nearby	Presence	Absence			
Plant life on sandbars, etc.	Much of marsh reed & tree	Much of marsh reed	A little of marsh reed	Absence	
Plant life outside riverbanks	Much of trees	A little of trees	Grass land	Absence	
Plant life within riverbanks	Forest	Grass land	Agricultural land	Street trees	Absence
Number of fish species	More than 21 species	16～20 species	11～15 species	6～10 species	Less than 5 species
Water quality (BOD)	Less than 3.0	5.0～3.1	9.9～5.1	31～10	More than 31
Form of river in cross section	Valley	Natural embankments on both sides	Natural embankments on one sides	Dig down type	Dikes on one side	Dikes on both sides

Table 2 Ratio of Evaluation Ranks

Evaluation Elements	Evaluation Ranks				
Riverside roads	Roads on both sides (19.9%)	Road on one side only (25.0%)	Absence of road (55.1%)		
Direct-route roads	Presence of bus route (26.5%)	Absence of bus route (27.5%)	Absence of road (46.5%)		
Distance from railway station	Less than 1 km (46.9%)	1～2 km (21.4%)	2～5 km (22.4%)	More than 5 km (9.1%)	
River width	More than 40 m (11.7%)	40～20 m (25.5%)	20～10 m (29.6%)	Less than 10 m (33.2%)	
Distribution of nearby parks	Absence of park (in urban area) (25.5%)	Presence of neighborhood park (in urban area) (13.3%)	Presence of community park (in urban area) (18.8%)	Presence of regional park (in urban area) (14.4%)	Absence of park (in nonurban area) (27.6%)
Population (persons/ha)	More than 40 (31.3%)	Less than 40 (68.8%)			
Legal status	Urban area (24.5%)	Urbanarea > nonurbanarea (25.5%)	Urbanarea < nonurbanarea (20.4%)	nonurban area (29.6%)	
Pleasantness	Highest (1.5%)	Higher (21.4%)	Normal (33.2%)	Lower (34.2%)	Lowest (9.7%)
Openness	Highest (7.1%)	Higher (18.4%)	Normal (39.8%)	Lower (25.0%)	Lowest (9.7%)
Naturalness	Highest (14.8%)	Higher (29.1%)	Normal (27.6%)	Lower (17.4%)	Lowest (11.2%)
Harmony with background	Highest (17.9%)	Higher (30.6%)	Normal (31.6%)	Lower (17.4%)	Lowest (2.6%)
Land use nearby	Forest (20.4%)	Agricaltural land (34.7%)	Built up area (44.9%)		
Valuable plants	Presence (5.1%)	Absence (94.9%)			
Valuable animals nearby	Presence (30.1%)	Absence (69.9%)			
Plant life on sandbars, etc.	Much of marsh reed & tree (2.6%)	Much of marsh reed (14.3%)	A little of marsh reed (33.7%)	Absence (49.5%)	
Plant life outside riverbanks	Much of trees (19.9%)	A little of trees (11.7%)	Grass land (23.0%)	Absence (49.4%)	
Plant life within riverbanks	Forest (47.5%)	Grass land (3.6%)	Agricultural land (19.9%)	Street trees (8.2%)	Absence (20.9%)
Number of fish species	More than 21 species (0.0%)	16～20 species (27.6%)	11～15 species (18.4%)	6～10 species (39.3%)	Less than 5 species (14.8%)
Water quality (BOD)	Less than 3.0 (34.7%)	5.0～3.1 (11.7%)	9.9～5.1 (26.0%)	31～10 (24.5%)	More than 31 (3.1%)
Form of river in cross section	Valley (16.8%)	Natural embankments on both sides (5.6%)	Natural embankments on one sides (10.7%)	Dig down type (51.0%)	Dikes on one side (2.0%)	Dikes on both sides (13.9%)

(2) *Discussion of Evaluation Elements and Ranks*

An attempt was made to grasp present conditions in the subject river by using the evaluation elements and ranks mentioned above. Problems related to evaluation element data, interdependency of evaluation elements, and the validity of evaluation rank divisions were clarified. As a result, problems were detected in evaluation elements and ranks having to do with "river width," "presence or absence of a floodplain," "land use nearby," "animals that are normally present," and "number of fish species." Then these evaluation elements and their ranks were restructured as described below.

Regarding "river width," it was found that most of the subject river fell into the "less than 20 meters" rank. This rank was judged to be inappropriate and was therefore divided into a "less than 10 meters" rank and a "10-20 meters" rank. A similar problem was encountered on the subject of floodplains. A large majority of the subject river fell into the "floodplain absent" rank, so it was decided that "presence or absence of a floodplain" was an inappropriate element by which to evaluate a second-class river on the urban fringe area. This element was therefore dropped. With regard to "animals that are normally present," the survey area was small and the data were incomplete, so this evaluation element was also dropped. For two evaluation elements —"land use nearby" and "number of fish species"— there were no locations that could be described by the uppermost ranks of "natural forest" or "more than 21 species," respectively. These evaluation ranks were therefore combined with others.

Based on the above considerations, another attempt was made to grasp present conditions in the subject river by using the restructured evaluation elements and ranks. The results can be seen in Table 2. Validity was confirmed by a more even distribution of observations across evaluation ranks. Another characteristic of the subject river was also clarified; namely that the effects of urbanization were stronger on the lower reaches of the river than on the upper reaches, and stronger in the north than in the south. In areas where urbanization was strongly felt, natural elements were lacking.

2) Discussion of the Evaluation Axes for Evaluating Riverine Functions

(1) *Establishing evaluation axes*

In order to evaluate the numerous functions possessed by river spaces from the viewpoint of conservation of the natural environment and utilization to human beings, evaluation axes were established as shown in Figure 2. Accessibility, usefulness of river spaces, and demand for park-use of river spaces were established as the evaluation axis relating to utilization to human beings (utilized potential). Landscape value, surrounding natural environment, and ecosystem of river spaces were established as the evaluation axis relating to conservation of the natural environment (conservation potential). Evaluation elements tested in the previous experimental step were grouped according to functions that corresponded to these axes.

(2) *Discussion of evaluation axes*

In Step 1, mesh data from the subject river were used on each of the above grouped evaluation axes in order to quantity evaluation elements as "items" and evaluation ranks as "categories" through a case study in which Type III Mathematical Quantification Theory was applied. Taking into consideration the arrangement of range values assigned to evaluation ranks, the validity of the evaluation elements and ranks that made up each axis was discussed.

With regard to accessibility, demand for park-use of river spaces, and surrounding

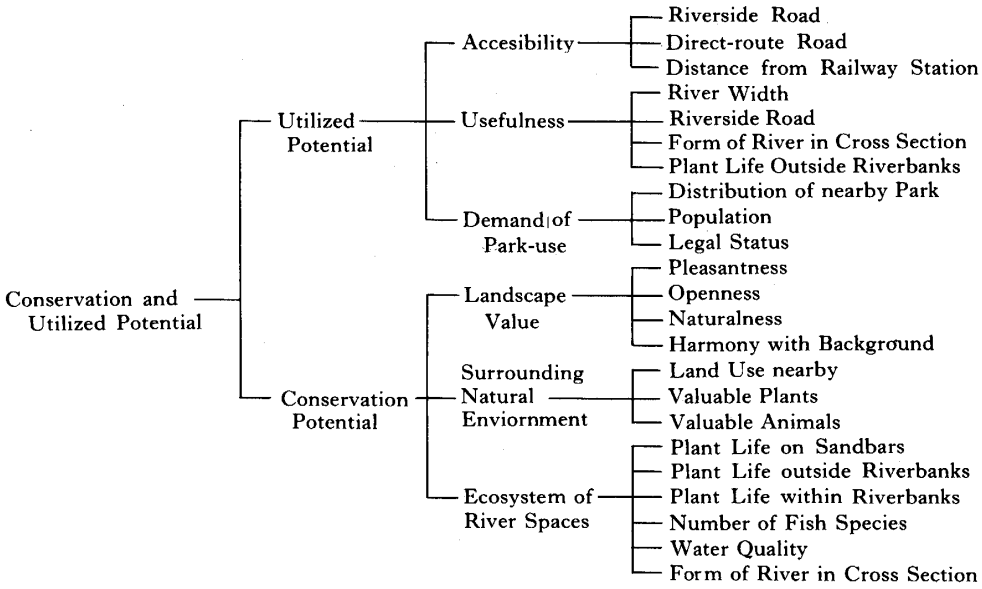

Fig. 2 Evaluation Axes

natural environment, it was found that rangevalues either rose or fell consistently as the range values assigned to each evaluation rank went down. Evaluation axes were therefore thought to be valid because it could be determined that the contents of the evaluation elements making up each axis were homogenous. In contrast, usefulness of river spaces, landscape value, and natural environment of river spaces showed no consistent upward or downward trend as the range values assigned to each evaluation rank went down. Because of this, there were thought to be problems in the contents of the evaluation elements that made up each axis. Therefore, it was thought that the elements "plant life within riverbanks" and "form of river in cross section," both of which were among the problematic evaluation elements making up utilization of river spaces, were actually more suited to evaluating conservation of the natural environment than utilization of river spaces. These two evaluation elements were dropped from the axis, and usefulness of river spaces was evaluated using the two elements "river width" and "riverside roads." Landscape value consisted in part of "openness," but it was thought that "openness" was an element more suitable for evaluating the utilized than the conservation potential of a landscape resource. "Openness" was dropped from the axis, and landscape value was evaluated using the three elements "pleasantness," "naturalness," and "harmony with background." Looking at natural environment of river spaces, it was found that there was little consistency in range values assigned to any of the six evaluation elements. It was thought that the contents of each evaluation element were heterogeneous, so this evaluation axis was split into two, one axis for terrestrial parts of the natural environment and one for aquatic parts. Terrestrial parts of the natural environment was composed of three evaluation elements: "plant life outside riverbanks," "plant life within riverbanks," and "form of river in cross section." Aquatic parts of the natural environment was composed of two evaluation elements: "number of fish species" and "water quality."

In Step 2, the evaluation elements that were restructured in Step 1 were used in the three evaluation axes relating to utilized potential and the four evaluation axes relating to conservation potential. The seven axes were analyzed using the same method as in Step 1 to determine the validity of the elements and ranks by which utilized and conservation potential were evaluated.

The results of the analysis of utilized potential and conservation potential are shown in Figures 3 and 4, respectively. Both analyses showed that within each item, the range values assigned to each evaluation rank generally went down as the number of the rank went down, and any exceptions to this pattern were slight. From this it was determined that the elements and ranks used to evaluate utilized and conservation potential were valid. Using the above analytic results, it can be seen that the utilized potential of the

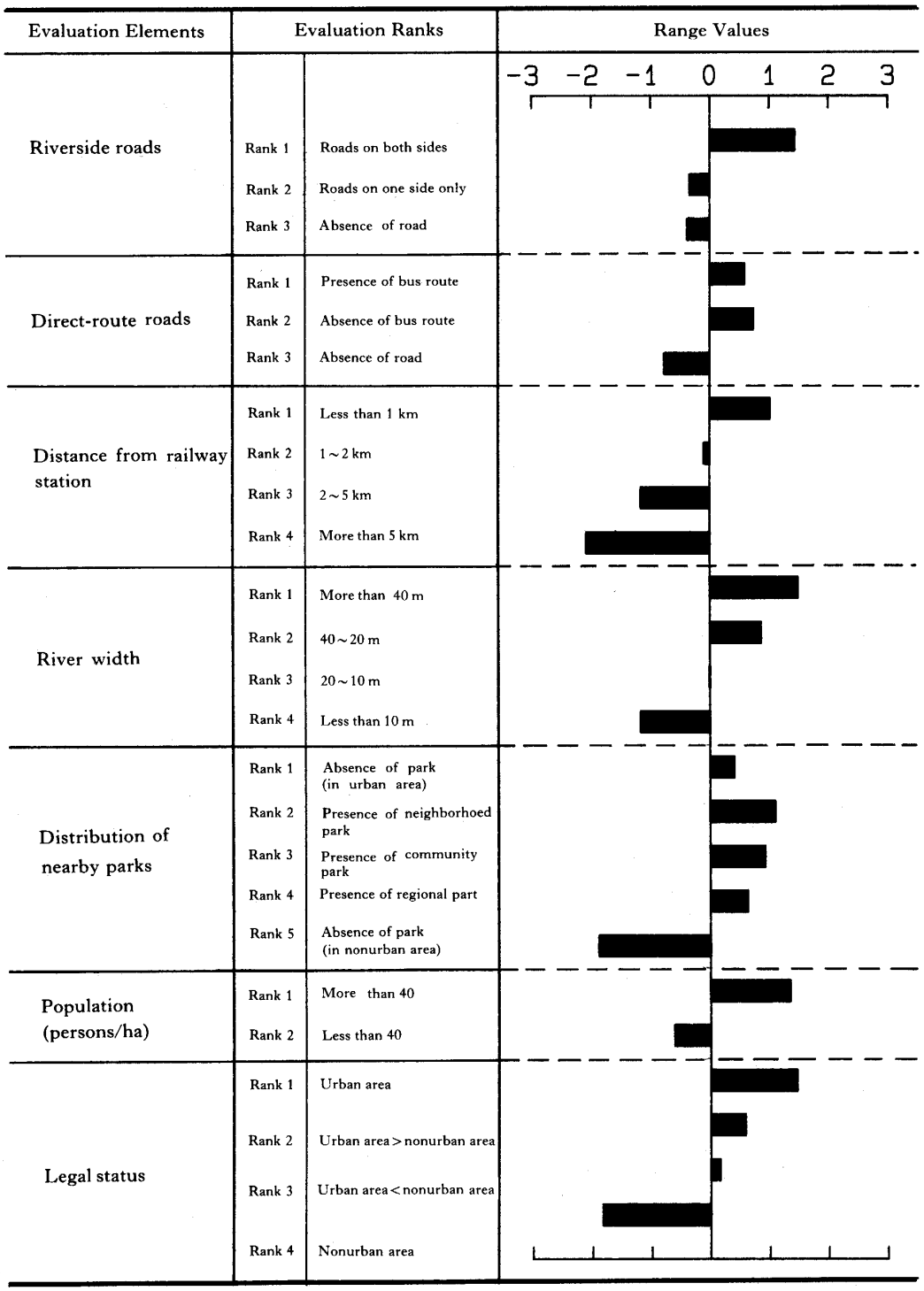

Fig. 3 Results of Analysis of Utilized Potential

subject river was greater on the lower reaches of the river and in the north. The upper reaches of the river and in the southern had less utilized potential. With conservation potential, a nearly opposite pattern was seen. Therefore, it was clear that urbanization had a strong effect on both potentials.

Evaluation Elements	Evaluation Ranks	
Pleasantness	Rank 1	Highest
	Rank 2	Higher
	Rank 3	Normal
	Rank 4	Lower
	Rank 5	Lowest
Naturalness	Rank 1	Highest
	Rank 2	Higher
	Rank 3	Normal
	Rank 4	Lower
	Rank 5	Lowest
Harmony with background	Rank 1	Highest
	Rank 2	Higher
	Rank 3	Normal
	Rank 4	Lower
	Rank 5	Lowest
Land use nearby	Rank 1	Forest
	Rank 2	Agricultural land
	Rank 3	Built up area
Valuable plants	Rank 1	Presence
	Rank 2	Absence
Valuable animals	Rank 1	Presence
	Rank 2	Absence
Plant life outside riverbanks	Rank 1	Much of trees
	Rank 2	A little of trees
	Rank 3	Graes lard
	Rank 4	Absence
Plant life within riverbanks	Rank 1	Forest
	Rank 2	Grass land
	Rank 3	Agricultural land
	Rank 4	Street trees
	Rank 5	Absence
Form of river in cross section	Rank 1	Valley
	Rank 2	Natural embankments on both sides
	Rank 3	Natural embankments on one sides
	Rank 4	Dig doum type
	Rank 5	Dikes on one side
	Rank 6	Dikes on both sides
Number of fish species	Rank 1	More than 16 species
	Rank 2	11～15 species
	Rank 3	6～10 species
	Rank 4	Less than 5 species
Water quality (BOD)	Rank 1	Less than 3.0
	Rank 2	5.0～3.0
	Rank 3	9.9～5.0
	Rank 4	31～10
	Rank 5	More than 31

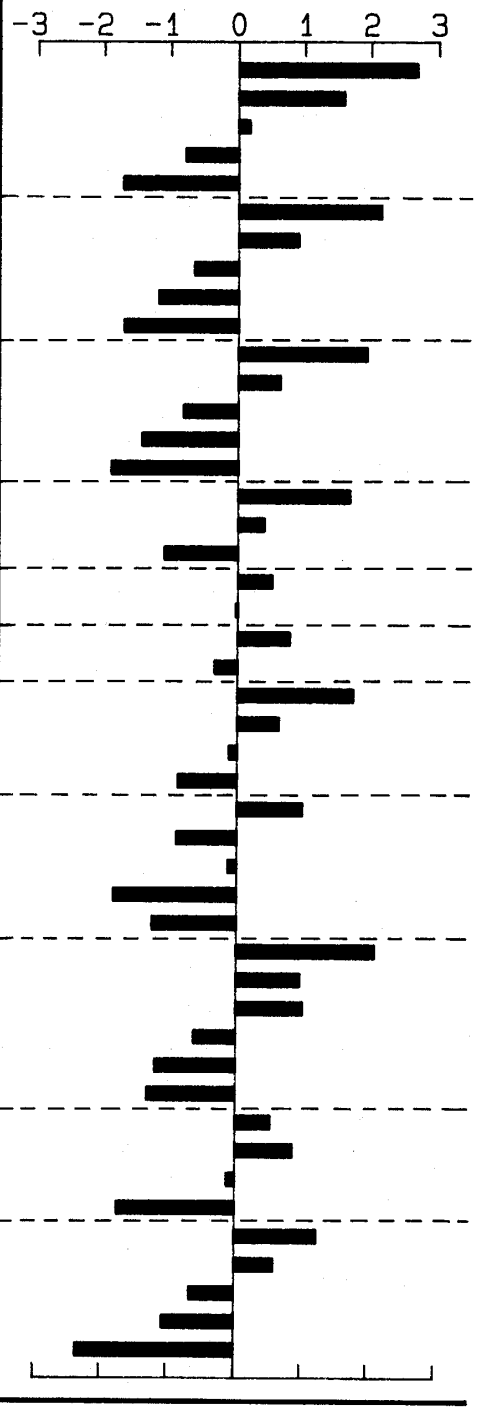

Fig. 4 Results of Analysis of Conservation Potential

3) Discussion of the Method for Evaluating Riverine Functions

Next, the validity of a proposal for evaluating the comprehensive conservation and utilized potential of river spaces was discussed.

In a comprehensive evaluation, the number of evaluation elements is large and the effect of each one is small. In the previous experimental step, it was assumed that evaluations were analogous in cases where the differences between range values assigned

Evaluation Elements	Evaluation Ranks	
Riverside Roads	Rank 1	Road on both sides
	Rank 2	Road on one side or Absence
Direct-route roads	Rank 1	Presence of road
	Rank 2	Absence of road
Distance from railway station	Rank 1	Less than 1 km
	Rank 2	1～2 km
	Rank 3	2～5 km
	Rank 4	Mou than 5 km
River width	Rank 1	More than 40 m
	Rank 2	40～20 m
	Rank 3	20～10 m
	Rank 4	Less then 10 m
Distribution of pearby park	Rank 1	Absence (in urban area)
	Rank 2	Neighborhood and Community Park
	Rank 3	Regional Park
	Rank 4	Absence (in nonurban area)
Population (persons/ha)	Rank 1	More than 40
	Rank 2	Leis than 40
Legal status	Rank 1	Urban area
	Rank 2	Urban area > nonurban area
	Rank 3	Urban area < nonurban area
	Rank 4	Nonurban area
Pleasantness	Rank 1	Highest
	Rank 2	Higher
	Rank 3	Normal
	Rank 4	Lower
	Rank 5	Lowest
Naturalness	Rank 1	Highest
	Rank 2	Higher
	Rank 3	Normal
	Rank 4	Lower
	Rank 5	Lowest
Harmony with background	Rank 1	Highest
	Rank 2	Higher
	Rank 3	Normal
	Rank 4	Lower
	Rank 5	Lowest
Land use nearby	Rank 1	Forest
	Rank 2	Agricultural land
	Rank 3	Built up area
Valuable plants	Rank 1	Presence
	Rank 2	Absence
Valuable animals	Rank 1	Presence
	Rank 2	Absence
Plant life outside riverbanks	Rank 1	Much of trees
	Rank 2	A little of trees
	Rank 3	Grass land
	Rank 4	Absence
Plant life within riverbanks	Rank 1	Forest
	Rank 2	Grass land
	Rank 3	Agricultural land
	Rank 4	Street trees
	Rank 5	Absence
Form of river in cross section	Rank 1	Valley
	Rank 2	Natural embankments
	Rank 3	Dig down type
	Rank 4	Dikes type
Number of fish species	Rank 1	More than 16 species
	Rank 2	11～15 species
	Rank 3	6～10 species
	Rank 4	Less than 5 species
Water quality (BOD)	Rank 1	Less than 3.0
	Rank 2	5.0～3.1
	Rank 3	9.9～5.1
	Rank 4	30～10
	Rank 5	More than 30

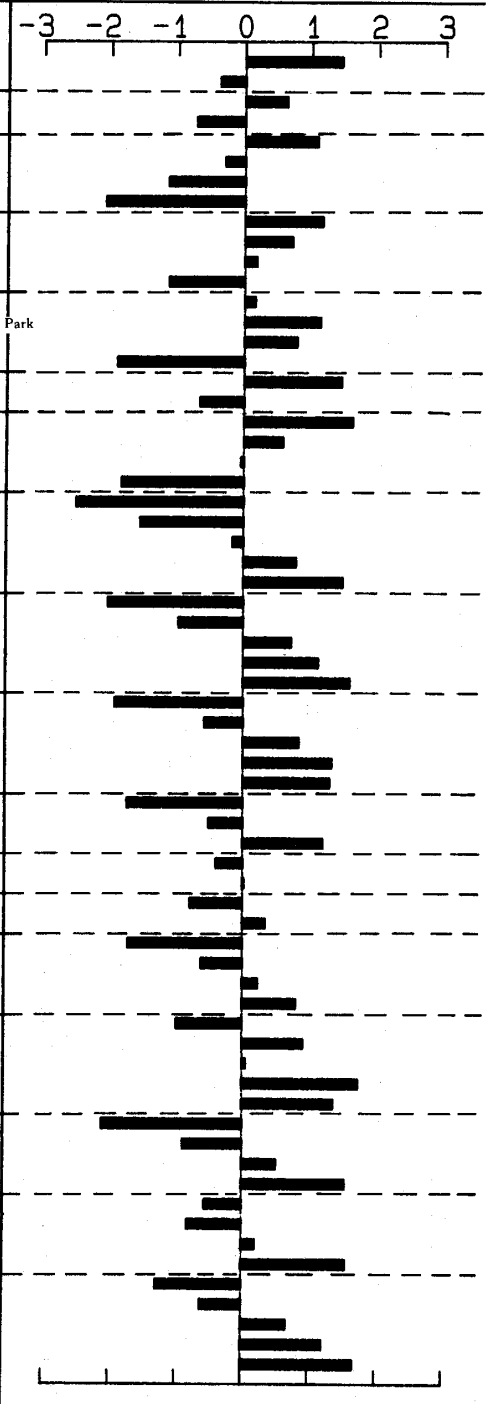

Fig. 5 Results of Analysis of Conservation and Utilized Potential

Table 3 Evaluation Elements and Ranks

Evaluation Elements	Evaluation Ranks				
Riverside roads	Roads on both sides	Road on one side only or Absence of road			
Direct-route roads	Presence of road	Absence of road oute			
Distance from railway station	Less than 1 km	1～2 km	2～5 km	More than 5 km	
River width	More than 40 m	40～20 m	20～10 m	Less than 10 m	
Distribution of nearby parks	Absence of park (in urban area)	Presence of neighborhood and community park (in urban area)	Presence of regionaly park (in urban area)	Absence of park (in nonurban area)	
Population (persons/ha)	More than 40	Less than 40			
Legal status	Urban area	Urbanarea＞nonurbanarea	Urbanarea＜nonurbanarea	nonurban area	
Pleasantness	Highest	Higher	Normal	Lower	Lowest
Naturalness	Highest	Higher	Normal	Lower	Lowest
Harmony with background	Highest	Higher	Normal	Lower	Lowest
Land use nearby	Forest	Agricultural land	Built up area		
Valuable plants	Presence	Absence			
Valuable animals nearby	Presence	Absence			
Plant life outside riverbanks	Much of trees	A little of trees	Grass land	Absence	
Plant life within riverbanks	Forest	Grass land	Agricultural land	Street trees	Absence
Form of river in cross section	Valley	Natural embankments	Dig down type	Dikes type	
Number of fish species	More than 16 species	11～15 species	6～10 species	Less than 5 species	
Water quality (BOD)	Less than 3.0	5.0～3.1	9.9～5.1	31～10	More than 31

to evaluation ranks were very small. In such cases, ranks were combined as described below.

In the "riverside roads" evaluation element, the ranks "road on one side only" and "roads on both sides" were combined. In the "distribution of nearby parks" element, "neighborhood park along riverside" and "community park along riverside" were combined. In the "form of river in cross section" element, "natural embankments on both sides" and "natural embankment on one side" were combined, as were "dikes on both sides" and "dike on one side." As shown in Table 3, this resulted in 18 evaluation elements, each divided into two to five ranks. A proposal was made for evaluating the overall conservation and utilized potential of a river space using these ranks. Mesh data from the subject river were assigned to the evaluation ranks, and the validity of the proposed evaluation method was determined in a case study that was carried out through application of Type III Mathematical Quantification Theory.

As shown by the analytic results of conservation and utilized potential in Figure 5, some reversal phenomena can be seen in the range values assigned to each evaluation rank, but these inconsistencies were extremely small. Furthermore, negative values were given to high evaluation ranks that related to utilized potential, while positive values were given to high evaluation ranks that related to conservation potential. Confirmation of this consistent trend indicated that the elements and ranks that were proposed for evaluating conservation and utilized potential in this research were valid.

Based on the above analytic results, one can see that the upper evaluation ranks become less prevalent as the focus of the study shifts from the lower reaches of the river to the upper, and from the north to the south. At the same time, utilized potential goes

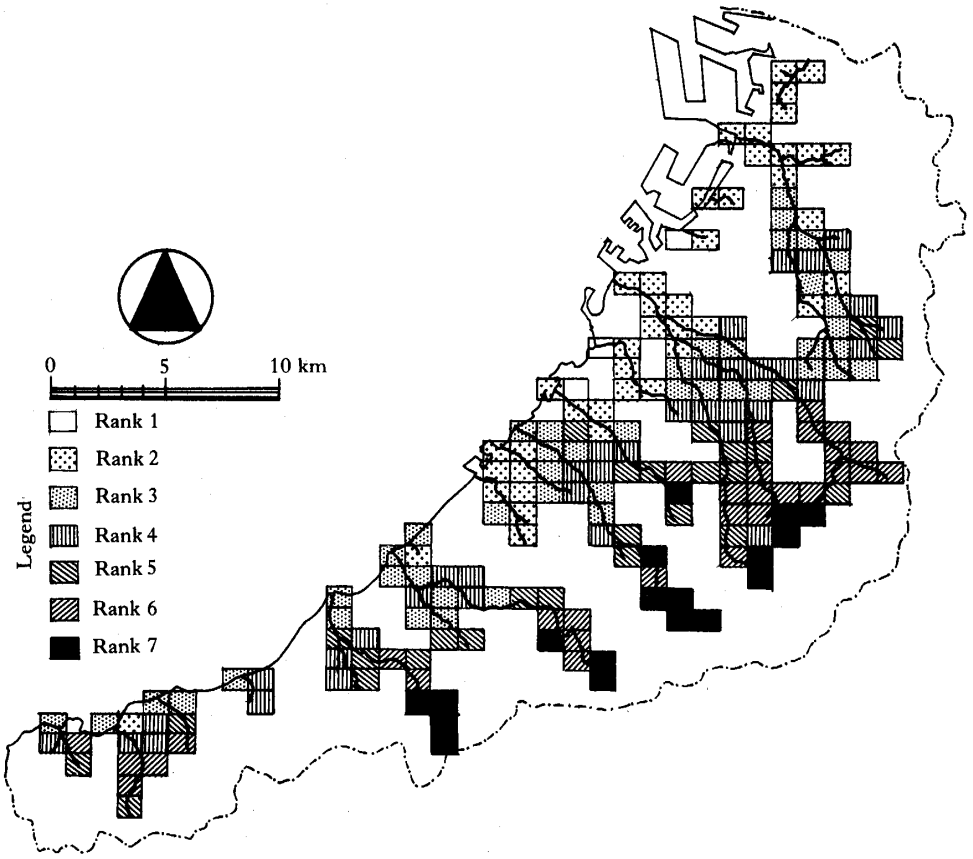

Fig. 6 Conservation and Utilized Potential of Subject River

down where conservation potential is high.

Conclusion

As described above, the numerous functions possessed by river spaces can be evaluated from the viewpoints of conservation of the natural environment and utilization to human beings. A comprehensive evaluation method based on evaluation elements and ranks that corresponded to each riverine function was proposed. However, the spatial volume of a second-class river on the urban fringe area is limited, so it can be said that the conservation and utilized potential of such a river are directly affected by urbanization in the vicinity of the river. It is no exaggeration to say that these potentials are prescribed by the extent of urbanization.

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