sustainability

MDPI

Article

Temporal Variations of Citizens' Demands on Flood Damage Mitigation, Streamflow Quantity and Quality in the Korean Urban Watershed

Chang-Yu Hong [1] and Eun-Sung Chung [2,*]

1 Nohad A.Toulan School of Urban Studies and Planning, Portland State University, 506 SW Mill Street, Suite 350, Portland, OR 97201, USA; changyu@pdx.edu

2 Department of Civil Engineering, Seoul National University of Science and Technology, 232 Gongneung-ro, Nowon-gu, Seoul 01811, Korea

* Correspondence: eschung@seoultech.ac.kr; Tel.: +82-2-970-9017

Academic Editor: Nicos Komninos

Received: 16 February 2016; Accepted: 16 March 2016; Published: 13 April 2016

Abstract: Sustainable watershed management (SWM) can be achieved through recognition and reflection upon the values of citizens. Collaborative governance consisting of citizens is crucial for successful SWM. Collaborative governance definitely requires an active participatory decision-making process that reflects citizens' preferences. Citizen preference also tends to substantially change with life pattern and life quality. These shifts can be caused by slight variations in both social priorities and personal preferences for SWM. Therefore, collaborative water governance must be frequently renewed in response to citizens' values through the participatory framework. The An'yang Stream in South Korea is generally regarded as a representative urban stream restoration case that has been successfully led by collaborative governance. By conducting individual surveys with citizens on-site, this study addresses how citizens' preferences of the stream's management have changed between 2005 and 2015. In addition, this study used three quantitative hydrologic vulnerability indices: potential flood damage (PFD), potential streamflow depletion (PSD), and potential water quality deterioration (PWQD). They can spatially quantify citizen preference using the Analytic Hierarchy Process (AHP), which can systematically derive citizens' subjective relative-weighted preferences. In the end, this study identified critical differences in priorities in regard to vulnerable areas between in 2005 and in 2015.

Keywords: sustainable watershed planning; collaborative governance; analytic hierarchy process (AHP); hydrological vulnerability; potential flood damage (PFD); potential streamflow (PSD); potential water quality deterioration (PWQD)

1. Introduction

Environmental planning processes are generally considered to be political mechanisms. Because the diverse objectives of various stakeholders conflict, decision makers must find compromise solutions that have the strong support of citizens and display clear justifications through public discourse. Of course, in-depth technological and scientific background research is required at all stages of public discussion. Environmental planning and management for sustainability have recently been regarded as a practice of participatory governance and a means to reflect the diverse opinions of stakeholders because most processes occur based upon a chain of governance structure that consists of interdisciplinary members and topics. In particular, uniform methods based on technical and institutional innovation in environmental planning processes have resulted in strong disputes between stakeholders, as even advanced knowledge has only a limited capacity to help in resolving conflicts resulting from uncertainty and complexity inherent in the process of environmental planning and management.

The diverse opinions and values of different stakeholders must be included in environmental planning and management. To establish such a system that embraces the various values and interests of stakeholders, theories of environmental planning have been reviewed and are used to seek better solutions by stream restoration managers. In terms of recognizing stakeholder preferences, adaptive management provides a key to finding a mediated solution that addresses the uncertainty and complexity of conflicts between different values. This framework tends to play a key role within a collaborative governance framework for water management by structuring decision processes, sharing scientific knowledge, and recognizing the diverse values attributed to stream restoration through mutual communication between stakeholders and decision makers.

Collaboration is a dynamic process by which two or more parties with different views seek compromise solutions by understanding the tradeoffs of different opinions [1]. That is, any governance should include a number of participants that belong to various interest groups and can develop policies through interactive communication. Collaborative governance maximizes the value for the public involvement by organizing and mobilizing various resources held by community members [2]. It also contributes to creating public value and interest through mutual interactions between actors and organizations across political boundaries [3]. Thus, collaborative governance can be a practical way to operate a system that integrates and addresses diverse values beyond any specific topic using a collaborative policy making process, led by groups of citizens, non-governmental organizations (NGOs), and governmental organizations (GOs).

"Participation" and "Involvement" are the core of collaborative governance building. Again, participation and involvement can be understood as a process of formulating problems and solutions during stakeholders' interplay in the governance [4]. Before exploring the processes of defining key problems and seeking solutions to conflicts within water governance, different value positions of the stakeholders should be tested and compared by the governance participants. Thus, understanding the different values of the stakeholders in terms of collaborative governance can be used to evaluate levels of participation in watershed management [5]. Stakeholders use their capacity to persuade others and share their views with others through this participation. Participatory governance catalyzes successful collaborative governance [6]. The governance participants' abilities and efforts influence the scope of participation and the appropriation of participants representing stakeholder groups. Participation provides the size and scale of governance through interaction among stakeholders. These elements directly result in an effective process for consensus-building. The surveying of citizens' values is a required course to initiate participatory solutions for collaborative governance before deciding a final strategy.

The concept of socio-ecological systems (SESs) has been developed to provide the various values of the stakeholders [7–9]. A conceptual and methodological relationship exists among the analyses of SESs, complexity research, predictability, uncertainty, and trans-disciplinary concepts. Moreover, the research on SESs has usually used a trans-disciplinary framework to achieve adequate problem orientation and to ensure integrative results from the interaction between the interests and values of the stakeholders under the guidance of SESs [7]. In understanding adaptive and sustainable approaches to stream restoration in terms of SESs, one is compelled to consider the relevant stakeholders' intangible values.

The adaptive management paradigm [10] interprets the dynamics of diverse values and goals of ecological management in response to disturbances and unpredictable changes in the watershed environment. Adaptive management has been described as actively communicating through interactive feedback and addressing complexity and uncertainty among diverse values [11]. As a tool of adaptive management, integrated watershed management (IWM) has been introduced coupled with the concept of socio-hydrology [12]. IWM provides a mechanism to integrate a complex system of the water environment, ecosystems, landscape, human life, culture, *etc.* The integrated system of values in the context of IWM is considered a representative model of socio-hydrology and SESs [13].

A participatory approach for IWM should be necessary for sustainable watershed management (SWM) [9,14–19]. For simplicity, three important factors, floods, streamflows and water quality, are primarily considered in the process of IWM. Therefore, previous researchers have completed the survey to ask "what was the most important target for sustainable stream environment among the three objectives: flood damage mitigation, prevention of streamflow depletion, and water quality enhancement?" [18]. Without this value-finding process from stakeholders, sustainability cannot be guaranteed even after the implementation of IWM.

Incorporating various stakeholders' values could thus yield more sustainable decision-making tools for environmental planning. Conceptually, there is a convincing narrative that peoples' values about environmental planning management affect the set of conscious behaviors that the actors believe will save water, which could be reflected to some extent by empirical management. In fact, the conservation literature suggests that individual voluntary and public participation appears to have catalyzed the conservation behaviors, such as sustainable green programs [20]. In particular, decision-makers for stream restoration must understand the citizens' comparative analyses of the three key values of hydrologic vulnerability: potential flood damage (PFD), potential streamflow depletion (PSD), and potential water quality enhancement (PWQE). This study proposes a framework of analytic hierarchy process (AHP), in particular, to recognize the preferences of citizens of the Korean urban watershed in 2015 and compare to the previous research in 2005 [21]. Based on those values, the specific objectives of each stream region can be prioritized by reviewing and comparing two different weighted citizens' preferences to three objectives of PFD, PSD, and PWQD for stream restoration which were obtained in 2005 and 2015, respectively, from the same questionnaire and at the same locations.

2. Research Design and Data Analysis

2.1. Background

For the past 15 years, a number of implemented projects have been completed to rehabilitate the distorted hydrologic cycle of the An'yang Watershed by central and regional governments. With these efforts, several NGOs such as the An'yang Gunpo Euiwang Federation for Environmental Movements have endeavored to improve the stream environment in various ways [15–19]. However, all historical efforts were not designed systematically and without any consideration of residents' demands. Therefore, in this study, sets of citizens' preferences on three stream restoration objectives, flood, streamflow quantity and quality, were surveyed in 2005 and 2015, respectively, and then were compared. From this analysis, three basic questions will be considered.

(1) How did the citizens' values vary with regard to the An'yang Stream restoration after ten years of restoration works starting in 2005? Why?
(2) Is water quality improvement still the most important value in stream restoration because of the water quality innovative policy implications by the government?
(3) What are the implications for sustainable governance in the future, based on testing the preferences of the citizens?

Therefore, this study consists of three following steps. The first step is to classify all sub-watersheds into six separate regions having obvious hydrologic vulnerabilities of PFD, PSD, and PWQD in 2005 because the whole watershed is too large. The second step is to identify the citizens' preferences on three objectives in 2015 and compare the two weighted sets from 2005 and 2015 so that the variation over the last decade can be identified. The third step is to elucidate the potential strategies that could retain sustainability and respond to the citizens' demands correctly.

2.2. Analytical Hierarchy Process (AHP)

In defining the environmental problem, the policy-makers must ensure that they understand what it is. The policy-makers also must know the alternatives that are available to solve the problem. Using these alternatives and the predetermined criteria, a hierarchy can be built [22]. Each criterion on this level is decomposed into sub-criteria at the next level and so on. The alternatives lie at the bottom of the hierarchy. Essential to the entire AHP methodology is the determination of the respective weights of the criteria and sub-criteria. One common method for determining weights is through a process of pairwise comparison [22,23].

Therefore, AHP is a reliable method to facilitate systematic and logical decision making in the various fields of urban development, natural resource management, and business choice models [24]. Additionally, it is a mathematical tool that enables the explicit ranking of tangible and intangible factors against each other for the purpose of resolving conflicts or setting priorities. AHP is a strong tool to evaluate values originated from both qualitative and quantitative data [17,24–26]. It elucidates the factors that are more influential in decision making and resolves water conflicts in the face of diverse interests because it treats decision criteria and their weighting values in an open and explicit manner [27].

AHP provides a systematic method for the comparison, weighting, and integrating the multiple criteria and alternatives by the main actors [28]. This AHP helps researchers with an assessment which can contribute to easily compare each factor as well as to elucidate the relative interrelations between the factors by using quantitative information such as pairwise comparisons and reliability of the obtained weights [28]. Stream restoration requires a method such as AHP because it is the subject of such diverse conflicts and interactions between ecological ideas and elements of socio-economic development. All actors involved in the process should make their final decisions based on the extensive investigation of each related interest and goal. In short, AHP can be considered a method and planning framework with the potential to implement effective and multi-dimensional decision making in the field of stream restoration. This study used AHP to understand citizens' values regarding the An'yang Stream because the results from AHP are able to analyze their values in terms of quantified levels of individual citizens' interests. The values of citizens have changed all the time, so policy makers require a system to embrace their changed values actively and positively through a quick, quantitative survey such as AHP to reduce uncertainty in decision-making in the future.

2.3. Survey Design and Data Collection

The active participation of citizens and recognition of their values is a popular topic for the SWM. However, water resource governance in the Republic of Korea has struggled to find a good solution to the issue of participatory management due to the lack of proper leadership in providing sustainable planning and collaborative governance as well as paying only nominal attention to public opinion. This governance tends to take a passive and limited stance in accepting a participatory decision-making process. Thus, these authors wanted to compare how much citizens' values about stream restoration of the An'yang Watershed have been included in the existing participatory processes. Recognizing the values and preferences of diverse citizens regarding stream restoration is essential to provide sound watershed management. We asked citizens who lived within the regions of the An'yang Watershed what they considered being the most important objective for stream restoration. Improvement of PFD, PSD, and PWQD were regarded as the most important. To update governance regulations, it is vital to embrace change and the diverse values of the citizens. These values include ecology, landscaping, and stream-friendly spatial renovation, as well as other considerations for sustainable outcomes. Hence, this research is the first instance to establish the sustainable stream restoration systems through citizen surveys as a method to identify the citizens' demands.

The interviews aimed to recognize the citizens' primary values concerning stream restoration of the An'yang Watershed. Using AHP, we asked the citizens "what was the most important issue among flood prevention, stream flow control, and water quality improvement?". The respondents were randomly selected and invited to waterfront areas in each region. In this study, we used a simple random sampling of ordinary citizens. The surveyors went to each survey region to choose respondents randomly. In the selection process, we did not put any restriction on the citizens' demographic information such as age, sex, income level, and educational level. In July 2015, we conducted a field survey of the citizens in the six stream regions as previous researchers [21] had, and we collected data using the same survey form that was used in May of 2005. During the field survey, 30~35 respondents from each region (total respondents: 190) were selected and asked to answer their preference with regard to values in the An'yang Stream restoration. These surveys conducted in the six regions were reclassified based on a consistency index (CI < 0.2), in accordance with the guidelines of the previous researchers [17]. After calculating each weighted preference, they were compared to those in 2005.

2.4. Watershed Evaluation Index (WEI)

According to Chung and Lee [21], the vulnerability of each stream region was evaluated by quantifying the potentials of the flood damage, streamflow depletion, and water quality deterioration. To determine a comprehensive watershed management model in the An'yang Watershed, the concept of PFD, which indicated the vulnerability to floods was applied to each sub-watershed using the pressure-state-response (PSR) framework [29]. Then the results were quantitatively computed. Chung and Lee also developed the concepts of PSD and PWQD [21]. These values of PFD, PSD, and PWQD were facilitated to calculate the Watershed Evaluation Index (WEI) using the following equations:

$$WEI_n = \frac{(PFD_n + PSD_n + PWQD_n)}{3}(p_n = q_n = r_n = \frac{1}{3}) \quad (1)$$

or

$$WEI_n = p_n PFD_n + q_n PSD_n + r_n PWQD_n \quad (2)$$

PFD, PSD and PWQD values were obtained from available hydrological and statistical information could be integrated into one composite index, WEI by coupling individual preferences collected from personal interviews to citizens regarding the An'yang Watershed. WEI works best by adopting weighted preferences among different citizens' values and interests through AHP in the decision-making processes. These values can critically affect the comprehensive watershed management from collaborative governance. In June 2015, 180 respondents were asked to quantify their preferences among PDF, PSD, and PWQD in the AHP questionnaire (30 respondents in each of the six watershed regions). Additionally, Chung and Lee [17] conducted the same research survey with 321 respondents in 2005 at the same survey locations. Similarly, we designated six stream regions having the distinct different characteristics of hydrologic vulnerability. Figure 1 shows the locations of the six grouped regions.

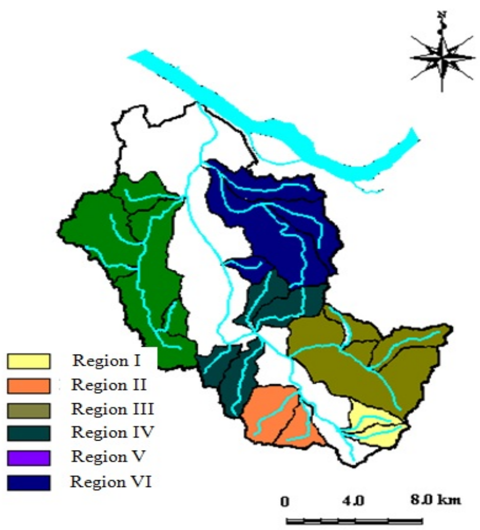


Figure 1. Six regions of the An'yang Stream categorized in watershed measurement.

According to Figure 1 and Table 1, region I is located in the uppermost part of the An'yang Stream, and it retained good water quality at an appropriate level of flood vulnerability, but it was not effective in maintaining the streamflow level during the drought season. Region II is located in the upper stream region and included the covered stream sectors of the An'yang Stream. Both Regions II and VI required urgent restoration solutions because both regions earned poor ratings in all of the surveyed factors: flooding risk, stream flow deterioration, and water contamination. At the same time, Region III retained high-quality levels in flooding risk, streamflow deterioration, and water quality. Region III showed the best stream conditions in the An'yang Watershed. Region IV, located in a steep mountain region, exhibited good water quality, but its PFD and PSD were not stable during the evaluation. Region V, located in a downstream basin, showed strength in PFD, but it did not perform well in PSD or water quality studies. Stream restoration was not aggressive and barely existed except in the region of flood prevention. In particular, Region V had to conduct stream restoration using advanced engineering technologies, while preventing stream flow depletion and water quality devastation.

Table 1. List of Sub-Watershed by regions.

Region	Name of Sub-watershed
I	WG, OJ
II	DJ, SB
III	HU
IV	SS, SA
V	MG
VI	SH, DR

2.5. Study Area

The An'yang Stream flows into the Han River, which is located approximately 32.5 km south of Seoul and Gyeonggi-do, and the watershed area is 286 km^2. The watershed lies between the latitudes 37°18′ N and 37°33′ N and between the longitudes 126°47′ E and 127°04′ E. In the An'yang Watershed, 14 local governments represent the 3.5 million people who live along this stream. Due to the geographical proximity to the political and economic capital of Seoul, the An'yang Watershed has experienced rapid urbanization and industrialization in the past forty years. These social changes in the An'yang Watershed have negatively influenced the water quality and the eco-system of the An'yang Stream [30,31]. Ultimately, severe contamination of the An'yang Stream induced ordinary citizen groups to work together for the stream restoration.

In the past, watershed management tended to focus on flood and streamflow control by the authorities, which aimed at the rapid industrialization and urbanization. Thus, it also caused water quality deterioration and indiscreet channelization in the An'yang Watershed [32,33]. In the late 1990s, many public debates about the local river or stream restoration were held as a result of the self-governing capacity of South Korean local autonomy systems and the citizens' increasing demands. Local governments and citizen groups in the An'yang Watershed wanted to find an efficient solution to streamflow contamination.

The An'yang Stream Protection Network (ASPN) was initiated by a collaborative gathering of private sector members and organizations in the mid-1990s [34]. In 1998, the Always Green An'yang 21 was formed by the City of An'yang, citizen groups, environmental professionals, local politicians, and NGOs [35]. In other words, the ASPN played the role of an ignition agent, as well as the being first group to contribute to building environmental governance in the City of An'yang. This governance network proclaimed the Always Green An'yang 21's agenda, which aimed to lead and organize diverse groups for sustainable urban planning in the region of An'yang City. The decontamination of the An'yang Stream was one of the major projects on the agenda [35]. Furthermore, the An'yang Stream Governmental Council for Water Quality Improvement (AGCWQ) was established by local governments to improve its water quality [34]. Most GOs, as well as citizens and NGOs, had the same goal: the water quality of An'yang Stream should be improved by collective collaboration. The AGCWQ intended to fund a conference twice per year, as well as to participate in the periodic watershed joint research, to investigate water ecology, and to provide sponsorship for environmental monitoring by citizen watchdog programs. This sponsorship resulted from their financial executive powers because each participant and the local government of the AGCWQ had the authority to allocate the budget only for water quality improvement.

The An'yang Stream Restoration Master Plan [34], as shown in Figure 2, included mostly technocratic factors to achieve successful scientific restoration. The master plan restrictedly described the importance of synergy and of building collaborative governance and conducting citizen surveys to identify feelings about the An'yang Stream restoration. Social, educational, cultural, and historical components should have been reviewed through the governance network, but those values were ignored. Hence, these authors believe that the stream restoration process under the An'yang Stream Restoration Master Plan [34] could not provide appropriate opportunities for an in-depth investigation of the citizens' interests within the governance.

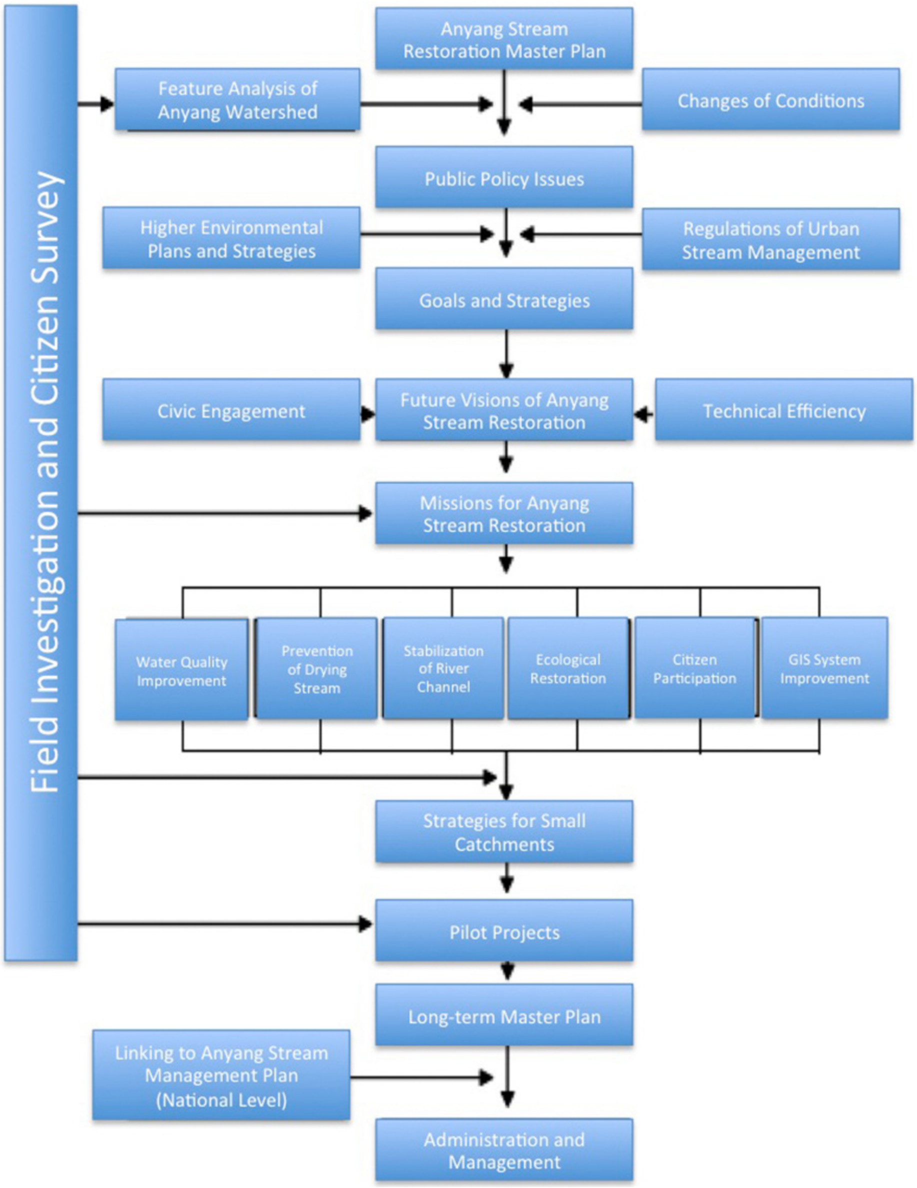


Figure 2. Diverse goals and visions in An'yang Stream Restoration Master Plan [34].

3. Case Study Results

This study compared the results collected from citizen surveys in both 2005 and 2015. The citizens' preferences by regions were derived by using the AHP method as described above.

3.1. Surveyed Results of Citizens' Preferences in 2005

According to the survey results from previous researchers [17] (Table 2), the weighted values in six regions reflected that each region had various levels of priorities in evaluating the PFD, PSD, and PWQD because the citizens had different preferences on the An'yang Stream restoration project. This data had drawn how the citizens in each sub-region variously placed weighted values on PFD, PSD, and PWQD. As a result, most of the respondents were likely to evaluate the water quality as the most important factor {0.506 (50.60%)}. On the other hand, the importance of and interests in PSD and PFD were quantified as relatively less important. The weighted values of PSD and PFD were 0.261 (26.1%), and 0.233 (23.33%), respectively. The results showed that the citizens in 2005 were slightly more concerned about streamflow devastation and the issue of the drying stream in the watershed.

Table 2. Potential flood damage (PFD), potential streamflow depletion (PSD), potential water quality deterioration (PWQD)and watershed evaluation index (WEI) of six regions of 2005 [18].

Region	Name of Sub-Watershed	Description				
		PFD	PSD	PWQD	Location	WEI
I	WG, OJ	Mixed	Poor	Good	Upstream	0.41
II	DJ, SB	Poor	Poor	Poor	Upstream	0.52
III	HU	Good	Good	Good	Mid-stream	0.32
IV	SS, SA, SB1	Mixed	Mixed	Good	Mid-stream	0.42
V	MG	Good	Poor	Poor	Downstream	0.46
VI	SH, DR	Poor	Poor	Poor	Downstream	0.67

Based on these values, the characteristics of six stream regions can be identified, as shown in Table 2. By each region, the measured value of the Region I indicated that the water quality issue was the most important factor, although Region I retained relatively good water quality, and an insufficient streamflow level existed in the stream. In particular, even in both the most reliable case, Region III, and the case of a covered stream, Region II, the highest demand was found for water quality management. Only in the case of Region IV, which hardly registered, PSD was the most important value in the restoration process. The citizens of Region V, with a low level of water quality, aimed to achieve water quality improvement through this previous restoration project. The citizens near the drying stream, in Region IV, pursued the value of PFD as the most significant. Thus, the citizens' values regarding stream restoration in each region could vary considerably under different social and natural conditions in 2005. In addition, it was not a proper method to consider the An'yang Watershed as one region with only one attribute. In particular, missing both participatory processes and bottom-up governance in decision-making led to the negative effect that the public administrators could not react rapidly to the diverse values of the users in each region. Additionally, the coefficients of variation (CVs) of the weights among PFD, PSD, and PWQD were discussed. The downstream Regions V and VI were likely to have consistent demands about the specific value of stream restoration (Table 3). Except for the PWQD (with a value of 0.424), most calculated CVs appeared in a slightly higher level, indicating that the values of the citizens surveyed guided us to water quality improvement, with ecological restoration considered the most important value. Regarding water quality improvement, the gap between the average level and the calculated values from the response sets of the individual respondents was smaller than in the respondents' other values. In other words, it was found that the citizens' constant and wholehearted interests and values regarding water quality control among respondents were demonstrated by this quantitative analysis evaluating and measuring the citizens' values in 2005.

Table 3. Weighted percent ratio of 2005 [18], considering the weighted values and coefficients of variation (CVs) of PFD, PSD, and PWQD.

Region	Number of Total Data	Number of Available Data	Water Restoration Values							
			PFD		PSD		PWQD		Total Weighted Value (PFD+PSD+PWQD)	Average CV
			Weighted Value	CV	Weighted Value	CV	Weighted Value	CV		
1	78	53	0.224	0.924	0.297	0.731	0.479	0.457	1	0.704
2	57	31	0.159	1.145	0.228	0.583	0.613	0.307	1	0.678
3	48	32	0.225	0.778	0.192	0.828	0.584	0.356	1	0.654
4	48	36	0.225	0.973	0.403	0.474	0.373	0.483	1	0.643
5	41	27	0.169	0.864	0.198	0.697	0.633	0.321	1	0.627
6	49	24	0.397	0.582	0.247	0.785	0.357	0.622	1	0.663
Average	54.40	35.80	0.233	0.878	0.261	0.683	0.506	0.424		0.662

Table 4. Weighted percent ratio of the values of 2015.

Region	Number of Total Data	Number of Available Data	Water Restoration Values							
			PFD		PSD		PWQD		Total Weighted Value (PFD+PSD+PWQD)	Average CV
			Weighted Value	CV	Weighted Value	CV	Weighted Value	CV		
1	30	20	0.250	1.086	0.148	0.840	0.600	0.441	1	0.789
2	27	21	0.315	0.768	0.119	0.687	0.565	0.448	1	0.634
3	26	23	0.208	0.735	0.123	0.631	0.668	0.294	1	0.553
4	30	20	0.119	1.198	0.449	0.609	0.430	0.597	1	0.801
5	28	24	0.447	0.620	0.136	0.996	0.416	0.671	1	0.763
6	28	22	0.406	0.606	0.165	0.679	0.427	0.604	1	0.630
Average	28.17	21.67	0.291	0.836	0.190	0.740	0.518	0.509		0.662

These WEIs which were the numerically weighted values of PFD, PSD and PWQD addressed the hydrological vulnerability of each region in the mid-stream of the An'yang Stream. The WEIs in 2005 represented the objectively quantified measures elucidating official water quality indicators and environmental conditions in the An'yang Stream. The results contributed to the IWM of the An'yang Stream when combining with citizens' demands, interests and most preferred values for the restoration project of the An'yang Stream. The participants belonging to the governance of the An'yang Stream can use this WEIs when they made decisions such as the evaluation of priorities and the set of the agenda in the An'yang Stream Restoration Master Plan [34].

3.2. Surveyed Results of Citizens' Preferences in 2015

The same survey as that administered in 2005 was conducted in 2015, and the results are shown in Table 4. According to the results from 2015, the weighted values in six regions show that each region of the mid-stream region had various levels of priorities in evaluating the PFD, PSD, and PWQD with regard to the long-term master plan for the An'yang Stream restoration [34]. These results explain how the citizens in the each mid-region variously held the weighted values of PFD, PSD, and PWQD. In particular, most respondents rated water quality as the most important factor {0.518 (51.8%)}. The interests in PFD {0.291 (29.1%)} and PSD {0.190 (19%)} were measured as lower than PWQD the same as the survey results of 2005 showed earlier. The results showed that the respondents in the survey from 2015 were slightly more concerned about flood prevention and damage mitigation in the region.

The results provided information about the CVs of the weighted values among PFD, PSD, and PWQD analyzed by AHP. When examining the data from 2015, the downstream regions are still likely to pay consistent attention to the worth of water quality enhancement in stream restoration (Table 4). Including the value (0.509) for water quality improvement (PWQD), most CVs indicate high levels, suggesting that the citizens' values would allow us to pay more attention to water quality improvement, like the preceding results from 2005. Regarding water quality improvement, the gap between the average and the calculated values from the answer sets of the individual respondents was smaller than that from respondents' rating for PFD and PSD. In other words, the constant and wholehearted interests and values of water quality control of the respondents could be explained by these numerical data, based on the quantitative analysis of citizens' values in 2015.

4. Discussion

The water quality of the An'yang Stream has improved since 2000 because of various governance efforts, as shown in Figure 3. This governance is a collaborative stakeholder partnership consisted of GOs, NGOs, and stakeholders or citizens. In the An'yang Stream project, governance contributed to the water quantity and quality improvement accomplished by utilizing the advanced engineering technologies and collective governmental efforts initiated in the late 1990s. However, it was not a perfect stream restoration project because the diverse opinions of the citizens were not properly considered, and there were limitations on citizen participation.

4.1. Research Motive

This study considered opportunities for the potential contribution of understanding citizens' diverse preferences in the gradual amelioration of the An'yang Stream. In terms of scientific indicators, the Biochemical Oxygen Demand (BOD) concentration was 6.5 mg/L in 2015, which was drastically improved compared to the results from 2005. The City of An'yang agreed that the interests of the citizens and their participation in the process must be considered when evaluating the success of water quality improvement [35]. However, many citizen groups and NGOs were also very active in stream restoration activities and programs [34], but they could not directly lobby for their values and interests in the decision-making process. Many documents and public reports have tended to pay attention only to the roles and contributions of science to water quality improvement in the An'yang Stream [35]. Again, it would not be effective to evaluate this achievement of water quality enhancement by scientific indicators alone or by the use of new engineering technologies, without considering citizens' interests, preferences and intangible participatory efforts. The invisible efforts of the citizens cannot be evaluated using scientific measuring systems, but we can see how citizens contributed during the project's progress. However, there has been scant research public documentation that describes the diverse collaborative restoration efforts of citizens and the adoption of their values concerning the An'yang Stream restoration projects. Thus, these authors were highly motivated to recognize, study, and understand the diverse opinions of citizens living along the An'yang Stream. The An'yang Stream Restoration Master Plan [34] aims to address how their values were changed and to find its meaning for the sustainable stream restoration.

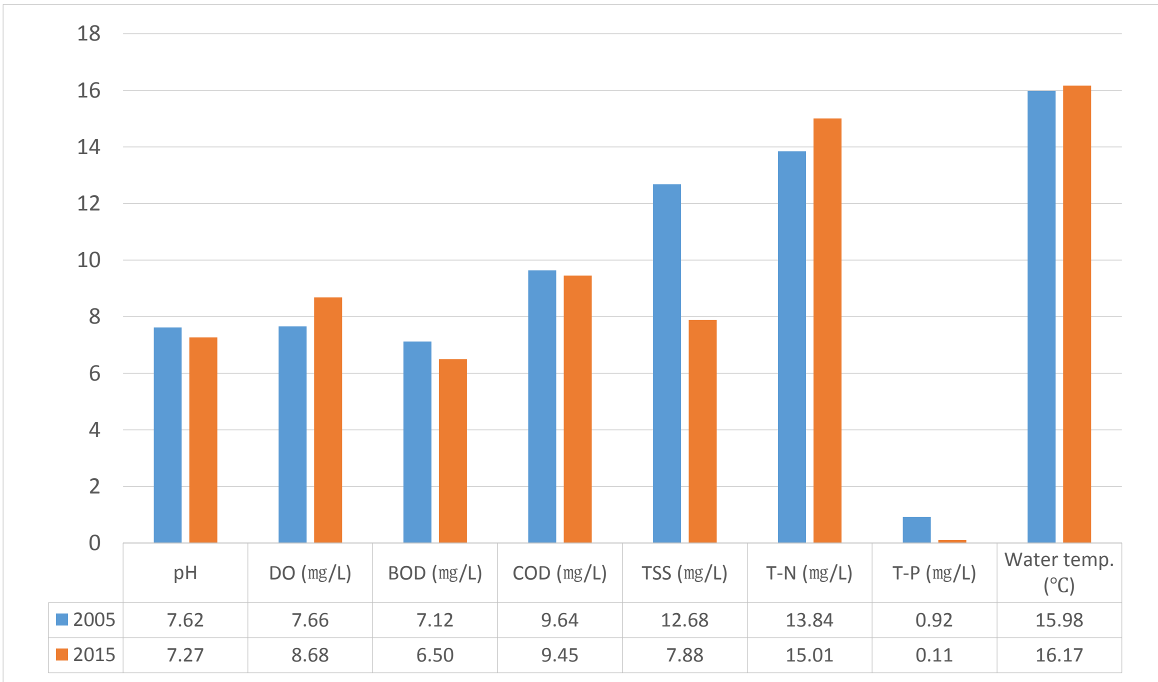


Figure 3. Water quality indicators of the An'yang Stream showing the changes of ecological features of the An'yang Stream (2005 *vs.* 2015): Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Total Nitrogen (T-N), Total Phosphorus (T-P).

4.2. Changes of Citizens' Values

First, we compared citizen values surveyed in 2015 with those reported in 2005, as shown in Figure 4. The results in 2005 indicated that the weighted value of water quality improvement was 50.6%, while that in 2015 was 51.8%. It was found that, after ten years, the citizens still considered water quality improvement to be the primary value in the An'yang Stream restoration, although the An'yang Stream had undergone tremendous improvement in water quality. In other words, the citizens in the An'yang Watershed have been exposed to the same, unchanged stream restoration policies and agendas guided by the governance partnership. We expect that the citizens do not want to have the serious water contamination problems that existed before this stream restoration project was implemented. Hence, they want their governments to oversee the direction that water quality maintenance will take in the An'yang Stream restoration. In terms of stream restoration, these findings provide a solid principle for policy making and governance development in the future. There is a need to discuss our developments in detail and to produce relevant graphs before presenting recommendations to the decision makers in the governance.

Figure 4. Average relative percentage of the Analytic Hierarchy Process (AHP) with citizen preferences data on An'yang Stream restoration in 2005 (**a**) and 2015 (**b**). Average percentage weighted values of AHP and average of CVs in 2005 (**c**) and 2015 (**d**).

This study contributed by conducting a comparative and consecutive field analysis of citizens' preferences about the An'yang Stream restoration. It was also valuable because the field survey was conducted in 2015 at the same sites where the 2005 citizen surveys were administered, using the same questionnaire. Another contribution is that AHP analysis quantitatively indicated the citizens' preferences among their values related to the An'yang Stream restoration.

First, examining the results obtained through AHP analysis, the weighted value of flood prevention management in the An'yang Stream management was 23.3% (0.233) in 2005, but it was 29.1% (0.291) in 2015. The awareness of citizens showed that flood prevention and management are more important in 2015, compared with the data gathered in 2005 regarding the future direction of the management for the An'yang Stream. In other words, concerns about flooding risk have been increased among the residents. In contrast, in the region maintaining the stream flow rate, the comparative weighted value in 2005 was 26.1%, and the comparative weighted value in 2015 was 19.0%. In terms of the preference survey, streamflow control was considered less important than the other preferences.

For citizens, streamflow management was not considered a primary issue because it was difficult for citizens to recognize droughts or floods.

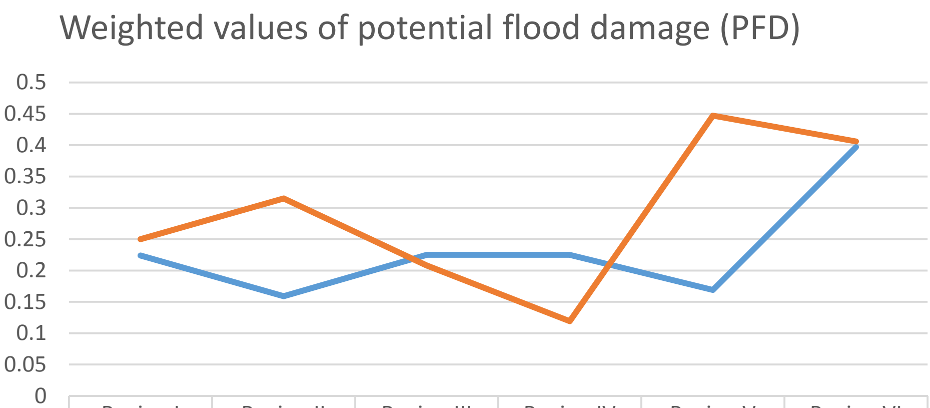
4.3. Water Quality Enhancement is Still Important?

Water quality was rated as the most important value among the three major values in the stream restoration by the citizen surveys conducted in 2005 and 2015. The results were 50.6% in 2005 and 51.8% in 2015. We can interpret this numbers from this two perspectives: (1) public sharing concerning the importance of water quality enhancement in the An'yang Stream with citizens worked well and established a cooperative bond with the governance; and (2) stream restoration efforts failed to result in the citizens considering and supporting other values after achieving successful water quality improvement due to the lack of participatory citizen involvement in a constructive fashion. The governance activities of the An'yang Stream led to improved water quality based on collaboration, but it relied too much on the use of innovative scientific and engineering technologies only for the water quality issue. This excessive reliance might have hindered the communication about the intangible values and interests of the citizens of the An'yang Stream. Scientific indicators of water quality level are the most tangible, but not the most inclusive, method to evaluate the success of stream restoration. In other words, the citizens still want better water quality, although the water quality level has been recorded as optimal by the indicators. Thus, it is very important to recognize the citizens' preferences to plan strategies and to establish agendas for the An'yang Stream restoration.

There were no significant differences in relative weighted values between water quality and the other preferences when comparing the AHP results of 2015 with those of 2005. Citizens could not catch the threat of floods or droughts when the season was mild, and no risk was apparent. The roles of participants and planners from the An'yang Stream restoration governance must include educating the citizens about diverse ways to consider and embrace new values in agenda setting for sustainable stream restoration. In the case of the An'yang Stream, citizens tended to adopt opinions published by the government or by prestigious organizations because they did not have sufficient experience or knowledge to understand the complex scientific studies and indicators. To summarize, if the An'yang Stream watershed or the region experiences drought, citizens might not realize the importance of seeking solutions to these problems. In addition, they did not understand how managing the An'yang Stream can mitigate and reduce the damage resulting from stream flow control and flooding without active citizen participation in the decision-making processes of the An'yang Stream governance.

The AHP results indicated that most regions had a pattern of increased preference for PFD and PWQD and a decreased preference for PSD. However, Region IV showed a different trend in increased stream flow management and decreased flood prevention when analyzing the citizens' preferences. We can assume that Region IV experienced an enormous impact from regional development, which provided more affordable housing for the increased population of the region. These social and physical changes influenced the scientific evaluation parameters of water quality despite the water quality conservation activities of the An'yang Stream restoration governance. Additionally, the CV between 2005 and 2015 increased because Region IV experienced pressure from development and urbanization that could draw various interests. Region IV struggled due to a drying stream phenomenon, so minimum environmental flow was supplied to provide a specific stream flow level in 2009 [21], which might be associated with the citizens' values in the 2015 survey results, in which their values on stream flow management increased compared with the 2005 survey results because the governance of the An'yang Stream restoration conducted public hearings and made announcements through the media. The WEI score of Region IV was generally low (see Table 2). Hence, these influences in the An'yang Stream regions recommend the redrafting of current policies and regulations on stream restoration and regional planning in the An'yang Stream watershed.

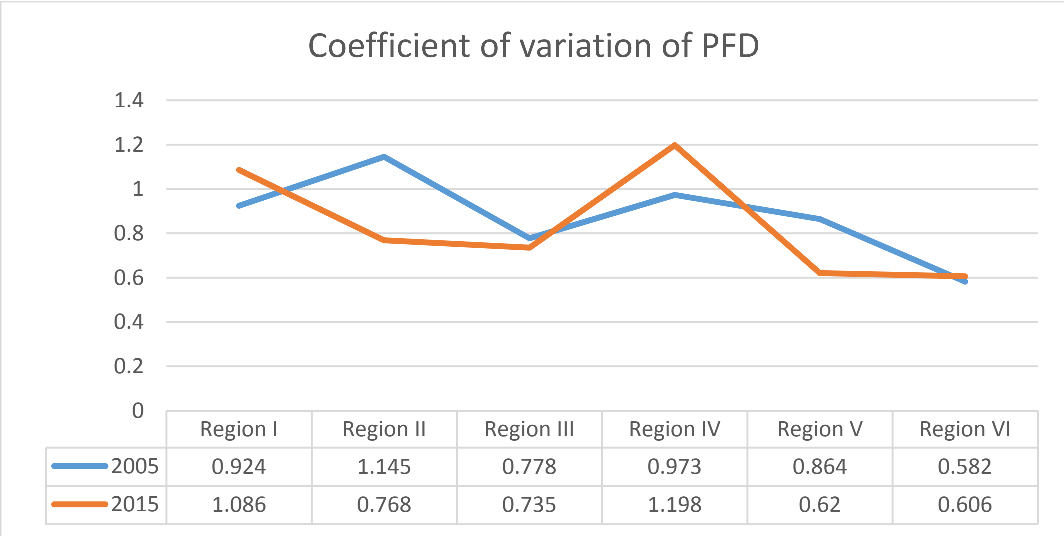
The regional results of PFD, PSD and PWQD in 2005 and 2015 are shown in Figure 5. Region V had an enormous challenge in coping with floods because it is located in a downstream basin of the An'yang Stream. The decision makers within the An'yang Stream restoration governance had to consider building additional water sewage recycling treatment plants and increasing minimum environmental flow during the drought season in this region because of the effects of increased urbanization. Thus, there could be a drastic decrease in citizens' consideration of the prevention of stream flow depletion and the enhancement of water quality as significant values: the comparative weighted value of water quality enhancement (mentioned as PWQD) was 63.3% in 2005 and 41.6% in 2015. Interestingly, Region II showed a similar change in the pattern of citizens' preferences in rating values concerning the An'yang Stream. The survey results describe a significant decrease in the number of citizens considering the prevention of stream flow depletion and water quality deterioration: the comparative weighted value of water quality enhancement was 61.3% in 2005 and 56.5% in 2015. The weighted value of PFD of Region II was the most important value for the citizens when compared to other regions. Although Region II is located in the upstream, PFD risk was higher than the other values in the AHP analysis undertaken by water resource professionals [18]. The PSD and PWQD of both Region II and V were lower than in the other regions, which shows that citizens in both Regions agree with the experts that the threat of hazardous flooding of the An'yang Stream is real. Consequently, urban planners and water resources engineers supervising the restoration of the An'yang Stream must include and reflect the trend of these preferences from 2005 and 2015 at the planning for the next decade.



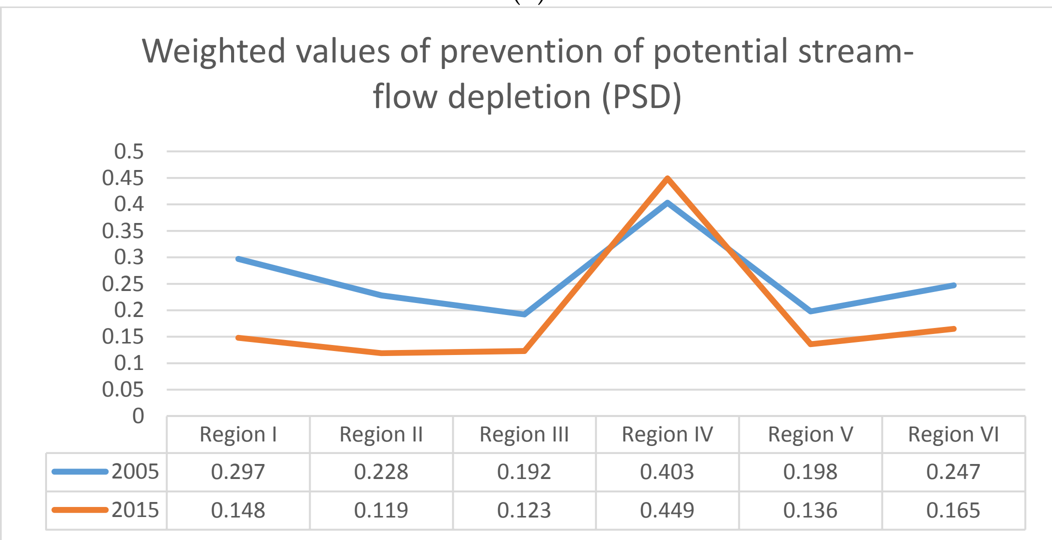
	Region I	Region II	Region III	Region IV	Region V	Region VI
2005	0.224	0.159	0.225	0.225	0.169	0.397
2015	0.25	0.315	0.208	0.119	0.447	0.406

(**a**)

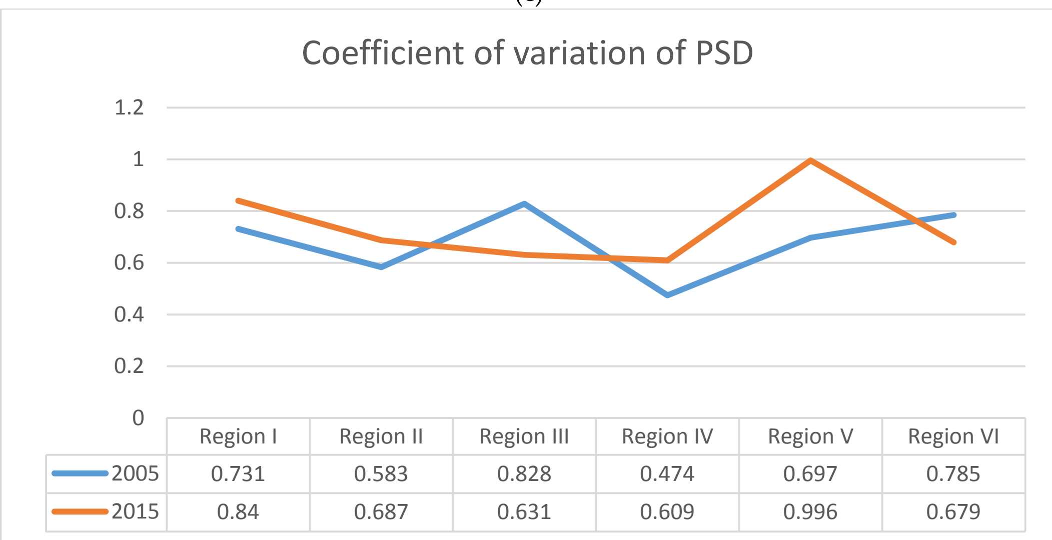
Figure 5. *Cont.*



(**b**)

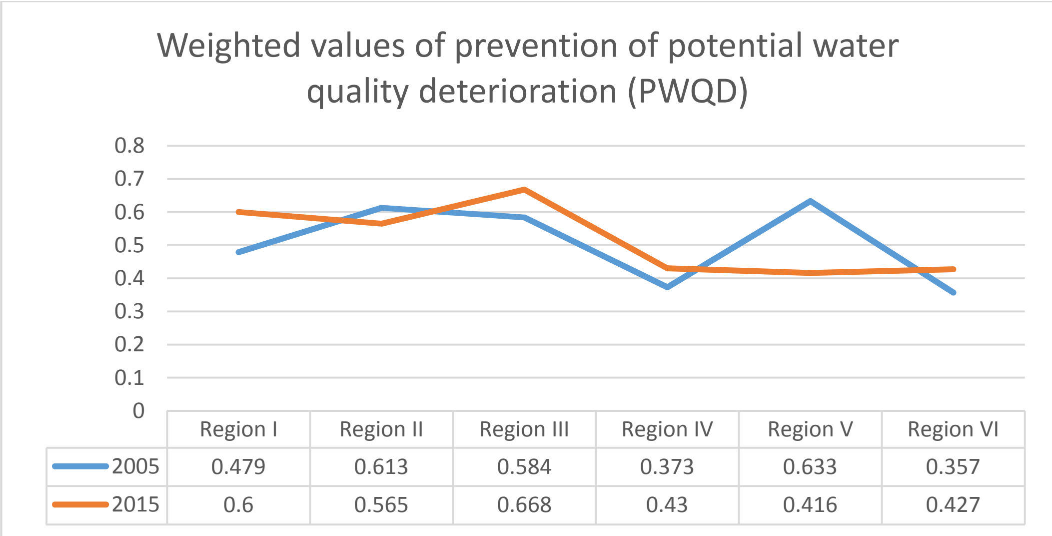


(**c**)

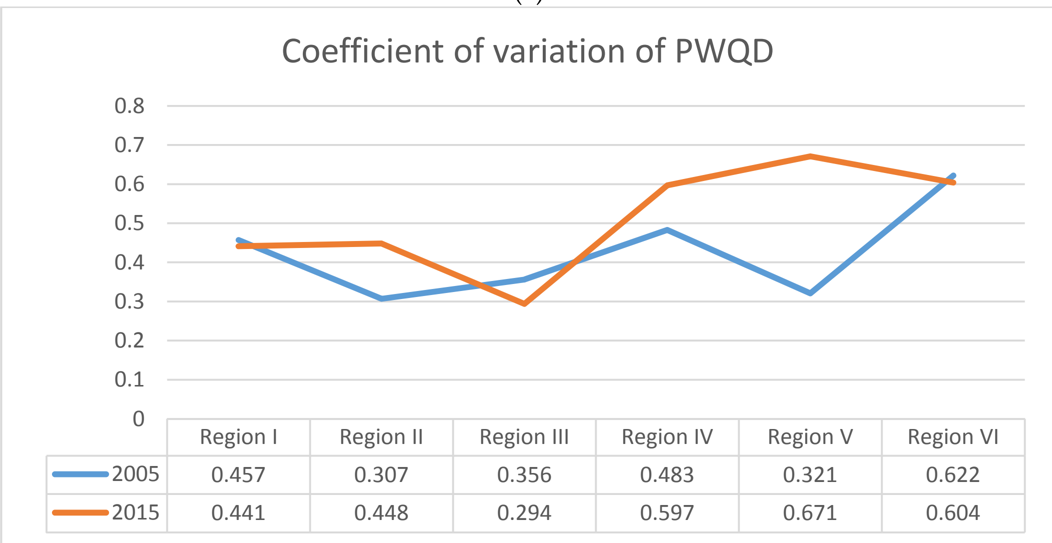


(**d**)

Figure 5. *Cont.*



(**e**)



(**f**)

Figure 5. Changes of citizens' preferences on PFD, PSD, and PWQD and the CV by region: (**a**) average relative percentage of AHP weighted values of PFD by region in 2005 and 2015; (**b**) average CV of PFD in 2005 and 2015; (**c**) average relative percentage of AHP weighted values of PSD by region in 2005 and 2015; (**d**) average CV of PSD in 2005 and 2015; (**e**) average relative percentage of AHP weighted values of PWQD by region in 2005 and 2015; and (**f**) average CV of PWQD in 2005 and 2015.

5. Conclusions

Stream restoration projects should consider the complex conditions in the mission's agenda, embracing diverse values since the sustainable paradigm of river management has changed. However, the governance systems for stream restoration projects have not been able to cope flexibly and rapidly with the changing and challenging paradigm in the field of stream management. This study tested if the government strategies determined by the stream restoration authorities and the professional research institutes have influenced and reflected the citizens' interests in the An'yang Stream restoration. Because of the lack of appropriate participatory decision-making processes, the policies and programs implemented by the An'yang Stream restoration governance have tended to drive the restoration strategies toward water quality improvement as the primary value. In addition, the policies and programs of stream restoration were formed based on top-down decision-making processes because the governance aimed to achieve an efficient water quality enhancement in the short term. Hence, this research could find that the citizens' values on the An'yang Stream are affected by these trends. (Table 5).

Table 5. Importance ranking of the key stream restoration principles.

Rank	Principle
1	Potential water quality deterioration (PWQD); (0.506, 50.6%)
2	Potential streamflow depletion (PSD); (0.261, 26.1%)
3	Potential flood damage (PFD); (0.233, 23.3%)

The most valuable contribution of this research is the quantitative interpretation of citizens' preferences to the interests on stream restoration, in showing the relative-weighted relationships among the interests, which have not yet been fully attempted by previous researchers. This research's view is also different because it is a comparative research design of the citizen preference surveys conducted in 2005 [9] and 2015. This comparative analysis is essential in reflecting the newly updated citizen' preference patterns to rate the specific values of the An'yang Watershed. Furthermore, this comparative analysis, with the differences between the citizens' preferences in 2005 and 2015 clearly indicates that, in 2015, the citizens were still concerned about water quality issues on the An'yang Stream; they valued water quality enhancement as the main agenda more than flood management and streamflow control, which the citizens valued more in 2005. However, the citizens who live in frequently flooded regions are inclined to hold a higher fear of and concerns about flooding than citizens in other regions. The citizens in some regions that recorded low streamflow levels responded that the An'yang Stream restoration strategies should solve the streamflow issues in tandem with water quality enhancement. Therefore, the decision-makers of the An'yang Stream governance should establish a participatory and flexible river management system by accepting the unique regional features and the citizens' interests in planning a long-term river management strategy. However, the reality showed that the present governance system aims for shortsighted top-down decision-making in achieving water quality improvement. The importance of participatory decision-making is undeniable for embracing and valuing various goals as well as the water quality issue in the stream management system of the An'yang Stream basin. In the next research, strategies to establish more active participatory decision-making based on the findings of this research for the An'yang Stream society will be addressed.

Acknowledgments: This research was sponsored by Tokyo Foundation SYLFF Research Grant Fund. This study was also supported by funding from the Basic Science Research Program of the National Research Foundation of Korea (NRF-2014R1A1A2056153).

Author Contributions: Chang-Yu Hong and Eun-Sung Chung wrote the article in equal shares.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Gray, B. *Collaborating: Finding Common Ground for Multiparty Problems*; Wiley: San Francisco, CA, USA, 1989.
2. Castells, M. *The Information Age: Economy, Society and Culture*; Blackwell: Cambridge, MA, USA, 1996.
3. Shergold, P. Governing through Collaboration and Conclusion. In *Collaborative Governance: A New Era of Public Policy in Australia?*; O'Flynn, J., Wanna, J., Eds.; ANU E Press: Canberra, Australia, 2008.
4. Yang, J.S.; Kim, S.U.; Chung, E.S.; Kim, T.W. Prioritization of water management under climate change and urbanization using multi-criteria decision-making methods. *Hydrol. Earth Syst. Sci.* **2012**, *16*, 801–814. [CrossRef]
5. Carr, G.; Blöschl, G.; Loucks, D.P. Evaluating participation in water resource management: A review. *Water Resour. Res.* **2012**. [CrossRef]

6. Fung, A.; Wright, E.O.; Abers, R. *Deepening Democracy: Institutional Innovations in Empowered Participatory Governance*; Verso: London, UK, 2003.
7. Berkes, F.; Folke, C.; Colding, J. *Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience*; Cambridge University Press: Cambridge, UK, 1998.
8. Díaz, S.; Lavorel, S.; de Bello, F.; Quétier, F.; Grigulis, K.; Robson, T.M. Incorporating Plant Functional Diversity Effects in Ecosystem Service Assessments. *Proc. Natl. Acad. Sci. USA* **2007**, *104*, 20684–20689.
9. Chung, E.S.; Kim, Y. Development of fuzzy multi-criteria approach to prioritize locations of treated wastewater use considering climate change scenarios. *J. Environ. Manag.* **2014**, *146*, 505–516. [CrossRef] [PubMed]
10. Holling, C. Adaptive Environmental Management. *Environ. Sci. Policy Sustain. Dev.* **1986**. [CrossRef]
11. Scholz, J.T.; Stiftel, B. *Adaptive Governance and Water Conflict: New Institutions for Collaborative Planning*; Resources for the Future: Washington, DC, USA, 2005.
12. Sivapalan, M.; Savenije, H.H.G.; Blöschl, G. Socio-hydrology: A New Science of People and Water. *Hydrological Processes* **2012**, *26*, 1270–1276. [CrossRef]
13. Ostrom, E. A General Framework for Analyzing Sustainability of Social-Ecological Systems. *Science* **2009**, *325*, 419–422. [CrossRef] [PubMed]
14. Heathcote, I.W. *Integrated Watershed Management: Principles and Practice*; Wiley: New York, NY, USA, 1998.
15. Lee, K.; Chung, E.S. Development of integrated watershed management schemes for an intensively urbanized region in Korea. *J. Hydro-Environ. Res.* **2007**, *1*, 95–109. [CrossRef]
16. Lee, K.; Chung, E.S.; Kim, Y.O. Integrated watershed management for mitigating streamflow depletion in an urbanized watershed in Korea. *Phys. Chem. Earth* **2008**, *33*, 382–394. [CrossRef]
17. Chung, E.S.; Lee, K. A social-economic-engineering combined framework for decision making in water resources planning. *Hydrol. Earth Syst. Sci.* **2009**, *13*, 675–686. [CrossRef]
18. Chung, E.S.; Lee, K. Prioritization of water management for sustainability using hydrologic simulation model and multicriteria decision-making techniques. *J. Environ. Manag.* **2009**, *90*, 1502–1511. [CrossRef] [PubMed]
19. Kim, Y.; Chung, E.S. An index-based robust decision-making a framework for watershed management in a changing climate. *Sci. Tot. Environ.* **2014**, *473–474*, 88–102. [CrossRef] [PubMed]
20. Oskamp, S.; Harrington, M.J.; Edwards, T.C.; Sherwood, D.L.; Okuda, S.M.; Swanson, D.C. Factors influencing household recycling behavior. *Environ. Behav.* **1991**, *23*, 494–519. [CrossRef]
21. Chung, E.S.; Lee, K. Identification of Spatial Ranking of Hydrological Vulnerability Using Multi-Criteria Decision Making Techniques: Case Study of Korea. *Water Resour. Manag.* **2009**, *23*, 2395–2416. [CrossRef]
22. Hirayama, N.; Nakamucasra, M.; Ide, S. Proposal of a tool for evaluating people's values regarding Lake Biwa. *Lakes Reserv. Res. Manag.* **2011**, *16*, 205–209. [CrossRef]
23. Chow, T.E.; Sadler, R. The consensus of local stakeholders and outside experts in suitability modeling for future camp development. *Landsc. Urban Plan.* **2010**, *94*, 9–19. [CrossRef]
24. Lee, G.K.L.; Chan, E.H.W. The Analytic Hierarchy Process (AHP) Approach for Assessment of Urban Renewal Proposals. *Soc. Indic. Res.* **2008**, *89*, 155–168. [CrossRef]
25. Saaty, T. *The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation*; McGraw-Hil: New York, NY, USA; London, UK, 1998.
26. Saaty, T. *Fundamentals of Decision Making and Priority Theory with the Analytic Hierarchy Process*; Analytic Hierarchy Process Series; RWS Publications: Pittsburgh, PA, USA, 2000.
27. DeSteiguer, J.; Duberstein, J.; Lopes, V. The Analytic Hierarchy Process as a Means for Integrated Watershed Management, 2003.
28. Stefanidis, S.; Stathis, D. Assessment of Flood Hazard Based on Natural and Anthropogenic Factors Using Analytic Hierarchy Process (AHP). *Nat. Hazards* **2013**, *68*, 569–585. [CrossRef]
29. OECD. *OECD Core Set of Indicators for Environmental Performance Reviews*; OECD Environmental Monographs, No. 83; OECD: Paris, France, 1993.
30. Chang, H. Spatial analysis of water quality trends in the Han River basin, South Korea. *Water Res.* **2008**, *13*, 3285–3304. [CrossRef] [PubMed]
31. Kim, Y.; Chung, E.S. Integrated assessment of climate change and urbanization impact on adaptation strategies: A case study in two small Korean watersheds. *Clim. Chang.* **2012**, *115*, 853–872. [CrossRef]

32. Lee, K.; Chung, E.S. Planning and Implementation for Integrated Watershed Management. *J. Natl. Acad. Sci.* **2011**, *50*, 153–191.
33. Water Information System. Available online: http://water.nier.go.kr/main/mainContent.do (accessed on 3 July 2015).
34. Anonymous. *An'yang Stream Restoration Master Plan, City of An'yang*; Samyoung Publisher: Gyeonggi, Korea, 2001.
35. Anonymous. *An'yang Environmental Master Plan 2009–2018, City of An'yang*; Samyoung Publisher: Gyeonggi, Korea, 2009.