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Heterogeneous Value of Water: Empirical Evidence in South Korea

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Abstract: Anthropogenic pressures have exacerbated self-sustaining river services, and growing concerns over sustaining river system become global problematic issues that lead us to implement river restoration projects. Of those projects, governing diverse needs and desires from stakeholders for those who have various water values are key elements of identifying the success of the project. In fact, the Korean government has had concern over restoring the rivers which brings to construct 16 weirs in four major rivers and may fail to achieve main goal of the project, which is to ameliorate water quality. In this study, principle component analysis and multinomial logit model were executed to investigate major socioeconomic variables to influence water values in terms of sustainability in Korea. Evitable evidences have been found that age, income, education level, and city dwelling are the most effective variables to estimate water values. In addition, a monotonous water development project and a myopic view could cause major dejection across the nation and may lead to the failure of water governance. Unfortunately, the latter may be observed in Korea as one of the reasons for the recent amplification of major conflicts.

Keywords: multinomial logit model; principle component analysis; river; sustainable development; water value

1. Introduction

Water is a fundamental resource for human survival and a key ingredient for sustaining economic development. After the end of the millennium development goals, the value of water resources has been increased in the context of the sustainable development goals, as in target goal 6, "Ensure availability and sustainable management of water and sanitation for all." In many parts of the world, in fact, water is allocated to less valued users, water quality continues to degrade, groundwater aquifers suffer from overexploiting, water-related ecosystem services encounter inadequate attention from public, and water-related disasters take an unnecessarily severe toll on human property [1]. In addition, if climate change projections provided by many atmospheric scientists are accurate, changes in temperature are expected to result in greater water demand and decrease the available water supply. Since increased anthropogenic activities combined with climatic changes are likely to exacerbate current water allocation patterns and usages and become challenges in water resources management, it is important to value water resources in order to efficiently allocate the available water to maximize its environmental, social, and economic values in harmony with each other.

Determining, however, the value of water is sometimes derived from the misconceptions. A well-known Dublin Statement on Water and Sustainable Development indicates that water should be recognized as an economic good, but past failure to characterize the economic value of water led to exacerbating its uses. In the field of economics, competitive markets are a relatively good solution for determining and responding to individual preferences for many needs and desires [2]. Due to the distinguishing characteristics of water, it is not a good for trade on a conventional market, and non-priced side effects frequently accompany water use. Moreover, the value of water can be changed over time or differed from its users' demands. In these regards, exploring the heterogeneous value of water should be perceived as a major component to decision makers, especially when they plan to implement water resource management strategies, such as constructing dams, barrages, or weirs.

In 2008, the president of the Republic of Korea announced the national-level development strategy called "Low-Carbon Green Growth" that allow the economic structure to shift from a conventional development to an environmental friendly one [3]. This action not only envisioned a new growth pathway but also emphasized sound natural resources management for the future water scarcity, coupled with forecasted climate change scenarios. To implement this strategy in the water domain, the Korea government spent approximately $17.3 billion to construct 16 weirs in four major rivers (the Han, Geum, Nakdong, and Yeongsan rivers) in the name of the "four major rivers restoration project." The main purpose of this mega project is to prevent flood, to capture sufficient water resources, to improve water quality, and to increase total water volume up to 1.3 billion cubic meters [4]. In spite of these good intentions, Lee et al. [5] pointed out that policy makers excessively overused public expenditure and ignored various stakeholders' water demand related to it values.

Considering the characteristics of water resources in terms of an implementing water resource management strategy for the future, a number of critical research questions have been brought up. For planning and implementing a mega project such as the four major rivers restoration project in Korea, should we consider different water values and demands among regions or stakeholders? If so, what variables will affect the water value? How can we categorize the water values in different perspectives, i.e., in terms of sustainable development? What should we consider for future water resource management plans?

Many economists investigated valuation methods to estimate the value of water and empirical analyses of efficient water resource management schemes. For instance, Faux and Perry [6] estimated irrigation water value in Oregon, US, by applying hedonic price analysis. Howe et al. [7] explored the value of water in urban water system by conducting a contingent valuation method. In addition, Young and Loomis [1] summarized various valuation methods to estimate the value of water. However, most economic literature focuses on the monetary value of water. On the contrary, there are a few studies to investigate the various types of water value using conceptual approaches. For instance, Tàbara and Ilhan [8] introduced a transition theory to analyze the role of culture as one neglected value in the Spanish water domain. Wolfe [9] explored water cognition to identify priority clusters with in a Canadian water community. Pahl-Wostl et al. [10] emphasized the importance of social learning and culture as a new paradigm of sustainable water resource management. Recent studies attempted to explore more complex methodologies to estimate the values of water in various usages, but none of literatures attempted to merge heterogeneous water values in terms of the sustainable development concept into the ex-post assessment framework of mega projects.

In this paper, we investigated the heterogeneous water value and assessed a past mega project, the four major rivers restoration project, in the context of sustainable development to enhance national-level water value in Korea. Our analysis is based on a national-level water demand and value survey that allows us to conduct further statistical analyses, e.g., principal component analysis and multinomial logit regression similar to those done in other studies (e.g., [5,11]). The rest of the paper is organized as follows. Section 2 describes a background of the case study which is the four major rivers restoration project in Korea, and the survey design that we conducted for measuring water value in Korea, including general water-related data in Korea. Section 3 provides an overview of theoretical approaches to prioritize water value and characterize consumer behaviors. Section 4 presents empirical results from the case study, and in the last section, we conclude the paper with a summary of the main findings, with a brief suggestion for policy dimensions.

2. Case Study and Application

2.1. The Four Major Rivers Restoration Project

The annual average precipitation in the Korean Peninsula is about four times greater than the world average, but two-third of its rainfall is concentrated during the monsoon season (June to September), and there is little rain during the rest of the year. Due to its unbalanced precipitation pattern, Korea is categorized as a water-stressed country, and annually repeated water-related disasters such as droughts and floods are commonplace [12]. To eradicate these natural disasters, the Korean government decided to implement the "four major rivers restoration project" as a part of the "Green New Deal" policy in 2008. The four rivers are the Han, Nakdong, Geum, and Yeongsan rivers (Figure 1). The main objective of the project was to restore those four rivers and enhance water security, flood control, and ecosystem vitality by constructing 16 weirs. In addition, the project was designed to promote historical and cultural tourism [13]. The expected outcomes of the project were to improve water quality, to secure water resources, to restore ecosystems, to create multipurpose riverside spaces, and to accelerate the regional economy. The project was designed to construct 16 weirs by dredging 570 million m^3 of sediment and graveling almost 700 km of riverbed. It was the costliest construction projects in recent Korean history [12]. The total budget for this mega project was approximately $17.3 billion dollars, but Lee et al. [5] concluded that the economic value created by the project was extremely smaller than its cost. This might be the result of the failure of reflecting various stakeholders' demands and desires of water value or ignoring the trend of river restoration concept in terms of sustainability.

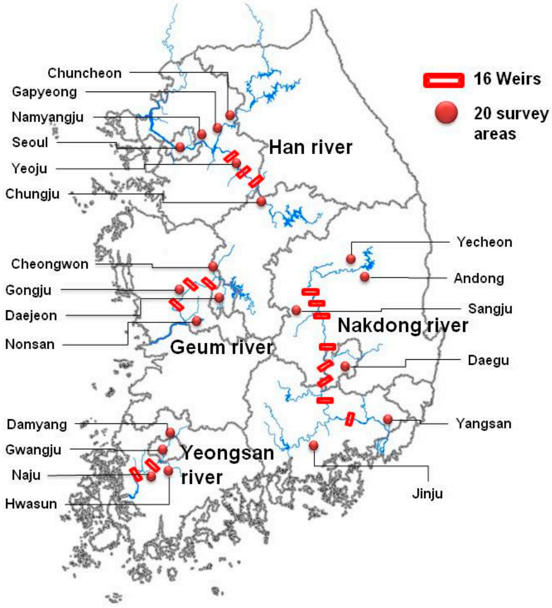

Figure 1. Four major rivers and 20 survey areas.

2.2. Survey Design and Data

National-level water demand and value survey in terms of sustainability was conducted to collect information from 20 cities and provinces, i.e., Han (including Chuncheon, Gapyeong, Namyangju, Seoul, Yeoju, Chungju), Nakdong (Yecheon, Andong, Sangju, Daegu, Yangsan, Jinju), Geum (Cheongwon, Gongju, Daejeon, Nonsan), and Yeongsan (Damyang, Gwangju, Naju, Hwasun) river watersheds where these cities and provinces are the best representatives watershed areas directly influenced by the four major rivers restoration project. Considering demographic characteristics, 2850 samples were collected by a professional survey company from August 2012 to November 2012. Highly trained interviewers conducted telephone surveys through random digital dialing during a given time period and explained about the value of water for the purposes of this survey.

Followed by Pahl-Wastl et al. [10] and Tàbara et al. [14], the main questionnaire consisted of seven parts: (1) cognizance on function of rivers, (2) problem awareness of rivers, (3) policy awareness of rivers, (4) cognizance on possible value of rivers, (5) awareness of conflicts among each value created by water, (6) cognizance on complementary relationships among each water value, and (7) cognizance on river restoration policy direction and governance problems. These questions were intended to categorize water demand and values into three dimensions: (1) environmental (or ecological) value, (2) social value including historical and cultural value, and (3) economic value. Table 1 illustrates the description of variables and summary of statistics.

Table 1. Variable description and summary statistics.

Variables	Description	Mean	95% Confidence Interval	
Sample	Sample size for each rivers (Quota sampling based on demographic and regional characteristics of population)	2850 (Han, 900; Nakdong, 850; Geum, 550; Yeongsan, 550)		
Gender	Male 1, Female 0	0.490 (0.009)	0.471	0.508
Age	Year	49.721 (0.311)	49.111	50.331
Job	White-color 1, otherwise 0	0.603 (0.135)	0.336	0.870
Education	Under elementary 1, under middle 2, under high school 3, college 4, college graduate 5, above college 6, otherwise 7	3.554 (0.034)	3.487	3.621
Household Income	<\$2000 1, <\$3000 2, <\$4000 3, <\$5000 4, <\$6000 5, <\$7000 6, <\$8000 7, >\$8000 8, Otherwise 9	4.347 (0.060)	4.229	4.465
Upstream dummy	Upstream 1, otherwise 0	0.596 (0.009)	0.578	0.614
City dummy	City 1, otherwise 0	0.438 (0.009)	0.420	0.456

Note: Numbers are mean and in parentheses are standard errors.

3. Model Specification

3.1. The Multinomial Logit Model

The multinomial logit model is one of the well-known conventional methods for dealing with a discrete choice among a set of alternatives in economics [15]. For instance, Hensher [16], McFadden [17], and many other economists have applied this method to estimate the travel mode of urban commuters. Schmidt and Strauss [18] and Boskin [19] have used an unordered multinomial logit model to analyze occupational choice among multiple alternatives. Since our study is based on the national water value cognizance survey 2012, the data set can be defined as unordered and individual specific. Therefore, analyzing data with a multinomial logit model is adequate. The unordered choice model can be originated by a random utility model, which can be written as follows:

$$U_{ij} = z'_{ij}\beta + \varepsilon_{ij} \tag{1}$$

where U is individual utility, i is observed individual, j is ith consumer's choice among alternatives, z is regressors, β is coefficient, and ε is error term. If the individual chose j choice in particular, then it is assumed that U_{ij} is maximized utilities among the J utilities. Hence, the statistical probability model can be driven as follows:

$$\text{Prob}(U_{ij} > U_{ik}) \text{ for all other } k \neq j \tag{2}$$

In general, two models can be considered: probit and logit. Because of the need to calculate multiple integrals of the normal distribution, the probit model has a limited availability, unlike the binomial case. The logit, however, has a more relaxed assumption in this case. McFadden [17] has shown that if and only if the J disturbances are independent and identically distributed (iid) with Gumbel distribution, multinomial logit model can be written as follows:

$$\text{Prob}(Y_i = j) = \frac{\exp(\beta_j' \mathbf{x}_i)}{\sum_{k=1}^{J} \exp(\beta_k' \mathbf{x}_i)},\ j = 1, \ldots, J \tag{3}$$

where Y_{ij} is a priority cognizance of water value driven from the PCA score for ith observed individual and $\mathbf{x}$ is a matrix of regressors (e.g., socioeconomic factors). Before proceeding, we selected the base result (β^*), which is the most chosen cognizance of water value from the data set and defined $\beta_j^* = \beta_j + q$ for any vector q [15]. In general, because the parameters of multinomial models are hard to interpret directly, the marginal effect (ME) can be used for alternative explanations [20]. Functional form can be as follows:

$$\text{ME}_{ijk} = \frac{\partial \text{Prob}(Y_i = j)}{\partial \mathbf{x}_{ik}} = \frac{\partial F_j(\mathbf{x}_{ij}, \theta)}{\partial \mathbf{x}_{ik}} \tag{4}$$

In addition, we can also compute J log-odd ratios, as follows:

$$\ln\left[\frac{\text{Prob}(Y_i = j)}{\text{Prob}(Y_i = k)}\right] = x_i'(\beta_j - \beta_k) \tag{5}$$

Finally, the log-likelihood function can be written as follows:

$$\ln L = \sum_{i=1}^{N} \sum_{j=0}^{J} d_{ij} \ln \text{Prob}(Y_i = j) \tag{6}$$

One of the well-known problems of the aforementioned model is that the logistic model becomes unstable due to the strong dependence among predictors [21]. It seems that no one variable is important when all the others are included in the model which causes a high-dimensional multicollinearity problem. Like many other regression method, the logistic regression usual to have a very high number of predictor variables so that a reduction dimension method is needed to improve accuracy of the logistic estimation [22]. The following data reduction technique, principal component analysis (PCA), can be introduced to correct this problem.

3.2. Principal Component Analysis

Principal component analysis (PCA) is a well-established multivariate statistical analysis for dimensionality reduction, and numerous applications can be found in the field of data compression [23]. The key feature of this method is that it allows relatively straightforward projection of data from higher to lower dimensional space without any assumption on the data distribution [24]. In principal, PCA can be applied various social science field as an orthogonal linear transformation, allowing the data to a new coordinate system. For a set of observed data matrix, X, with zero mean, where each of the n rows indicates a different individual and each of the p columns gives a water value cognizance from an individual. According to Jolliffe [25], mathematical formation of the aforementioned statement can be written as follows.

The transformation is defined by a set of p-dimensional vectors of loadings $\mathrm{W}_{(k)} = (w_1, \ldots, w_p)_{(k)}$ that map each row vector $\mathrm{X}_{(i)}$ of X to a new vector of principal component scores $t_{(i)} = (t_1, \ldots, t_p)_{(i)}$, given by $t_{k(i)} = \mathrm{X}_{(i)} \cdot \mathrm{W}_{(k)}$, where t considered over the data set successively inherit the maximum possible variance from X with each loading vector W constrained to be a unit vector. Then the first component can be derived as follows:

$$\mathrm{W}_{(1)} = \underset{\|\mathrm{W}\|=1}{\operatorname{argmax}} \left\{ \sum_i (t_1)_{(i)}^2 \right\} = \underset{\|\mathrm{W}\|=1}{\operatorname{argmax}} \left\{ \sum_i \left(\mathrm{X}_{(i)} \cdot \mathrm{W}\right)^2 \right\} \tag{7}$$

Since $W_{(1)}$ has been assumed as a unit vector,

$$W_{(1)} = \text{argmax}\left\{\frac{W^{T}X^{T}XW}{W^{T}W}\right\} \quad (8)$$

where the first component, $W_{(1)}$, can have a score $t_{1(i)} = X_{(1)} \cdot W_{(1)}$.

By applying the above procedure, the kth component can be found by subtracting the first $k-1$ principal component from X, then the loading vector that extracts the maximum variance from a new data matrix can be written as follows:

$$W_{(k)} = \underset{\|W\|=1}{\text{argmax}}\left\{\|\hat{X}_{k}W\|^{2}\right\} = \text{argmax}\left(\frac{W^{T}\hat{X}_{k}^{T}\hat{X}_{k}W}{W^{T}W}\right) \quad (9)$$

where $\hat{X}_{k} = X - \sum XW_{(s)}W_{(s)}^{T}$.

We applied this ubiquitous decomposition technique to estimate multiple choices from national water value cognizance survey.

4. Empirical Results

Table 2 illustrates the estimates of factor loadings from PCA by analyzing results from the main questionnaire. The questionnaire was asked to interviewees whether respondents feel satisfaction or agree with in terms of five-point scale measures. Estimates of factor loading from PCA are clearly categorized into three parts, which align with an assumption that the value of water can be divided into three dimensions: (1) environmental (or ecological) value, (2) social value including historical and cultural value, and (3) economic value. This result shows that the environmental, social, and economic value of water can be explained by 32.49, 35.29, and 40.93%, respectively.

Table 2. Estimates of factor loadings from principal component analysis (PCA).

Questionnaire	Environmental Value	Social Value	Economic Value
River is an ecological place to animals and plants for their living	0.585		
River ecology needs to restore urgently	0.467		
River development should be conducted environmental friendly way	0.692		
Environmental friendly river development can provide environmental shelter for human	0.602		
River ecology will be degraded by outbound tourists	0.473		
River is a place for local history and culture		0.621	
Conservation of local river culture and modern succession are urgent issues		0.578	
River development should reflect local history and culture faithfully		0.699	
Historical river development can enhance local brand power		0.583	
Local river culture can be destroyed by a commercial development logic		0.465	
River should be a place for local economic benefits			0.602
River development is urgent for a local economy vitalization			0.684
River development should be supplement local economy			0.704
Economic river development can create more jobs and increase a household income			0.645
Economic river development can be delayed by emphasizing environmental and social river development			0.552
Total explained variance	32.49%	35.29%	40.93%

We conducted the varimax rotation in PCA to estimate scores for each city and province, which is shown in Table 3. Results show, for example, that Chuncheon and Chungju, located upstream of the Han River, indicate a higher standard of the environmental value of water, while Yecheon and Damyang, relatively upstream of rivers, shows the lowest standard of environmental value. For social value of water dimension, Gapyeong and Chungju, located upstream of the Han River and having potential developing leisure industries, scores the highest standard, but Namyangju and Damyang show the lowest standards of the social value of water. Contrary to those results, respondents from Nonsan and Yecheon illustrate the highest score of economic water value, and Cheongwon and Gwangju indicate the lowest economic value of water. In addition to this, Seoul, one of the metropolitan cities around the world, shows relatively low cognizance of economic water value.

Table 3. PCA scores for each city and province.

River	Cities/Provinces	Environmental Value	Social Value	Economics Value
Han	Chuncheon	0.26	0.07	0.05
	Gapyeong	−0.12	0.18	−0.02
	Namyangju	−0.16	−0.20	−0.07
	Seoul	0.18	0.04	−0.10
	Yeoju	−0.15	0.09	0.04
	Chungju	0.19	0.18	0.03
	Mean	0.07	0.04	−0.02
Nakdong	Yecheon	−0.34	−0.12	0.28
	Andong	−0.13	−0.04	0.11
	Sangju	−0.25	−0.14	0.14
	Daegu	0.04	0.04	0.06
	Yangsan	0	−0.08	0
	Jinju	−0.02	0.13	−0.06
	Mean	−0.05	−0.05	0.06
Geum	Cheongwon	0.03	−0.07	−0.19
	Gongju	0.10	0.14	0.09
	Daejeon	0.11	−0.03	−0.09
	Nonsan	0.11	0.07	0.42
	Mean	0.08	0.05	0.00
Yeongsan	Damyang	−0.31	−0.19	0.08
	Gwangju	−0.01	−0.08	−0.17
	Naju	−0.28	−0.12	−0.06
	Hwasun	−0.08	0.03	0.05
	Mean	−0.12	−0.05	−0.07

The aforementioned results overturn conventional patterns of water development that downstream regions have relatively high preference for environmental conservation in rivers and upstream regions strictly prefer more economic river development concepts. Figure 2 clearly illustrates geographical distributions of each water value. Moreover, it is evitable that there are wide variations of water values across and within regions, cities, and provinces. This complex structure of cognizance on water value drives us to execute further analysis, i.e., multinomial logit model, to consider the sociodemographic characteristics of consumers on what matters to select difference values of water.

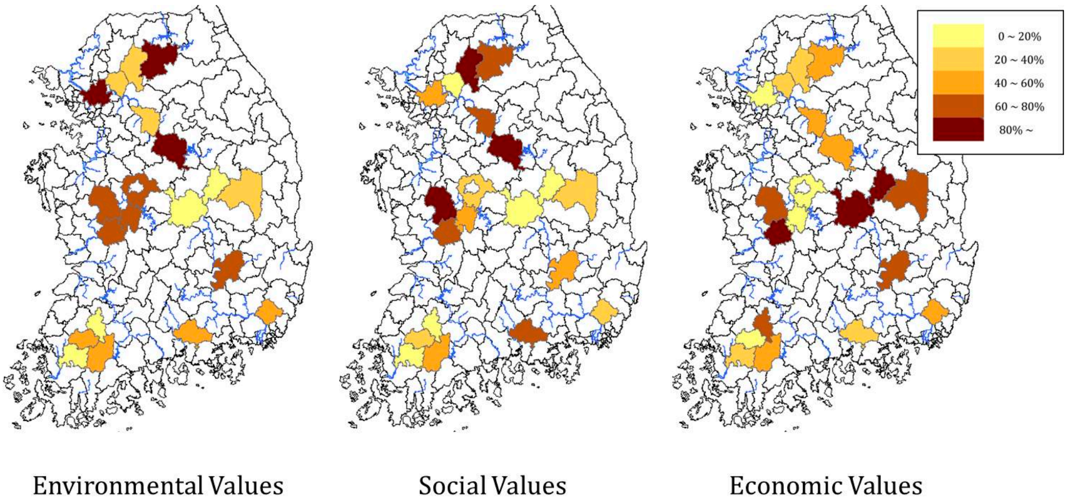

Figure 2. Geographical distribution of PCA scores for each value dimension.

Before proceeding, PCA scores for each individual were converted as count data, i.e., if an observed individual has the environmental value of water as the highest PCA score, it is coded as a dependent variable of 1. If the social value of water was chosen as the highest one, it was then coded 2. Finally, if a respondent indicated the economic value of water has the highest priority value, then we coded it as 3. This procedure allows us to convert our dataset into a case-specific one. Table 4 presents the empirical results for the multinomial logit model with coefficients as well as relative risk ratio (rrr).

Table 4. Multinomial logit model estimates for cognizance on water value.

Variable	Coefficient	rrr	std. err.	$P > \|z\|$
Environmental Value		**(Base Outcome)**		
Social Value				
Intercept	−1.252	0.285	0.072	0.000 **
Gender	−0.012	0.988	0.010	0.907
Age	0.017	1.017	0.003	0.000 **
Job	0.007	1.007	0.007	0.351
Education	−0.033	0.966	0.029	0.260
Household Income	0.051	1.052	0.017	0.002 **
Upstream Dummy	0.004	1.121	0.124	0.303
City Dummy	−0.405	0.666	0.074	0.000 **
Economic Value				
Intercept	−0.523	0.592	0.132	0.020 **
Gender	0.050	1.051	0.093	0.574
Age	0.018	1.018	0.002	0.000 **
Job	0.008	1.008	0.006	0.190
Education	−0.077	0.925	0.025	0.004 **
Household Income	0.020	1.020	0.015	0.160
Upstream Dummy	0.073	1.076	0.103	0.446
City Dummy	−0.313	0.730	0.070	0.001 **
Log likelihood = −3004.0026 Number of Observation = 2850; LR $\chi^2(14)$ = 110.58; prob > χ^2 = 0.000; Pseudo R^2 = 0.0181				

Note: ** indicates the significance at the 5% level.

Since environmental value of water is the base outcome, its estimation results do not appear in Table 4. Based on our estimation results, we can see that the regressors are jointly statistically significant at the 0.05 level due to LR $\chi^2(14)$ = 110.58, but the results of individual testing vary with the omitted category. LR test results can identify highly statistically significant variables. Of those seven variables, only age, education, household income, and city dummy turn out to be adequate ones. Thus, a one-unit increase in age leads to relative odds of cognizing the value of water from the social aspect rather than the environmental aspect that are 1.017 times higher. Similarly, cognizance on the value of water shifts from environmental to economic as people get older. More likely, if household income is higher, the social value of water is more likely than environmental value. Contrary to those interpretations, the higher the education level, the more likely the subject is to seek the environmental value of water rather than the economic value. We can observe a clear signal from the result that people who live in cities have a strong cognizance on the environmental value of water compared to both the social and economic value of water.

Marginal effects for each cognizance of water value at variables change still give us more details to interpret. Table 5 illustrates the estimate of marginal effect for three alternative water values at all variables change.

Table 5. Results of marginal effect.

Variable	Environmental Value		Social Value		Economic Value	
	dy/dx	$P > \|z\|$	dy/dx	$P > \|z\|$	dy/dx	$P > \|z\|$
Gender	−0.006	0.736	−0.007	0.656	0.013	0.479
Age	−0.004	0.000 **	0.001	0.013 **	0.002	0.000 **
Job	−0.002	0.197	0.000	0.720	0.001	0.280
Education	0.013	0.012 **	0.002	0.730	−0.015	0.007 **
Household Income	−0.007	0.019 **	0.007	0.005 **	−0.001	0.961
Upstream Dummy	−0.019	0.320	0.013	0.445	0.006	0.754
City Dummy	0.077	0.000 **	−0.042	0.017 **	−0.036	0.082 *

Note: * and ** indicates the significance at the 10% and 5% level, respectively.

For the marginal effect on alternatives of cognizance on water value, one unit of age increase people tend to perceive more social and economic value, 0.001 and 0.002 probabilities, respectively, rather than environmental value in −0.004 chances. Similarly, one unit of household income increases the probability of choosing social value of water rather than environmental or economic value of water by 0.005. However, increased household income leads to a less likely probability (0.007) of choosing the environmental value of water to other alternatives. The city dummy indicates that city dwellers are highly statistically likely to cognize the environmental value of water (0.077 probability) and are less likely to cognize the social and economic value of water (0.042 and 0.036, respectively). More educated people prefer the environmental value of water (0.013) over the economic value of water (0.015).

5. Conclusions

In 2008, the Korean government decided to construct a sequence of weirs in four major rivers to provide better river system services including water quality improvement, local cultural promotion, and local economic activity invigoration as a part of implementing the green growth strategy. This "four major rivers restoration project" was completed almost five years ago after spending approximately $17 billion dollars for construction. Like many public mega infrastructure construction projects, this project was advertised as remarkably successful. However, all those positive effects of this project on local communities are questionable because it was designed without any global consensus of various stakeholders and may not reflect their needs and desires in term of water value in a sustainable manners. Moreover, recent water quality degradation (e.g., Algal bloom) may mean that this mega project failed to achieve its main goal.

In this sense, this research tried to investigate the various value of water in term of sustainability among residents across the four major rivers in Korea and analyze how this value varies in those four watersheds. Although methods of valuing the water have been developed the literature, few have attempted to estimate heterogeneous value of water in a quantitative manner by collecting data from a national-level survey.

In this paper, principal component analysis was conducted to classify the value of water in sustainable terms by using 2850 samples across those four rivers, and the multinomial logit model was applied to characterize dwellers' selection behavior among water values. Furthermore, parameter coefficients for the multinomial logit model is difficult to interpret directly, so the marginal effect analysis was also conducted to estimate the impacts of explanatory variables unit changes on selected water value. Our estimation results clearly indicate that age, education level, and household income are the most significant variables to influence water values. In addition, city dwellers are the most environmental water value seekers, as we can assume. However, the four major rivers restoration project was a monotonous implementing plan ignoring the fact that residences of Korea have various needs and desires for water usage and may exacerbate individual utilities in many dimensions. This bureaucratic authoritarianism and myopic point of view may lead to the failure of the main goal of the project.

The results of this study can be interpreted into several water development policy perspectives: (1) people with higher age and higher household income tend to prefer the social and local cultural demand on water value to its environmental value; (2) individual education level has a significant positive influence on environmental value of water, but negative on economics value; (3) city dwellers have the highest marginal effect on all water values, positive to environmental value and negative to its social and economic value; and (4) gender, job, and upstream-downstream relation have insignificant marginal effects on all water values, meaning that conventional assumptions of upstream-downstream development agenda do not apply in four major rivers. Policymakers should realize these results and apply them when there is a plan for water policy reform and in the event future costly mega construction project like the four major rivers restoration project. Suffice to say that monotonous development plans and myopic views can cause national dejections, especially if policymakers fail to implement sound water governance. Although this paper has some limitations, such as that the survey only covered major cities and provinces in the four rivers watersheds and the study does not calculate social benefits of the mega project, it clearly envisions an inevitable pathway for the future water development project in Korea by revealing individuals' characteristics in terms of sustainability dimensions.

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