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The Right to Urban Streams: Quantitative Comparisons of Stakeholder Perceptions in Defining Adaptive Stream Restoration

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Abstract: Assuring healthy streams in the urban environment is a major goal for restoration scientists, urban planners, and city practitioners around the globe. In South Korea, many urban stream restoration efforts are designed to provide safe water to society and enhance ecological functions. We examined the extent to which the individual interests and different values of multiple stakeholders were considered in previous decision-making in two urban stream restoration projects. The relevant data on stream restoration were collected through the nominal group technique (NGT) and the analytic hierarchy process (AHP) for the two stream cases of a populated inland area and a coastal region in South Korea. The AHP results provide information about the comparative weights of the values of ecological restoration (priority score: 0.487), social restoration (priority score: 0.231), and landscape revitalization (priority score: 0.279) of the Ahn-Yang stream and ecological restoration (priority score: 0.527), social restoration (priority score: 0.182), and landscape revitalization (priority score: 0.290) of the Sahn-Jee stream. The stakeholders of the populated metropolitan area had a relatively high awareness of their role in environmental restoration, thus it was natural for them to place a high value on social restoration.

Keywords: urban stream restoration; stakeholder perceptions; analytic hierarchy process; nominal group technique analysis; comparative stakeholder analysis

1. Introduction

Water resources researchers and practitioners have recently worked on stream restoration projects to cope with urban change, such as ecosystem destruction and flooding caused by human activities, seeking the most sustainable solutions for the degradation of urban river systems through the integration of multiple concepts [1]. The success or failure of urban stream restoration may be evaluated by addressing the various interests of the residents [2,3]. However, many stream restoration cases tend to rely on the evaluation and implementation of only scientific and engineering efficiency. Aiming to meet these only technical standards, technocratic stream restoration mainly seeks to achieve water quality improvement and ecological enhancement in a short period of time. Therefore, the technocratic approach cannot adequately address the nonscientific interests of stakeholders. For example, citizen groups who use riverfront space may value more recreational activities than ecological enhancement. As such, the decisions directed by technical information with little integration of social values frequently cause conflict and mismatches among stakeholders who have different views and perceptions about stream restoration [4,5]. Consequently, different interests among different stakeholders often hinder a consensus decision-making system for urban stream restoration.

This study was motivated to investigate how the agendas of various key stakeholders can be relatively prioritized within the decision-making process of stream restoration management in South Korea and how much influence the different values hold for each stakeholder. The critical point here is that the perceptions of stakeholders, in addition to environmental issues, have become recognized as an essential factor in the decision-making process for stream restoration. Thus, this study examined the contribution of stream restoration stewardship, such as governance, from the viewpoints of the main interested parties. Before addressing some possible key factors in long-lasting, sustainable stream management that integrates participatory, transparent, and rigorous conditions, it is crucial to understand and review the temporal changes in stakeholder opinions [6]. By applying the snowball sampling method, the citizen group representatives were selected as key stakeholders of the study since most citizens depend on how they reflect and accept the policies, strategies, and plans on stream restoration [7].

We sought to answer the following research questions: (1) "What factors are considered to be the most important by each representative stakeholder?"; (2) "To what extent do the different stakeholders consider the various values related to urban stream restoration cases in Korea?"; (3) "How differently are urban stream restoration management agendas shaped between highly urbanized inland and less urbanized coastal regions?" Using the analytic hierarchy process (AHP), we showed the relative importance and priorities among each stakeholder's values within representative urban stream restoration projects in South Korea. This study considered sustainable opportunities to potentially understand stakeholders' diverse preferences for the restoration and conservation of urban stream systems. Therefore, the results will offer potential strategies for restoring urban streams in the future by investigating typical cases of coastal river restoration in urbanized island areas and river restoration in inland urban areas.

2. Conceptual Synopsis

The concept of river restoration ranges from revegetation programs through reflooding wetlands to remeandering rivers and reintroducing indigenous species and has been positively described as creative conservation [8]. The ideal goal of ecological restoration is to return an area to the original or natural state, which is often defined as the predisturbance state. That is, good ecological restoration work seeks to reestablish not only the predisturbance natural appearance of the environment but also its natural functions, such as regulating flow and water temperature and providing aquatic habitat [9].

Despite the importance of the ecosystem context, river restoration projects are as much a social undertaking as an ecological one [10,11]. Societal perceptions and expectations for river restoration projects ultimately determine whether it is a viable management option. The involvement of residents in the decision-making for river restoration projects is growing, and they have diverse preferences, institutional mandates, and expertise [12]. Therefore, restoration success is often judged on social considerations, which can be highly contentious, rather than on ecological performance [13].

Various perceptions of the meaning of restoration reflect the wide disparities in stakeholder interests, scientific knowledge, scales of interest, and the system constraints encountered in practice. In the language of river management, restoration describes activities ranging from quick fixes, such as bank stabilization, fencing, or the engineering of fish habitat at the reach scale, to river-basin-scale manipulations of ecosystem processes and biota over decades [12]. From a study of more than 38,000 restoration projects, Bernhardt et al. [14] found that the most commonly stated goals for river restoration in the United States were to (1) enhance water quality, (2) manage riparian zones, (3) improve in-stream habitat, (4) improve fish passage, and (5) improve bank stabilization. Determining what constitutes improved river conditions is highly subjective. Improvements may focus on the protection of property or on esthetic or recreational enhancements that do not necessarily improve ecological functions [14]. Therefore, the objectives of restoration can be defined differently according to the status of the stream or the demands of residents.

Rivers in mountainous cities are usually confronted with problems of short response time to peak flow, water shortages in the dry season, anthropization of the river channel, and degradation of aquatic habitat. In addition to the traditional requirements of flood control and drainage, urban rivers also have the functions of providing habitat, landscape, and recreation [15]. Therefore, two totally different streams in mountainous and urban regions usually have very similar demands from residents. Because the two streams included in this study were located in urbanized regions, it was assumed that the main goal of river restoration projects consisted of three specific common objectives: ecological improvement, flood control, and adequate streamflow during the dry period.

Successful stream restoration projects would not include only the achievement of water quality enhancement according to scientific quantitative indicators or the use of new engineering technologies without considering stakeholders' collaborative efforts. The efforts of the stakeholders cannot be evaluated using scientific measurement systems alone, but the contributions of the main stakeholders to the project's policy implementation process can be observed. However, there have been few studies or public documents that describe the various collaborative restoration efforts by stakeholders and the adoption of their values about urban stream restoration projects. Thus, this study was highly motivated to recognize, analyze, and understand the values of diverse stakeholder groups living along an urbanized stream, and it aimed to address how their values changed and identify the solutions for accomplishing long-term sustainable stream restoration after quantifying stakeholders' preferences.

3. Study Area

3.1. Ahn-Yang Stream

The Ahn-Yang stream is a tributary of the Han River in Korea. The study stream has a length of 32 km and a catchment area of approximately 287 km^2 [16]. In the Ahn-Yang stream watershed, 14 local governments oversee the 3.5 million people who live along this stream [17]. Due to the proximity to the political and economic capital of Korea, Seoul, the Ahn-Yang region experienced rapid urbanization and industrialization after the Korean War (1950–1953) [18]. Social and industrial changes in the Ahn-Yang negatively influenced the water quality and ecosystem of the Ahn-Yang stream [19]. Ultimately, the severe contamination of the Ahn-Yang stream prompted citizen stakeholder groups to work together for the stream restoration [20,21].

Before 1999 (Figure 1a), the Ahn-Yang city government undertook several engineering projects aimed at cleaning up the polluted local streams further downstream. However, those projects were unsuccessful due to the continuous dumping of waste by residents and wastewater flowing into the streams from nearby industrial sites. Since the late 1990s, various efforts through citizen mobilization and governmental collaboration have improved water quality. According to the Ministry of Environment [22], the downstream biochemical oxygen demand (BOD) level of the Ahn-Yang stream was 19.8 mg/L in 1994 but dropped dramatically to 3.2 mg/L in 2017 (Figure 1b).

In terms of ecological restoration (ER) based on traditional stream restoration paradigms, the water quality of 2005 was drastically improved compared to the results from 2001 for the Ahn-Yang stream. With growing citizen interests in environmental restoration, the new mayor of the Ahn-Yang highly valued a participatory decision-making process for stream restoration. Thus, the municipal government of the Ahn-Yang [23] agreed that the interests of stakeholders and their active participation in the process must be considered in evaluating the success of water quality improvement.

(**a**) (**b**)

Figure 1. Scenes of pre and post Ahn-Yang stream restoration near the city of Ahn-Yang: (**a**) Paved and covered urban stream; (**b**) Opened and restored urban stream. (Source: J. Kim 2014.).

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3.2. Sahn-Jee stream

The Sahn-Jee stream flows through Geonip-dong and Ildo 1-dong, the city of Jeju, South Korea's Jeju special self-governing province, and passes through the downtown areas of Jeju city [24]. The river is 12.90-km long, has a basin area of 11.69 km^2, and has an average width of 0.91 km. With an average shape factor of 0.07, this river path shows a slender stream type and does not have any tributary stream [25].

On the volcanic island of Jeju, local urbanites referred to the Sahn-Jee stream (Sahn-Jee Spring) as "living water" because communities obtained water from springs such as the Sahn-Jee stream and used it for drinking, laundry, washing, bathing, and watering livestock and fields [26]. This is the typical evidence that explains the human-water interactions in Jeju that are offered by the basin hydrological characteristics, as stated by Wada et al. [27].

In the 1960s, when industrialization was underway, the dense concentration of houses caused problems of raw sewage and waste contamination. Until 1965, the lower part of the Sahn-Jee stream was connected to the port of Jeju, which is the gateway to Jeju. Against that backdrop, the Sahn-Jee stream was covered and reconstructed in 1966 to create parking and road space as well as a commercial market area in the city. Due to continuous pollution problems even after changing the land use by covering the stream and its adjacent areas, restoration projects have become an issue of public concern and aimed to reopen the covered urban structures. The restoration began in 1995 and lasted until 2003 as the pollution problems continued to arise even after the restoration (Figure 2a). The restoration project was planned on the grounds that the concentration of residential and commercial districts in downtown Jeju would cause various kinds of issues, such as coastal flooding and the accumulation of urban waste, which would damage the beauty of the cityscape. Under the reconstruction project, 14 commercial buildings were constructed, and 286 building owners were moved in, contributing to the local economy by creating the main shopping district of Jeju city.

(a) (b)

Figure 2. Pictures of scenes of pre and post Sahn-Jee stream restoration near the city of Jeju: (**a**) Paved and covered urban stream; (**b**) Opened and restored urban stream. (Source: S. Yang 2010.).

The major part of the restoration project was completed in 2003, and it was transformed into a high-quality stream (BOD: 0.9 mg/L in 2019) for visitors and residents of Jeju Island via stream restoration based on conventional levee construction (Figure 2b). Furthermore, for the first time in South Korea, the riverfront structure was remodeled into an ecologically friendly coastal stream, with many species of fish inhabiting the river system.

4. Methods and Results

We designed the mixed methodology to combine information using analytic tools, including the nominal group technique (NGT) and AHP, to quantitatively observe and review the stream restoration process. Based on the result sets from the NGT and AHP, the t-test tool was performed to compare the difference in the essential stream restoration goals between the two sample groups of Ahn-Yang and Sahn-Jee streams (Figure 3).

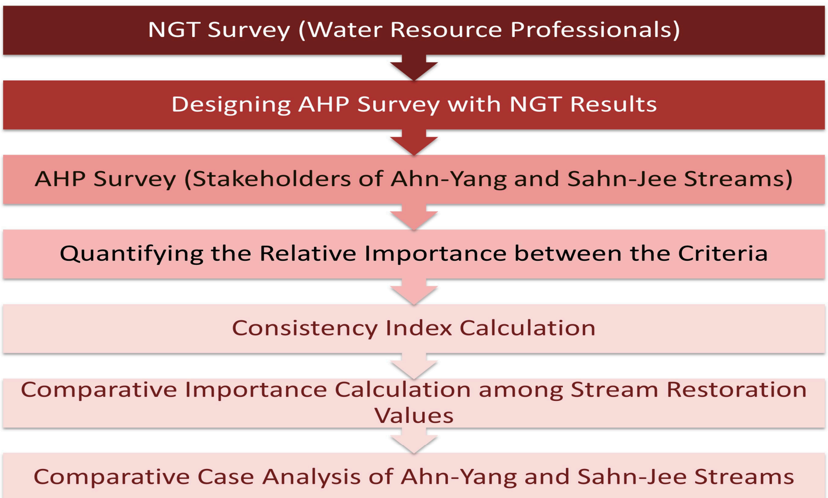

Figure 3. Flowchart of the research design. NGT: nominal group technique; AHP: analytic hierarchy process.

4.1. Nominal Group Technique (NGT)

The NGT is a structured, multistep, facilitated group decision-making technique that elicits and uses rankings to prioritize responses to specific questions [28]. "The primary advantage of the NGT is the enhanced opportunity for all participants to contribute many ideas and to minimize the domination of the process by more confident or outspoken individuals" [29]. Generally, the NGT helped to rank the values, and the top-ranked three values were then used in the survey questions in the AHP questionnaire. Additionally, the NGT and AHP methods were used to support and assist in analyzing the decision-making process; this combination is particularly suited for integrated water resource management considering multiple interests and goals [30].

Our research team implemented the NGT survey with 16 water resource professionals who were involved in urban stream restoration projects. The NGT participants, who requested anonymity, were asked to rank the top three crucial values regarding urban stream restoration. Subsequently, the AHP survey was designed using the NGT results to quantify the pairwise relative importance between the objectives (criteria) rated in the NGT.

4.2. Survey Construction

This study consisted of seven steps, as shown in Figure 1. Generally, the AHP provides a systematic multiple-criteria decision-making method for the pairwise comparison and weighting of the multiple criteria and alternatives of the stakeholders. In the first step, the stream restoration objectives were selected from a set of specific interests of the stakeholders that were obtained through the NGT [31,32]. Second, our research team established the hierarchy structure to set the main goal and several subobjectives (criteria) of urban stream restoration before the field survey. Third, the stakeholder-oriented AHP survey was conducted in Kyonggi Province in 2015 and Jeju self-governing province in 2019 by our research team in South Korea. The fourth step quantified the relative importance between the criteria through pairwise comparisons. In the fifth step, a consistency index (*CI*) was calculated to test the consistency of all weights. Finally, the results were analyzed after being filtered by using the standard ($CI < 0.1$) following Saaty [33]. Thus, if the *CI* is 0, the pairwise model can be regarded as having perfect consistency.

$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{1}$$

The *CI* was calculated where λ_max is the principal eigenvalue, and the changes between values imply the possible range of the changes. The model can be evaluated regarding the λ_max, with the difference between this λ_max and n being a good measure of consistency.

The AHP survey form was designed based on the NGT results, which indicated that ecological restoration (ER), social restoration (SR), and landscape revitalization (LR) were the top three attributes in stream restoration. LR implicitly consists of flood prevention and spatial redevelopment. According to a general NGT process modeled and created by Totikidis [34], this study designed the NGT survey process to occur before the AHP. The first stage of the NGT survey was to generate and record ideas as well as to introduce the significance of this work through email interviews or internet phone calls before the scheduled AHP survey. Second, a corresponding email was sent to ask the participants to discuss and clarify their ideas about urban stream restoration. The third stage was to ask them to vote and rate the values (beliefs and preferences) in their regional stream restoration projects. The interviewees rated the top three values for the Ahn-Yang and Sahn-Jee stream restoration. The last stage was to calculate and sum the ratings.

Before the field trip to the Ahn-Yang stream and Sahn-Jee stream in Korea, the NGT survey was conducted with water resource professionals who worked for and participated in the urban stream restoration projects of South Korea for more than ten years. The NGT survey requests were initially sent to 41 water resource professionals. Only 16 NGT interviewees, who requested anonymity, were able to answer to rank their top three most significant values in order of individual preference. These requests invited respondents from various groups of water professionals, public administrators, NGO representatives, and private engineering contractors to participate. To calculate the total score of their priorities, the first and second places were scored as 3 and 2 points, respectively, and the third place was scored as 1 point.

After calculating the results of the NGT analysis, the survey format and items for the AHP could be confirmed. As the respondents of the NGT analysis requested, a closed-door survey was conducted for approximately 30 min: it was designed as a blind interview, and thus they did not know who was invited to the NGT analysis survey. The results are described in Table 1. After reviewing and reflecting on the results, the AHP survey was sequentially designed to consider the relative priorities of the values of ER, SR, and LR. Each interviewee gave their relative preferences as the quantitative rated scores.

Table 1. The survey results of the NGT: priorities among diverse values.

Value in Stream Restoration	Priority Rank	Summed Score of Priority Value
Ecological Restoration (ER)	1	31
Social Restoration (SR)	2	10
Flood Prevention	3	9
Spatial Regeneration	3	9

4.3. Survey Deployment and Assessment

We conducted this AHP survey in 2015 for the Ahn-Yang stream case and in 2019 for the Sahn-Jee stream case. The year 2015 was approximately 10 years after the restoration of the Ahn-Yang basin, and 2019 was approximately 10 years after the restoration of the Sahn-Jee stream to its current spatial appearance. By analyzing the AHP survey results, the pairwise comparisons were assessed by pairing (1)ER and SR, (2)ER and LR, and (3)SR and LR. These comparisons indicated relative significance between the matched criteria (values). The AHP helped to calculate the relative importance of the three criteria. To maintain dependable reliability, the AHP results were calculated under the condition of CI < 0.15, as illustrated in the result tables (Tables 2 and 3). This study result was then extended to discuss and conclude that one criterion was relatively more important in the pairwise comparison when compared to the other two criteria. In addition, we assumed that the specific stakeholder groups might indicate preferred tendencies during agenda-setting for stream restoration.

Table 2. The relative importance test results of the AHP with Ahn-Yang stakeholders' values.

Group	Number of Total Data	Number of Available Data	Weighted Values						
			Ecological Restoration (ER)		Social Restoration (SR)		Landscaping Revitalization (LR)		Average CV
			Weighted Value	CV	Weighted Value	CV	Weighted Value	CV	
NGO	6	6	0.577	0.265	0.309	0.363	0.112	0.664	0.430
PA	9	9	0.488	0.404	0.322	0.429	0.189	0.592	0.475
WP	6	6	0.577	0.315	0.232	0.998	0.189	0.378	0.564
C	7	6	0.499	0.421	0.172	0.881	0.327	0.591	0.631
PE	5	4	0.298	0.700	0.120	1.011	0.580	0.566	0.759
Average	6.6	6.2	0.487	0.421	0.231	0.736	0.279	0.558	0.571

NGO: non-governmental organization, PA: public administrators, WP: water professionals, C: citizens, PE: private engineers, CV: Coefficient of variation.

Table 3. The relative importance test results of the AHP with Jeju Sahn-Jee stream stakeholders' values.

Group	Number of Total Data	Number of Available Data	Weighted Values						
			Ecological Restoration (ER)		Social Restoration (SR)		Landscaping Revitalization (LR)		Average CV
			Weighted Value	CV	Weighted Value	CV	Weighted Value	CV	
NGO	11	8	0.637	0.216	0.161	0.093	0.201	0.260	0.190
PA	8	8	0.609	0.072	0.258	0.070	0.132	0.090	0.077
WP	9	8	0.618	0.128	0.124	0.071	0.256	0.138	0.112
C	14	9	0.472	0.287	0.284	0.216	0.242	0.231	0.245
PE	8	8	0.299	0.180	0.083	0.039	0.617	0.188	0.141
Average	10	8.2	0.527	0.180	0.182	0.098	0.290	0.181	0.153

NGO: non-governmental organization, PA: public administrators, WP: water professionals, C: citizens, PE: private engineers, CV: Coefficient of variation.

We tried to verify the normal distribution between the stream restoration management stakeholder groups by evaluating the coefficients of variation and the variances in a two-tailed independent sample t-test with R. This research compared the means of the two respondent groups for the Ahn-Yang and Sahn-Jee streams from this AHP survey platform.

5. Comparative Review of Results

5.1. The Ahn-Yang Stream Case

As shown in Table 2, the relative weighted values (measuring pairwise relative importance) in the five stakeholder groups of professional and government participants within the decision-making network for the restoration of the Ahn-Yang stream had varying priorities in stream restoration (Figure 4). In particular, most respondents valued ER as the most important factor (0.487). The interest in SR and LR was lower than that in ER. The weighted values of SR and LR were 0.231 and 0.279, respectively.

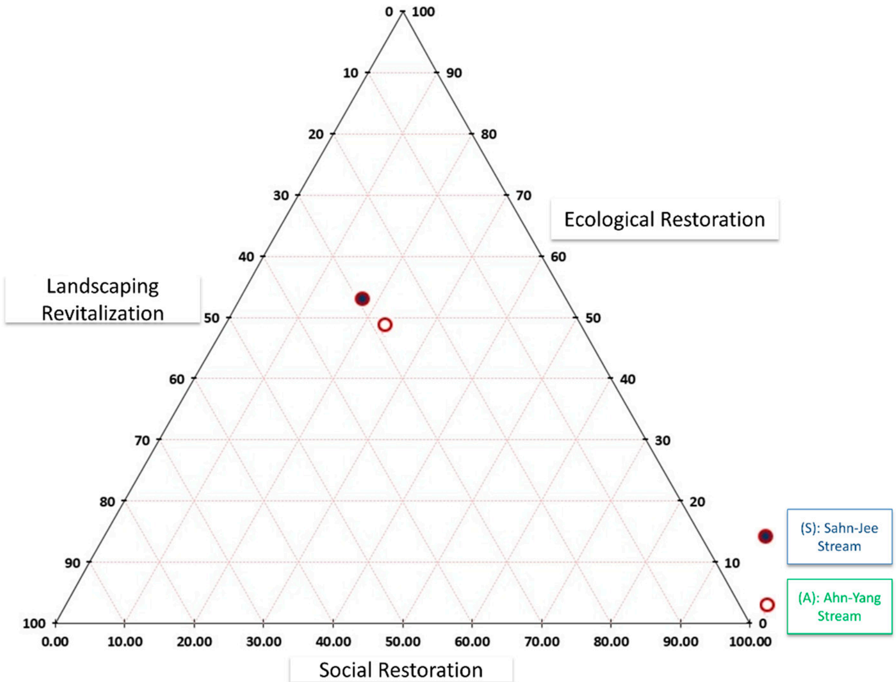

Figure 4. Triangular plot of the analytic hierarchy process (AHP) results of the Ahn-Yang and Sahn-Jee streams, South Korea.

Figure 5 provides information about their preferences in response to the question "Which value is the most important among ER, SR, and LR?". The group of water professionals, such as civil engineers and environmental scientists, gave the highest priority to ER (58%; 0.578) compared to the other values. The NGO employees (58%; 0.578), public administrators (49%), and citizens (50%) also considered ER as the most important item for the agenda. On the other hand, the engineering contractors who worked at private engineering enterprises and participated in the construction project had different views and ascribed low value to ER in stream restoration (0.298). They valued LR as the primary issue (0.581). Citizens considered LR at as much as 0.328 of their value setting in the Ahn-Yang stream restoration project. Additionally, SR was ranked and rated as the second critical priority by NGOs, water professionals, and public administrators, whereas it was listed as the least important by citizen representatives and private engineering contractors. In summary, members of the NGOs and water resource professionals were prone to value ER using innovative smart engineering technologies. Public administrators and citizen representatives also assigned high weight values to ER.

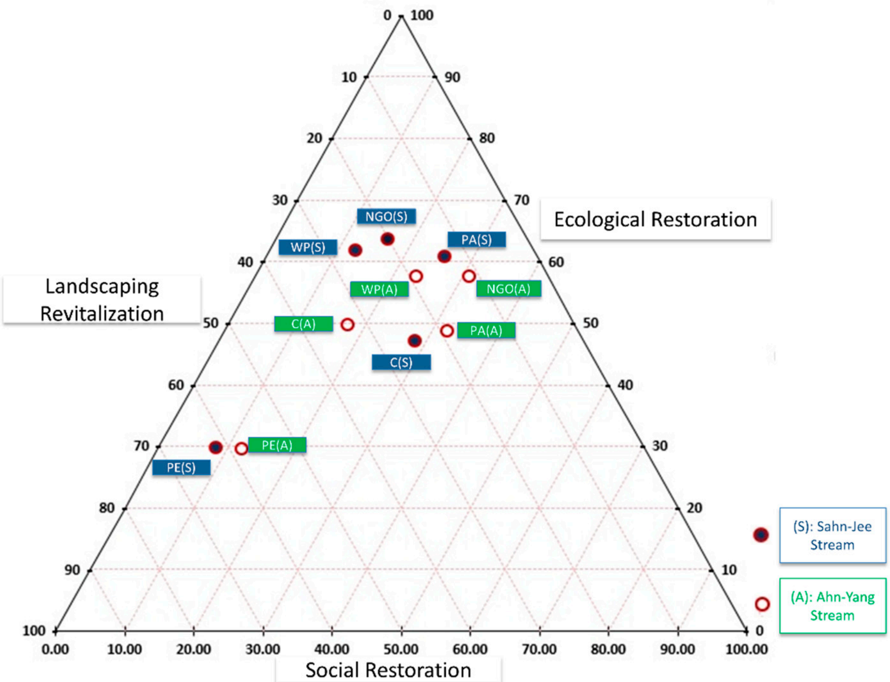

Figure 5. Triangular plot of the analytic hierarchy process (AHP) results of the stakeholder groups.

5.2. The Sahn-Jee Stream Case

As shown in Table 3, the relative weighted values based upon assessing the personal priorities of the five stakeholder groups regarding stream restoration of the Sahn-Jee stream restoration showed various positions on stream restoration. In particular, the concentration on ER was also the highest priority (0.527). However, the interests in SR and LR were lower than those in ER. The weighted values of SR and LR were 0.182 and 0.290, respectively. For the Sahn-Jee stream stakeholders, the value of LR was a critical value (rated as the second priority) examined in this AHP analysis. Furthermore, the value of SR was still less highly weighted than the other values, which was similar to case 1 of the Ahn-Yang stream.

Figure 5 directly explains the respondent groups' preferences for the same question "Which value is the most important among ER, SR, and LR?" The group of water professionals, such as civil engineers and environmental scientists, gave the highest priority to ER (62%; 0.618) in contrast to other values. The NGOs (64%; 0.637), public administrators (61%; 0.609), and citizens (47%; 0.472) also assessed ER as the most prominent item for the agenda.

Similar to the results mentioned above for the Ahn-Yang stream, the engineering contractors at private engineering enterprises who participated in the construction project expressed different views, placing a low value on ER in stream restoration (0.299). They gave the highest score to LR (0.617). The citizen groups evaluated LR at as much as 0.242 of their value setting in the Sahn-Jee stream restoration project. In the case of citizens and residents in the Sahn-Jee stream region, the score of SR (0.284) was higher than that of other stakeholders, but private engineering contractors gave the lowest marks to SR (0.161).

5.3. Summary

Through the independent samples t-test, there was a significant difference in the AHP scores for social restoration between the Ahn-Yang stream (Mean = 0.24, Standard Deviation = 0.13) and Sahn-Jee stream (Mean = 0.18, Standard Deviation = 0.13; $t(39) = -2.318$, p value = 0.026 (<0.05)) restoration cases. Although the two urban streams are located around completely different environmental conditions, the two Korean cases showed similar perceptions regarding the importance of social restoration in urban stream restoration. However, we could not report any significant effect on the AHP scores of ER and LR between the two cases.

The CV (coefficient of variation) scores showed how consistently the respondents of each group recognized the specific values on the urban stream restoration in both cases. According to Tables 2 and 3, the results for the Ahn-Yang stream case indicated different levels of CVs for ER (0.421), SR (0.736), and LR (0.558). In comparison with the Ahn-Yang case, the Sahn-Jee stream case showed lower CV values for ER (0.180), SR (0.098), and LR (0.181).

When we looked at the overall results of the AHP analysis, the groups of NGO representatives and water resource professionals were likely to maintain consistent interest in the value of ER, including water quality enhancement, in stream restoration (Tables 2 and 3). Regarding SR, the stakeholder groups for the Sahn-Jee stream case (0.098) largely indicated lower CVs than the Ahn-Yang stream case (0.736). Including the group of engineering contractors in the private sector from the Ahn-Yang stream (0.759), most stakeholder groups showed varying CVs. The NGO representatives were prone to be more coherent and consistent and had the lowest CV (0.43) in the Ahn-Yang stream case, while the public administrators showed lower CVs (0.08) for each stream restoration goal. On the other hand, the citizen groups of the Ahn-Yang stream (0.63) and Sahn-Jee stream (0.25) cases were less consistent compared to the other stakeholder groups.

These AHP results show that the value of ER (Ahn-Yang stream case: 0.49; Sahn-Jee stream case: 0.53) was the most substantial issue on the agendas in the decision-making process as well as the agenda-setting process for urban stream restoration. Notably, both water resource professionals and NGO representatives placed a high premium on the agenda of ER most in both decision-making and goal setting. The following section will discuss the quantitative research results to answer the question: to what extent and how were the values considered by the stream restoration stakeholders in both of the Korean cases?

5.3.1. Value 1: Ecological Restoration (ER)

Most participants in both cases held consistent and wholehearted interest and value in ER, which means the scientific restoration of environmental recuperation and water quality control. Members of NGOs and water resource professionals were prone to value ER that used innovative engineering technologies in both cases. Public administrators and citizens also placed high weight values on ER. However, the engineering contractors who worked at private engineering enterprises and participated in the construction project had different viewpoints, placing low levels of importance on ER in stream restoration. They placed a high value on LR, rating it as the top priority.

The fact that NGO members actively supported the interests and values of scientific restoration for environmental recuperation and water quality control has been examined and explained by these numerical data based on quantitative analysis by evaluating and measuring priorities and comparing values.

5.3.2. Value 2: Social Restoration (SR)

Both sets of results demonstrate that the participants placed a low value on the benefits of SR, such as social integrity, cultural revitalization, and the building of sustainable governance, which is shown by these numerical results (Ahn-Yang stream: 0.23; Sahn-Jee stream: 0.18). The NGO members (0.309) and public administrators (0.322) of the Ahn-Yang stream were more likely to consider SR critical than other participant groups (Figure 5), whereas the citizen representatives (0.284) and the public administrators (0.258) of the Sahn-Jee stream placed a higher value on SR than the other stakeholders. Comparatively, the engineering contractors did not give high marks to SR (0.121).

SR was not a preferred or primary value for the stakeholders in the Ahn-Yang stream restoration management. Some representatives of NGO groups valued social factors, such as educational, cultural, and historical approaches in the master plan, and they prioritized the value of SR of the Ahn-Yang stream. This finding implies that the participants' values revealed an excellent example of the trend in South Korean society to devalue invisible social factors in stream restoration. In other words, the fact that the participants from technical industries, such as the engineers and water professionals, deeply disagreed with the interests and values of SR, such as sociocultural recuperation and educational program development, was shown in the digitized index through the pairwise comparison of the values.

5.3.3. Value 3: Landscape Revitalization (LR)

The AHP analysis results showed that LR had the second-highest priority value (0.279; 0.290) (Tables 2 and 3). LR includes flood prevention and spatial expansion as well as esthetic beautification. The engineers from both cases were more likely to place the highest value on LR. Citizen representatives considered LR at as much as 32.7% (0.327: Ahn-Yang) and 24.2% (0.242: Sahn-Jee) of their value setting for the stream restoration projects. They believed that once they have a well-organized civic space and green space in the watershed, various benefits from the urban stream can be realized, such as outdoor appreciation and economic synergy.

The representatives of NGOs (0.113), public administrators (0.189), and water resource professionals (0.190) involved in the Ahn-Yang stream discussion did not preferentially award high priority to LR. The NGO involved in the Ahn-Yang stream restoration did not want to have economic development-oriented stream restoration through landscape beautification but rather through natural stream restoration and natural hazard control for both humans and nature. However, the NGO members who discussed the Sahn-Jee stream placed more value on LR for urban regeneration in the old civic center than those who discussed the Ahn-Yang stream. The public administrators were unlikely to welcome a typical landscaping project.

Remarkably, the participants from the NGOs showed large variance, regardless of the result from the AHP. This large variance indicated that the members of NGOs had diverse interests and differently assessed the values of stream restoration. Some NGOs who were working with local citizens could not resist addressing the high priorities placed on LR for the people for whom they advocated. In the Ahn-Yang stream case, except for the group of water resource professionals (0.378), most CVs of the participant groups on LR indicated a high level of variance. This implied that the scope of the participants' values might have been quite dispersed and diverse in considering and adopting the concept of landscaping and spatial renovation in the Ahn-Yang watershed. However, most of the participants in the Sahn-Jee stream survey showed low CV index results for LR, which can be understood based on the fact that the favorable perceptions based on the pros and cons of the waterfront redevelopment project were clearly positioned.

6. Discussion

After the comparative evaluation with the two cases, we could understand and compare the perceptions of major stakeholders around regional streams in urbanized islands and inland areas on river restoration. When examining the overall data from the survey datasets, most stakeholders were still inclined to pay consistent attention to the value of ER in stream restoration. At this point, this study had one question: "Why do the stakeholders in stream restoration management still consider ER to be the most important value after greatly improved ecological restoration has already been accomplished compared to the water quality in the 1990s?" According to the results, we could imagine that the future direction suggested by the participants would allow decision-makers and policymakers to pay more attention to ER, such as the results from the early stages of restoration. Concerning ER, the interval between the average and the calculated values was smaller than for the respondents' ratings of other values for the Ahn-Yang stream case. In other words, the respondents' constant and complete valuing of ER could be explained by these strong numerical data based on the quantitative analysis of the evaluation and measurement of the stakeholder values. However, the Sahn-Jee stream respondents indicated the lowest interval between the average and the calculated values for SR, even though they believed that ER was the most critical piece of the agenda on urban stream restoration.

Thus, this phenomenon can be explained based on the social consensus that had been formed in Jeju's local culture for a long time [35].

The stakeholders in the less urbanized river basin, Sahn-Jee stream on Jeju Island, showed perceptions of river management that differed from those of their counterparts in the highly urbanized Ahn-Yang stream case in an inland area. Because streams located in the less urbanized areas of Jeju Island have various forms of precipitation, local residents are relatively dependent on them as a drinking water source [26]. Since they have had a well-organized municipal water system since the 1970s, spatial regeneration-oriented river restoration has mainly been preferred to create benefits such as allowing resident activities in green vegetated waterfront spaces and directly mitigating flood damage.

Urban structure-oriented hydraulic conventional flood prevention and management are universal on volcanic islands because the urban streams in the islands are often heavily impacted by floods resulting from a considerable surge in the amount of runoff during heavy precipitation events [36]. In traditional flood management, structural control laws have been commonly used as the most effective countermeasures. However, indirect flood prevention, such as social-anthropological management and ecological services restoration, is also vital as there is a limit to structural flood prevention [5,37]. The stakeholders in urban stream restoration in less urbanized islands are more likely to have a greater interest in structural flood prevention than the stakeholders in highly urbanized inland urban stream restoration. In the case of island residents, there was a high level of interest in river management, which was not only on a civil engineering management aspect of river restoration but also a method of river management that emphasizes indigenous community-centered social culture, which is an important part of society. In particular, the residents who live near urban streams in islands significantly consider social mechanisms as well as engineering technologies in urban stream restoration because provisioning drinking water for household life is an essential part of their life.

In the case of the Sahn-Jee stream, there was a high interest in a river management plan that would combine local social culture as well as civil engineering management aspects. The indigenous people living on Jeju Island showed that their attachment and pride in environmental resources, which were the center of the previous local faith, are stronger than that of the local people on the land [38]. To prevent floods and secure aquatic habitat [39], the respondents showed a tendency to support and prefer island culture-centered river levee projects. However, little empirical evidence is available on the impacts of such factors on the resident perception of stream restoration in island regions. In summary, many stakeholders generally also considered the improvement of ecological indicators as the top priority in the case of ocean river restoration.

The ER of urban rivers in Korea is being promoted as the main goal in restoring urban river systems. The reason for this trend might be formed by the perception that the Ahn-Yang stream watershed experienced serious water pollution during intensive urbanization [40]. In addition, we could guess that the stakeholders of the Sahn-Jee stream emphasized ER because the Jeju Island authorities enacted a major policy to preserve green ecosystem resources. However, we concluded that interest in the restoration of the social and cultural value of rivers, which improve and develop social elements, was relatively low in both cases. The stakeholders in the Ahn-Yang stream areas were more interested in community stewardship-led river restoration that was centered on sociocultural factors than in the Sahn-Jee stream case. In other words, due to the active civic-centered water environment conservation campaign in the society living in the Ahn-Yang watershed [1], which was actively aiming to overcome rapid urbanization, the construction and composition of river restoration management around the Ahn-Yang watershed region was more balanced among the three goals than that of the Sahn-Jee stream in Jeju Island.

7. Conclusions

In this study, the NGT and AHP guided the quantification of stakeholder values for urban stream restoration in South Korea. As a result, the value of ER was found to be the most significant value held by the participants. An engineering-oriented lopsided stream restoration process aimed only at the ER value would be limited to providing long-term sustainable direction for urban stream management. Thus, our finding shows that the interests of stakeholders and the preferences of the participants for both SR and LR should be combined in future agenda-setting processes based on rational and resilient foundations.

In the case of the Sahn-Jee stream on Jeju Island, it is necessary to primarily manage and prevent floods in the coastal cities by activating SR-centered management factors. For the Ahn-Yang stream, however, the balanced performance of river restoration collaborative management can be obtained through an LR-centered river restoration strategy that emphasizes spatial functions. Therefore, we suggested that the adaptive river restoration vision and strategy should be accompanied by interactively considering the social and ecological conditions of urban rivers to efficiently achieve the restoration goals of urban rivers with different conditions.

Consequently, the leaders of stream restoration in both cases should have considered an advanced participatory decision-making process that could adaptively reflect the preferences of various citizens as well as the value of ER when setting the agendas. Our findings will contribute to the establishment of a new design for a sustainable and participatory long-lasting watershed master plan for Korean urban streams.

In this project, our study could not include the subjective interests and individual positions of the stakeholders in either case. These findings and results will potentially promote future research projects about sustainable urban stream restoration through actor-network analysis of decision-making management as a future addition to the contributions of the study.

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