Study on the Developing Evaluation Model for the Urban Water Cycle Restoration Policy
(Based on New Urban Development Projects)

By

KIM, Suk Chul

CAPSTONE PROJECT

Submitted to

KDI School of Public Policy and Management

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ABSTRACT

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By

Suk Chul, Kim

This paper aims to propose a comprehensive evaluation model for achieving a healthy urban water cycle restoration. To cope with climate change and environmental pollution, the technical demand for urban water cycle restoration facilities continues to increase. However, this study is meaningful in that the evaluation method was proposed by focusing on ways to improve the empathy and acceptance of stakeholders rather than the technical aspects of the policy.

It reports important factors to be considered by urban policy-makers through a survey of key actors in urban policy, VOC analysis, and qualitative interviews. Also, the expert AHP analysis indicates that a desirable urban water cycle evaluation model should reflect not only its technical benefits but also its vision & goals and feedback process for the 'sustainable growth' of the community.

Eventually, to ensure the success of the urban water cycle restoration policy, it is necessary to develop a new evaluation model that includes technical hardware as well as collaboration software that can reasonably reflect the needs of diverse stakeholders. To do so, we need to evaluate an inclusive governance framework that converges the opinion of various actors in urban development rather than the top-down government system.

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1. Introduction

1.1 Background of information

It is a common phenomenon that urban development policy should be changed to reflect the current paradigm shift (Lee, 2006). In the past, Korea's urban development policy has pursued two main objectives: "land and regional development" and "resolving metropolitan problems." Since the 1990s, five first New Town projects have been developed in the metropolitan area for the government's housing supply expansion policy. In the 2000s, the 2nd New Town Project such as Pan-gyo and Dong-tan, and the 10 Innovation City Projects across the country have made remarkable achievements in solving the problem of functional dispersion concentrated in the metropolitan area (Kim, 2013). Recently, however, the National Assembly report pointed out that new urban policies, primarily for the large-scale housing supply, need to be revised in line with new paradigm shifts such as the increase in housing supply rate, the decrease in population due to low fertility, and high level of the gross national income ((National Assembly, 2016). According to government statistics of MoLIT, the housing supply rate was 103.5% in 2014, and the absolute housing shortage was resolved, and the population is expected to decrease by 2030. Further, the economic growth rate has been around 3% since the 2010s, entering the low-growth era, and the GNI has been increased at more than $ 20,000 since 2010. As a result, the city should be transforming into space where citizens can improve their quality of life with an eco-friendly environment.

Based on this recognition, the urban water cycle restoration projects can be a new momentum that provides key solutions to this paradigm shift (Kim at el., 2017). Many advanced foreign countries consider the water as a key growth factor in the planning of urban development as well as regeneration and try to restore the distorted urban water cycle system as the main target of urban policies. (Kim & Zoh, 2015; Kim & Choi, 2011). Indeed, the importance of the water cycle restoration policies may be interpreted in the same context in Korea. However, unlike past urban development, it is expected to emphasize publicity over profitability, prioritize social and environmental values over economic efficiency, and become the mainstream of future urban policies in Korea. (Ministry of Environment Report, 2018).

1.2 Statement of problem

Although research on evaluation criteria of urban water cycle restoration in Korea is still in its infancy, the interest of policymakers and academia is very high with the current revision of "the Framework Act on Water Management" for the Integrated Water Management. To realize a desirable water cycle restoration policies, various organizations classified techniques for urban water management, analyzed its application effects, and announced guidelines (Baek et al., 2019; Kang, 2018; Lee & Park, 2014; Jang, 2009). However, to the best of our knowledge, there are no results in the literature on the more comprehensive and expanded evaluation criteria regarding systematic processes, the expansion of targets, and reflecting stakeholder perspectives to ensure social acceptance.

The limitations of previous studies may be summarized into three major categories. First of all, it does not provide process evaluation criteria for the overall water cycle system such as vision & goals that reflect regional watershed characteristics, urban planning, strategy for each facility, and maintenance & cooperation. Along with these process issues, most of the previous research has focused mainly on structural green Infra facilities to reduce runoff.

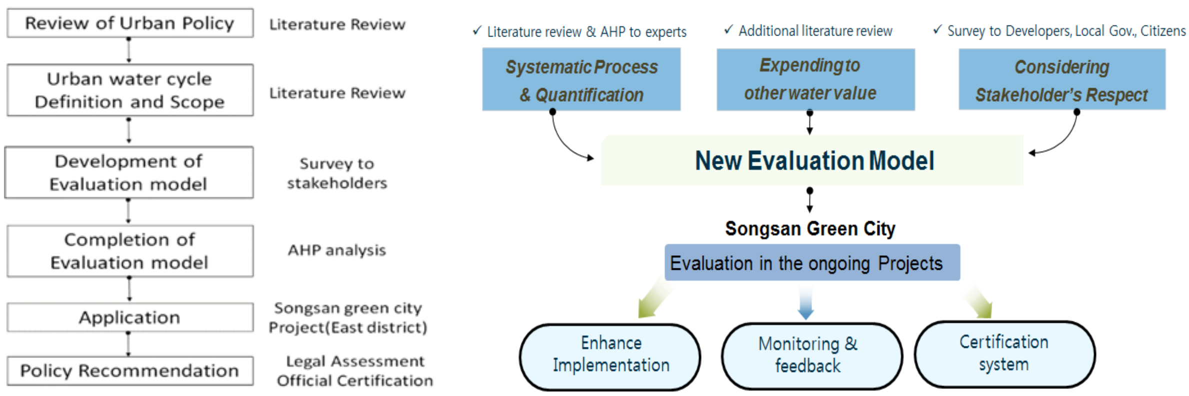
In other words, there is insufficient consideration of a comprehensive water balance that encompasses water demand, use and reuse through gray infra linkages such as clean tap water supply and sewage reuse. Lastly, research on social aspects is needed to fully consider stakeholder positions for the actual outcomes of policy. In particular, the acceptance of local governments, the main actors in the maintenance of the infrastructure, should be considered as an important indicator.

According to Choi et al., (2017), the LID infiltration facility of the Gimpo Han River New Town Project was completely withdrawn due to improper design, insufficient construction experience, and intense civil complaints. The A-san Tangjeong Urban Development Project, which introduced the distributed rainwater management system in Korea, invested 7.7% (6.8 billion won) of the total construction cost in the water circulation facility (Lee et al., 2013). However, it has also been reduced due to difficulties in maintenance, and even after the installation was completed, complaints of residents were prevalent due to safety and cleanliness issues (Choi et al., 2017). Refusal to take over infrastructure by local governments causes not only social conflicts, but also wastes investment costs such as re-construction, and it can act as a barrier to the formation of social consensus for the overall water cycle policy. Although the explanation and motivation of the urban water cycle policy are clear and valid for solving the urban problem caused by climate change in recent years, policy-makers should move beyond the limits of the theoretical box to achieve a more realistic outcome felt by the general public. It is now necessary to develop a practical evaluation model that is systematic, comprehensive and diverse stakeholder opinions are accepted in a balanced way.

1.3 Purpose of research

Comprehensive and specific evaluation indicators can be used not only as planning criteria for new projects but also as inducing projects to be carried out following the original intentions of policies by evaluating the plans in advance. Also, by providing incentives such as official certifications to projects that meet the evaluation criteria, it is possible to raise social awareness and improve the sustainability of policies (Lee, 2003). This study focuses on new urban development projects rather than urban regeneration projects improving the water cycle of existing cities. It has the advantage of having a large investment and low location limits, allowing various water circulation facilities to be applied. The purpose of this study is to present quantified evaluation indicators on the whole process of urban water cycle across 1)Vision & goals – 2)Urban planning – 3)Specific facility Strategy – 4)Maintenance & cooperation. Along with the technical aspects of the urban water cycle, it also suggests policy improvements to ensure the acceptability of local government and residents. Comprehensive process elements will be extracted through a review of previous studies and a survey of various policy actors and be quantified the evaluation indicators through expert AHP evaluation. This study will consult the actual urban development project with the resulting evaluation model to provide implications for desirable water cycle restoration policy.

Figure 1. Research plan



2. Literature review

2.1 Urban Water Cycle Restoration Policy in Korea

In the history of urban policy in Korea, there was a negative perception that focused only on quantitative growth for urgent economic circumstances, such as industrial complexes and the 1st new town projects (Kim, 2013). To make an appropriate response to the international urban development agenda represented by the UN SDGs in the early 2000s, the government (MoLIT, 2007) tried to include various values for cities from the 2nd new town projects by establishing “The Sustainable New-Town Planning Criteria” as a guideline of the Housing Site Development Promotion Act. Kang et al. (2005) added the value of "Sustainable New Town Planning Criteria" by combining the previous studies on urban sustainability. The authors prepared 45 planning indicators by dividing into four frameworks - livability, environmental, sustainability, and living-culture factors. However, according to Kim et al. (2008), although the 2nd new town projects have improved overall social, economic, and environmental sustainability, the water value sector, which has little clear indicators and is defined as scattered, has been estimated passively pursued.

Meanwhile, the waterfront project that promotes sustainable growth by using areas in the vicinity of national rivers systematically and strategically has become a new urban development model since 2010 (Kim, et al., 2017). The project has emphasized ecology and water cycle plans, which had been relatively underestimated from the Sustainable New-Town Planning Criteria, as the main goals. However, even though it provides a basic evaluation framework for the urban water cycle system, there are still limitations that the indicators highlighted only the planning aspect and are ambiguous. Kang et al. (2014) pointed out that these evaluation criteria need to be more specific from various perspectives since they have a significant impact on overall policy strategy. Fragmentary and ambiguous guidelines can be a means of avoiding the policy for developers and act as a barrier to balanced policy implementation. Therefore, it is important to focus on quantifying as much as possible from a variety of perspectives to ensure the concrete performance of the policy.

2.2. Urban Metabolism and the Water Cycle Restoration City

Kennedy et al. (2007) defined urban metabolism as “the sum total of the technical and socio-economic processes that occur in cities, resulting in growth, production of energy, and elimination of waste.” (44). Herbert Girardet (2006) argued that accelerated use of linear metabolism in urban development is a main factor in the global environmental crisis, suggesting that in the long term efforts should be made to transform the city into circular metabolism for sustainable growth. Ban et al. (2018) conducted a study to develop a framework for comprehensively evaluating urban safety using 'sustainable urban metabolism'. Similarly, in the United States, the resilient urbanism concept has emerged as a new approach to address natural disasters caused by climate change as well as social and economic fluctuations. In the ‘Resilient by Design’ Competition (2017), practical action models were presented in various areas for preparing for invisible disasters that have not yet occurred or gradually happening (Choi H. Y & Seo, Y. A, 2018). Among all these urban metabolism and resilience research fields, the water-related sectors can be highlighted due to the severe global climate change and the socio-environmental value such as waterfront amenity and ecological requirement.

The term “water cycle restoration city” was first used in 2013, beginning with the

Seoul City's “Comprehensive Plan for Healthy Water Cycle Management” and local governments and knowledge institutes paid keen attention to the urban water cycle restoration policy since the Ministry of Environment carried out an open competition to designate the national pilot projects in 2016 (Lee, 2018). Whereas, as far as we know, there is no clear consent definition and most of the previous research tends to focus on the hydrological field for urban safety. Choi et al. (2009) evaluated the urban water cycle health as a component of infiltration, direct runoff and evapotranspiration. On the other hand, it should include not only hydrological factors but also water quality and ecosystem. According to Article 9 of the Framework Act on Water Management, a sound water cycle is defined as maintaining its normal functions for the ecosystem and human activities, considering that water sustains life on earth while being cycled and plays an important role for people's life and industrial activities. Furthermore, Lee (2018) uses the term “the water cycle restoration & waterfront city” in a composite meaning, and defined it as the more extensive concept of urban development to enhance the quality of life for citizens by adding water values to housing, leisure, and cultural space. Accordingly, in consideration of the generality and flexibility of water characteristics, the urban water cycle restoration should be defined as a broad water welfare concept that incorporates environmental and social values.

2.3 Water cycle evaluation indicators in urban development

Based on this awareness, domestic research on the developing evaluation model for the urban water cycle restoration policy began with the concept of low impact development (LID) and green infrastructure system (Yoon et al., 2014). According to Yoon et al., (2014) LID was launched in Prince George's County, Maryland, USA in the early 1990s to minimize the hydrological water impacts of development. SUDS (Sustainable Urban Drainage System) in the UK, WSUD (Water Sensitive Urban Design) in Australia, and LIUDD (Low Impact Urban Design and Development) in New Zealand offer urban rainwater management as a key solution to climate change (Kang et al., 2014). It also highlighted the further environmental benefits such as reducing the heat island effect, purifying the air quality, and conserving the ecosystem, as well as socioeconomic outcomes like improving the urban landscape, developing the amenity, and rising land prices (Forest Research, 2010). However, evaluation indicators may be limited to rainwater management are not sufficient to represent the entire urban water value. It is necessary to access the total water balance level, such as gray water reuse, water-saving, and clean tap water supply management. Lee (2012) developed evaluation indicators for the green city and categorized the urban water cycle system into three areas in technical terms: water management (supply and treatment), hydrological circulation and artificial circulation such as a small stream, lake, artificial river, etc. Ahn (2011) pointed out that sewage reuse should be adopted as a tool for urban water cycle improvement and revitalizing the water industry by a government-led strategic policy and rational urban water circulation plan should be established based on water balance analysis and demand management.

Along with this comprehensive water balance approach, Wong et al. (2013) used the term "Water sensitive city" as a similar concept to the urban water cycle restoration city, suggesting the broad application of water supply of various resources, a supply of natural environment, and formation of the community for sustainability. In particular, the social value of community such as integrated governance and collective leadership was considered the major factor in the water sensitive city. In general, urban development is carried out through the process of planning, construction, resident migration, management. During this process, it creates continuous social, economic and environmental interaction with a developer, local government and residents. Therefore, the indicators should be able to accept the multifaceted process with these stakeholders (Kang et al., 2005). They also suggested that the evaluation model should be extended to post-development stages beyond the planning and construction. To ensure the success of urban water cycle restoration policies, it is necessary to develop a new evaluation model that includes not only technical hardware but also collaboration software that can reasonably reflect the needs of diverse stakeholders. To do so, we need to evaluate an inclusive governance framework that converges the opinion of various actors in urban development rather than the top-down government system. This process allows us to identify improvements in the project from a broad perspective.

3. Survey and Case Studies

3.1 Survey on Awareness of Water Cycle Restoration Policy

The main purpose of this study is to prepare a practical evaluation model for the enhancement of the urban water cycle restoration policy. First of all, a survey of quantitative analysis methods was conducted to investigate the differences in perceptions on urban policies by stakeholders (developers, local government and residents) at the East District, a pilot district for the Song-san Green City Development Project, which has been for two years after residents moved. The questionnaire was defined based on literature reviews, and each question was surveyed using the Likert 5-point scale. To secure the sample reliability of the quantitative analysis, more than 15 responses were obtained for each stakeholder and total, 78 results were analyzed. The main contents of the questionnaire consisted of 3 main topics, divided into the priority of the urban policy, the awareness of the urban water cycle restoration policy, satisfaction and improvement.

1. What are the policy priorities for the new urban development?

- Transportation policy, Housing supply, Natural environment, Convenient Infrastructure

2. What is the level of awareness of the urban water cycle recovery policy?

- Awareness, Necessity, Willingness to pay (WTP), Effectiveness, Satisfaction

3. What are the key strategies for achieving a water cycle restoration policy?

- Vision & Goals, R&D, Functionality, Aesthetic Value, Governance, Maintenance, Budget Support

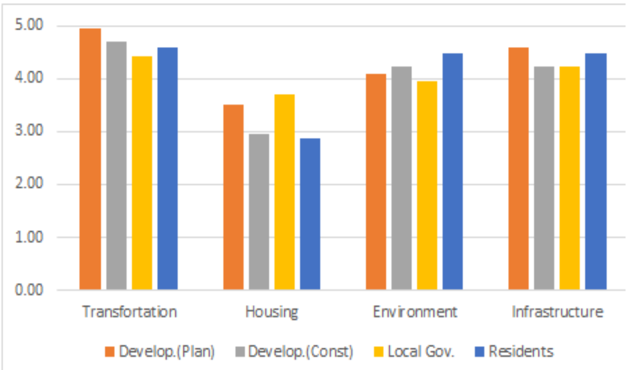


Figure 2. Priority of the urban policy.

Table 1 presents the average scores of priorities for urban policy by developers (plans, construction), local governments and residents. A notable finding in this questionnaire was found that transportation accessibility was the most important policy in all groups, with a preference for the natural environment and convenient living infrastructure over the purpose of housing supply. This result seems to be represented by the urban paradigm shift caused by the high-income level improvement mentioned in the literature review.

Table 1. Descriptive statistics of priority for the urban policy.

Item	Mean				Mean of Mean	Std. Deviation
	Urban Planer	Constructor	Local Gov.	Residents		
1. Transportation	4.95	4.71	4.42	4.60	4.67	.7130
2. Housing	3.50	2.94	3.69	2.87	3.25	1.0190
3. environment	4.10	4.24	3.96	4.47	4.19	.7175
4. Infrastructure	4.60	4.24	4.23	4.47	4.38	.7357

Second, the statistical analysis was performed using the SPSS (Statistical Package for Social Science) software concerning the technical analysis of the perception of differences among stakeholders. Independent sample t-tests were conducted with the hypothesis that project developers (Group 1), local governments and residents (Group 2) had different perceptions of the water cycle restoration policy.

$$H1: \mu 0 \neq \mu 1,$$

H1: Each group has different averages of Awareness, Necessity, WTP, Effectiveness, and Satisfaction.

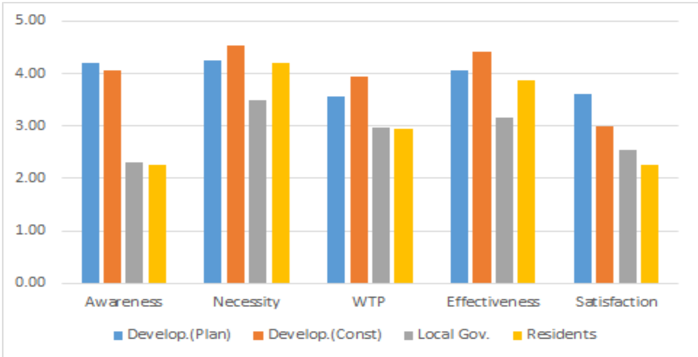


Figure 3. Recognition of the water cycle policy.

Table 2. Level of the policy recognition by stakeholders

Item	Mean				Mean of Mean	Std. Deviation
	Group 1		Group 2			
	Urban Planer	Constructor	Local Gov.	Residents		
1. Awareness	4.20	4.06	2.31	2.27	3.21	1.3532
2. Necessity	4.25	4.53	3.50	4.20	4.12	.8305
3. WTP	3.55	3.94	2.96	2.93	3.35	1.1712
4. Effectiveness	4.05	4.41	3.15	3.87	3.87	.9386
5. Satisfaction	3.60	3.00	2.54	2.27	2.85	1.1404

As a result of statistical analysis, the p-value was less than 0.05 in all items according to the stakeholder group, which has a statistically significant result. It is interpreted that local governments and residents have less awareness of urban water circulation policy than developers. On the other hand, clearly, the necessity of urban water circulation policy for urban value improvement and environmental improvement was agreed by all groups.

Table 3. Independent sample test of the perceptions by stakeholder

Item	Mean		Std. Deviation		t	p-value
	Group 1 (N=37)	Group 2 (N=41)	Group 1	Group 2		
1. Awareness	4.135	2.293	.8870	1.1010	8.082	.000
2. Necessity	4.378	3.756	.5940	.9160	3.593	.001
3. WTP	3.730	2.951	1.0710	1.1608	3.068	.003
4. Effectiveness	4.216	3.415	.7124	.9741	4.110	.000
5. Satisfaction	3.324	2.439	.9734	1.1412	3.666	.000

Along with this difference in perception of each stakeholder, the correlation between factors for water cycle restoration policy was analyzed. The awareness was found to have a relatively high correlation in all items (0.506~0.422). In particular, awareness had the greatest correlation with policy satisfaction. In general, Pearson's correlation coefficient is considered to be somewhat higher when it is in the range of ± 0.4 to ± 0.7. Therefore, to improve the effectiveness of the policy, it is necessary to seek not only a technical hardware approach but also software measures such as cooperative governance with local governments and residents, public relations and education programs.

Table 4. Descriptive statistics by policy recognition factors

Item	N	Mean	Std. Deviation
1. Awareness	78	3.167	1.3620
2. Necessity		4.051	.8358
3. WTP (Willingness to pay)		3.321	1.1787
4. Effectiveness		3.795	.9447
5. Satisfaction		2.859	1.1478

Table 5. Correlation matrix between policy recognition factors

Item	1	2	3	4	5
1. Awareness	1				
2. Necessity	.506**	1			
3. WTP (Willingness to pay)	.565**	.339**	1		
4. Effectiveness	.562**	.638**	.585**	1	
5. Satisfaction	.422**	.319**	.312**	.332**	1

*. p〈.05 level (2-tailed), **. p〈.01 level (2-tailed).

Lastly, the key factors for the urban water cycle restoration policy differed among stakeholders. For example, local governments prioritize administrative support, such as budget and workforce support for the maintenance of water cycle facilities and residents valued the aesthetic value of open spaces and their utility as landscapes rather than the technical effects of the facilities such as reduction of rainwater runoff and pollutants. These two stakeholders also emphasized the necessity of a procedure for gathering their opinions in urban planning. Interestingly, even the developers have some consensus on the importance of post-development maintenance. This is a positive signal for forming cooperative governance for efficient policy promotion.

Figure 4. Key factors for the policy by stakeholder (group 1)

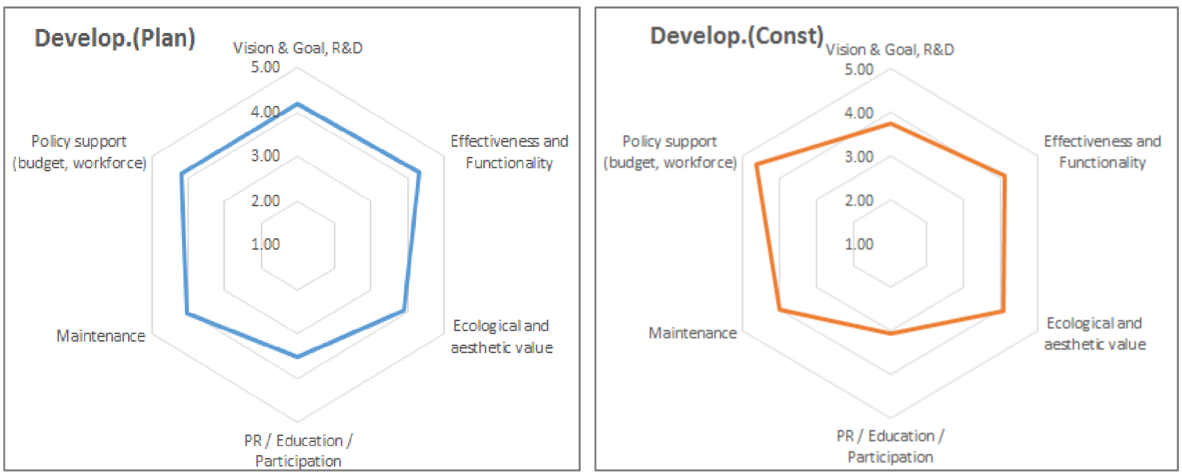


Figure 5. Key factors for the policy by stakeholder (group 2)

The limitation of this survey may have a lack of objectivity because the survey sample is limited to K-water that is focusing on the water cycle restoration city projects. In spite of that, recently the Ministry of Land, Infrastructure, and Transport and LH, which promotes the 3rd new town project, announced an MOU with the Ministry of Environment ('19 .6) to actively reflect the concept of a water cycle restoration. Considering this situation, the urban water restoration policy is a common national policy direction, and thus, this limitation can be overcome.

3.2 Case Analysis of VOC

Along with this awareness survey analysis, the VOC (voice of the customer) cases were reviewed during the construction and relocation of residents in the Song-san green city East district to identify complaints of residents about water cycle restoration facilities. The data were obtained from K-water's internal VOC system and analyzed for three years from 2017 to 2019. According

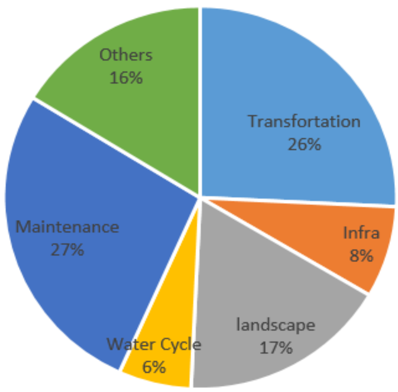


Figure 6. VOC rate.

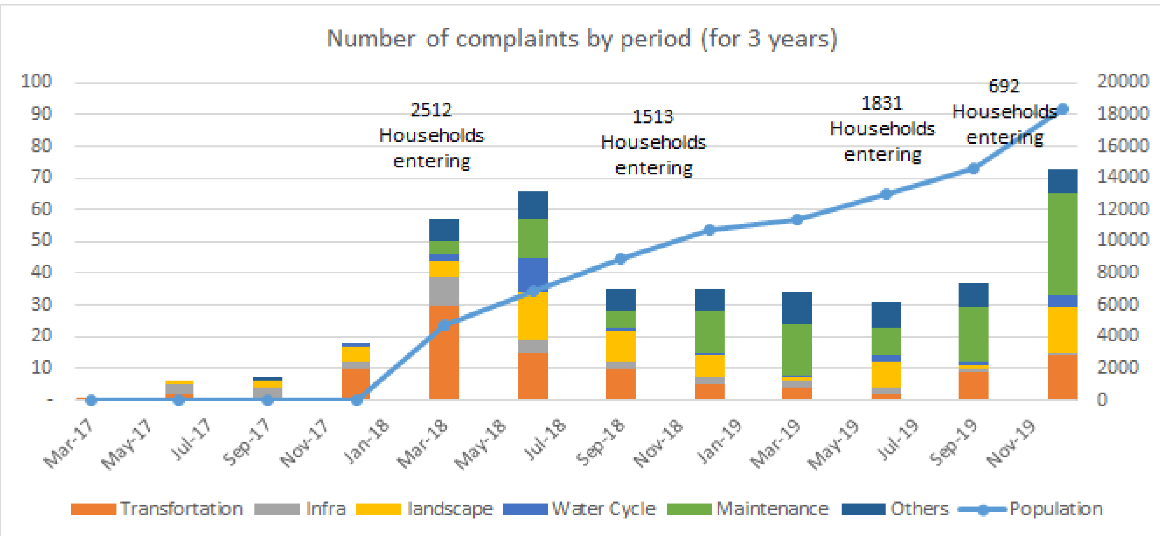
to the classification results, more than 50% of the 400 complaints were related to transportation and maintenance, and only 24 (6%) were related to water cycle facilities.

Table 6. Result of VOC classification in Songsan Green City (East district)

Year	Total	Trans-fortation	Infra	Land-scape	Water Cycle	Main-tenance	Others
Total	400	103 (26%)	31 (8%)	69 (17%)	24 (6%)	108 (27%)	65 (16%)
2017	32	14	8	8	1	-	1
2018	193	60	17	37	15	34	30
2019	175	29	6	24	8	74	34

In terms of complaints by period, the number of complaints soared when residents first moved in, but the complaints tended to decrease through immediate facility improvement and supplementation. In the beginning, most of the complaints were about infrastructures, such as lack of transportation and landscaping, but since then, complaints related to facility maintenance have increased. In the case of water cycle restoration facilities, complaints such as odor, bugs, safety, and lack of flow occurred, but it has been reduced by appropriately supplementing and improving the facilities by receiving the opinions of the residents.

Figure 7. Frequency of VOC occurrence by item & period



3.3 Qualitative Interview for the Case Study

In order to obtain other stakeholders' opinions, interviews were conducted with the developers who were directly responsible for construction and maintenance. As a result of the interview, due to difficulties in maintenance, the local government asked for the supplementation of the roadside infiltration channel, which inevitably resulted in the removal of the facilities. They also highlighted the follow-up management system, such as reflecting the maintenance budget to improve facilities.

Table 7. Major Complaints by Stakeholder about water cycle restoration facilities

Residents	➢ Risk of safety accidents due to deep reservoirs ➢ Reduced urban cleanliness with odor, bugs and green algae. etc.
Local Gov.	➢ Possibility of complaints from residents ➢ Supplementation due to deterioration of function, lack of operation manual ➢ Passive attitude of project operator to the request for defect repair ➢ Lack of administrative period for organization and budgeting
Developer (construction)	➢ Difficulty of additional budget input until the stabilization period ➢ Argument of takeover between local governments ➢ Insufficient verification of the water cycle restoration facility effectiveness

4. Methodology of Research

4.1 Evaluation Indicators

Considering the scope and contents of the water circulation recovery city defined by the literature study and the survey results of stakeholders, A total of 18 basic evaluation indicators were constructed in four categories which is 1)Vision & goals, 2)Urban planning indicators, 3)Specific facility Strategy and 4)Maintenance & cooperation. The evaluation indicators proposed in this study are summarized into three important aspects.

First of all, in terms of functional aspects, the concept of urban water cycle restoration, which was mainly focused on improving water permeability and water quality, was expanded to include water reuse including natural and artificial systems as well as SWM (Smart tap water supply management) considering water demand. Second, a circular review system was established to provide comprehensive feedback at the planning stage by including non-structural factors such as land-use planning. Lastly, user-based evaluation indicators such as regulation and incentives, monitoring and cooperation were included to ensure the stable settlement and execution of urban water circulation facilities while sharing the needs and values of urban water circulation with stakeholders.

Table 8. Urban water cycle restoration evaluation indicators

Categories	Item	Sub-item
1. Vision & Goals	Comprehensive plan	1.1 Comprehensive plan for urban water cycle
	Achievement goal	1.2 Quantitative target amount of rainwater sharing Quantitative target amount of water reuse
	*Regulation & incentive**	*1.3 Detailed reflection of district unit plan, Incentive policy**
2. Urban Planning	*urban planning process**	*1.4 Feedback system of Land use plan for the urban water cycle**
	Cluster development	2.2 Compact city, Multipurpose use, open space
	Linkage between land use	2.3 Arrangement waterfront, recreation & public facilities
3.Specific facility Strategy	Runoff reduction	3.1 Application of various LID Facilities
	Pollution Improvement	3.2 Non-point pollution suppression amount
	*rainwater Reuse**	*3.3 Application of reuse facility of rainwater**
	*Graywater Reuse**	*3.4 Application of reuse facility of gray water**
	*Tap water supply**	*3.5 Block system, SWM(Smart water management)**
4.Maintenance & cooperation	*Monitoring**	*4.1 Informatization using ICT, Monitoring & feedback**
	*Budget allocation**	*4.2 Budget Reflecting for Stabilization of Facilities**
	*Cooperation**	*4.3 Local Government Agreement Effort, Maintenance Manual**
	*R&D, Promotion**	*4.4 Efforts to Develop Water Cycle Facilities Technologies and Promotion & education**

* (Note) Evaluation indicators suggested and highlighted in this study.

4.2 AHP Analysis of Evaluation Indicators

Multiple Criteria Decision Making (MCDM) is needed to assess the relative importance of indicators for priority ranking and weighting. A technique called hierarchical analysis (AHP) is mainly used to solve this MCDM problem. A technique called hierarchical analysis process (AHP) is mainly used to solve this problem. It is a method of hierarchizing a decision-making problem and determining the importance of each property through pairwise comparison. This method is particularly useful in evaluating non-quantitative and qualitative criteria as well as quantitative cases. Also, it has been widely used in the decision-making of preliminary feasibility studies of national financial projects since 1999 (Cho et al., 2003). In this study, AHP analysis was conducted for 30 experts including K-water researchers, executive managers, and practitioners, and the final evaluation model was completed by reflecting the results. The paired comparison bridge used Satty's 9-point scale and the geometric mean method was used to calculate the group evaluation data. After the geometric mean of each individual data, a new matrix was created to extract the weight of importance for each indicator using the Expert Choice software package developed by Thomas Saaty and Ernest Forman in 1983. Expert Choice is an AHP dedicated software that is widely used by more than 20,000 users in governments, businesses and professionals at all levels in over 60 countries (McGinley, P. 2012).

The consistency ratio was checked to determine the reliability of the AHP analysis. The weighted CR of the binary comparison of the relative importance of all the categories was measured as 0.01, and the CR values for the weights of each sub-item were also measured to be less 0.1, indicating a very available consistency.

Table 9. Reliability measurement results of the AHP Survey

Item		Consistency index (CI)	Random Index (RI)	Consistency ratio (CR)	Remark
Total Categories		0.01	0.90	0.01	〈 0.1
Sub-item	1) Vision & Goals	0.001	0.58	0.002	〈 0.1
	2) Urban Planning	0.000	0.58	0.001	〈 0.1
	3) Facility Strategies	0.01	1.12	0.01	〈 0.1
	4) Maintenance & cooperation	0.01	0.90	0.01	〈 0.1

Table 10 shows the relative importance of the water cycle evaluation indicators. Interestingly, the four categories presented as major categories showed similar importance. Therefore, a meaningful finding was drawn that it is necessary to evaluate various non-structural indicators in a balanced manner along with structural techniques.

Specifically, the priority of the relative importance was identified as 1)vision and Goals (26.4%), 4)Maintenance & cooperation (24.9%), 2)urban planning (24.6%), and 3)Facility strategy (24.2%). Urban water cycle vision and goal was considered to be of high importance in determining the policy and investment intention at the planning stage. Also, administrative supporting factors such as incentives and regulations, monitoring systems, and stakeholder collaboration were considered critical to ensuring policy sustainability.

Table 10. AHP analysis result of the evaluation indicators

Categories	Weight	Sub-item	Sub weight	Sub ranking	Final weights	Overall ranking
Vision & Goals	0.2642	Comprehensive plan	0.2983	3	0.0788	6
		Achievement goal	0.3260	2	0.0861	5
		Regulation & incentive	0.3757	1	0.0993	1

Urban Planning	0.2456	urban planning process	0.4000	2	0.0983	3
		Cluster development	0.1990	3	0.0489	12
		Linkage between land use	0.4010	1	0.0985	2
facility Strategy	0.2416	Runoff reduction	0.2395	2	0.0554	9
		Pollution Improvement	0.2107	3	0.0509	10
		Rainwater Reuse	0.1668	4	0.0403	14
		Graywater Reuse	0.1584	5	0.0383	15
		Tap water supply	0.2345	1	0.0567	8
Maintenance & cooperation	0.2486	Monitoring	0.2486	2	0.0618	7
		Budget allocation	0.2020	3	0.0502	11
		Cooperation	0.3788	1	0.0942	4
		R&D, Promotion	0.1706	4	0.0424	13
Total	1	15 indicators			1	

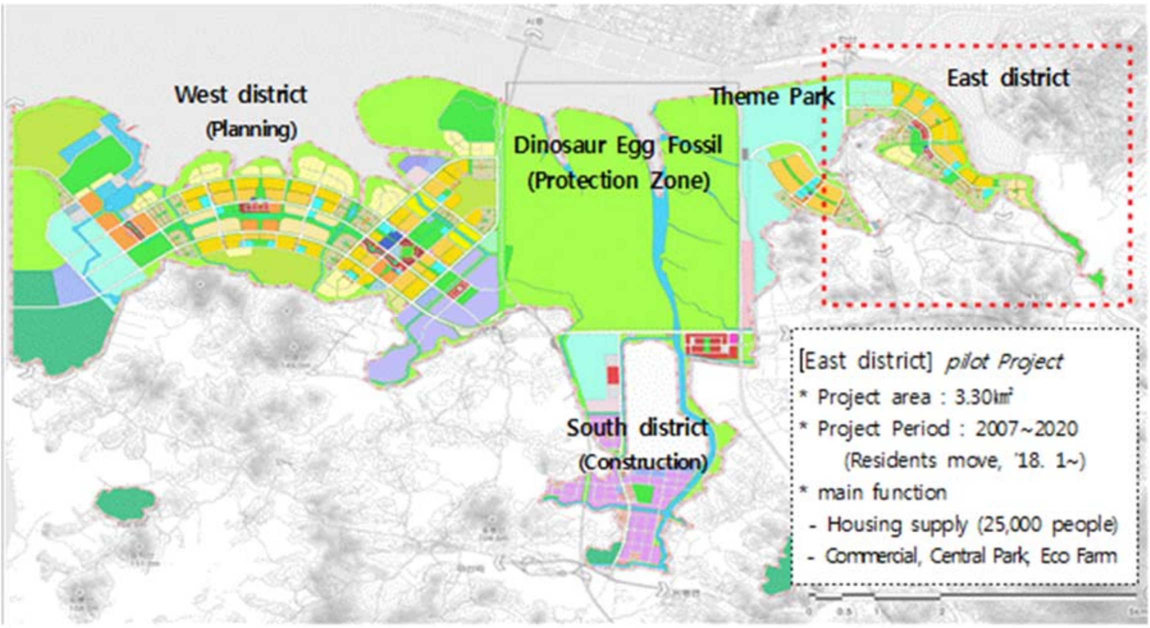
Meanwhile, in terms of the specific facility strategies, the runoff & pollution reduction and clean tap water supply were relatively important, while the water reuse items had low priorities. This may be interpreted that there is a lack of investment efficiency due to lower water prices than developed countries and anxiety about the safety of reuse water quality. According to Park et al. (2014), the most influential factor affecting citizens' awareness of the necessity of water reuse is the environmental protection aspect. Therefore, to revitalize water reuse, it should emphasize that environmental protection education and improved reliability of water quality are important along with water reuse policy. (Park et al., 2014).

Lastly, relative importance was also shown for nonstructural urban planning elements. Therefore, a process is needed to reflect land use, taking into account the arrangement of water cycle facilities from an early urban planning stage. In particular, it is important to plan for synergistic effects by securing the connection with waterfront parks and public/cultural facilities, rather than only focusing on the technical function.

4.3 Application of the Model

For the application of this evaluation model, the urban water circulation recovery suitability of Song-san Green City Development Project (East District) was evaluated. The evaluation results are more like a checklist than an absolute implementation request. Besides, since the area is a pilot district that takes up less than 10% of the total project area, it can be used as a consulting report to improve the shortcomings indicated in this model to a long-term plan.

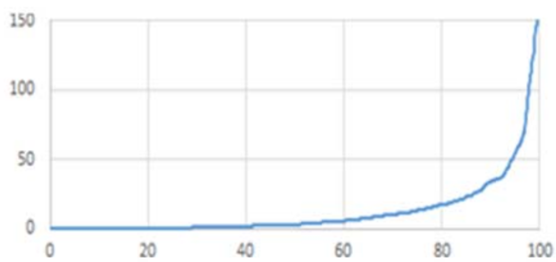
Figure 8. Project Overview of the Song-san Green City



- ✓ Total Area: 55.64 ㎢ (planned population 150,000)
- ✓ Main Concept : tourism, leisure, eco-city
- ✓ Project Costs : KRW 8.81 trillion, / Project Period : 2007 ~ 2030

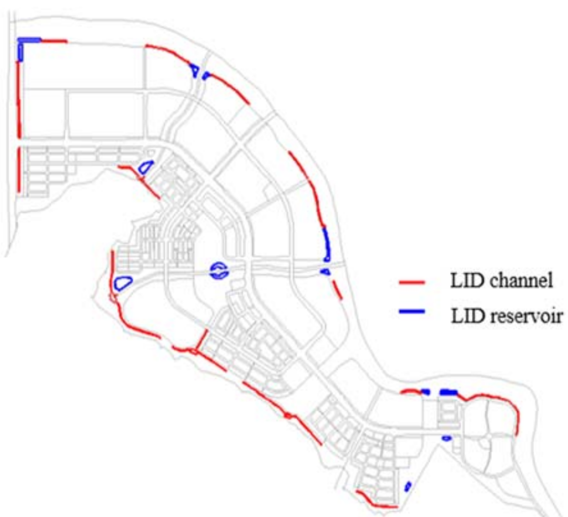
For the evaluation, a total of 17 questionnaires were prepared based on the evaluation indexes proposed in this study, and the degree of implementation of each question was divided into upper, middle, and lower points. Table 12 shows the questionnaire used for this assessment and the compliance of each assessment indicator. Among the major categories, 2) urban planning factor showed the highest level of compliance with 96%, and 1) vision and goal and 4) post-management items showed relatively low compliance. Concerning 1) Vision & Goal, it is necessary to establish a detailed water cycle comprehensive action plan and supplementary measures for water reuse, which have not yet been activated, should be considered. Also, special efforts should be made to establish cooperative governance with stakeholders by establishing an institutional system for 4) Maintenance & cooperation. For example, it is proposed to introduce an automatic monitoring center and publicity / education facilities. However, although the evaluation of this application was conducted based on reports and case analysis, there is a limitation that the judgment on the achievement of the evaluation question would be arbitrary. To overcome these limitations, it should be necessary to organize a pool of experts, and check the objective evidence with additional fieldwork.

Figure 9. Rainwater management targets and LID facilities for the project



Percentile	*Rainfall / day (mm)*
80	*17.5*
85	*23.0*
90	*34.5*

✓ *Rainwater Management Target: 21mm*



*(Source) K-water. (2016). Detailed Design Report for Song-san Green City East District Project

Table 12. Result of Evaluation for the Song-san Green City (East district)

Evaluation question	Good	Mid	Low	Score
1-1 Established a comprehensive water cycle management plan	8	6	4	***4***
1-2 Has the appropriate target amount of rainwater share been calculated?	5	4	3	***5***
1-3 Has the appropriate target amount of water reuse been calculated?	3	2	1	***2***
1-4 Have regulations & incentives been clearly defined?	10	7	5	***7***
Subtotal 26, Score 18, Adequacy 69%				
2-1 Feedback process of land use plan to conform to water cycle plan	10	7	5	***10***
2-2 Application of compact city, efficient use of Mixed-use and open space	5	4	3	***5***
2-3 Are water cycle facilities, waterfront area and public/cultural facilities linked?	6	4	2	***6***
2-4 How good is the layout and facilities of the waterfront space?	4	3	2	***3***
Subtotal 25, Score 24, Adequacy 96%				
3-1 Appropriate runoff index, eco area ratio	5	3	1	***5***
3-2 Nonpoint Pollution Inhibition / Nonpoint Pollution Generation Ratio	5	3	1	***5***
3-3 Rainwater reuse / district water use ratio	4	3	2	***3***
3-4 Sewage reuse / district water use	4	3	2	***2***
3-5 Application of SWM(Smart water management for the tap water supply)	6	4	2	***6***
Subtotal 24, Score 21, Adequacy 88%				
4-1 Establish a monitoring system for water circulation facilities	6	4	2	***4***
4-2 Administrative supporting system to improve facilities until stabilization	5	3	1	***3***
4-3 Cooperative and communication channel with local gov. and residents	10	7	5	***7***
4-4 R&D, public relations, and educational efforts	4	3	2	***3***
Subtotal 25, Score 17, Adequacy 68%				
Total	100	70	43	80

5. Conclusion

5.1 Summary of study

This study identified the necessity of the urban water cycle restoration policy according to the paradigm shifts for the new urban development and proposed a comprehensive evaluation model to secure the sustainability of the policy. Due to global environmental issues such as climate change and high national income levels, water awareness is being reinterpreted in terms of ecological, environmental and social aspects. In particular, the introduction of the unification policy for water management is forcing an innovative change to a future-oriented water management system that guarantees sustainability, equality, and applicability. This water management policy emphasizes ecosystem recovery and regional governance-based management systems through integrated management of water quantity and quality. To achieve this integrated water management policy, we should pay special attention to the sensitivity and effectiveness of cities as places where social activities and property are concentrated. Indeed, policymakers should prepare an efficient urban water circulation recovery plan that can ensure sustainable and practical execution according to the changing paradigm and policy environment of the times.

Through a survey of key actors, this study derives the recognition and improvement of the urban water cycle restoration policy that policymakers should keep in mind. Local governments and residents, who play a major role in the implementation and sustainability of urban development, also have a special interest in the objective of the policy, and they also appealed the institutional software such as follow-up management and education / PR rather than only focusing on technical factors. In addition, as the result of expert AHP analysis evaluated similar importance in the four major categories of evaluation indicators (Vision & goal - Urban planning - facility Strategies - Maintenance & cooperation), policymakers should establish a comprehensive and balanced evaluation system for the whole process of the urban water cycle.

By applying this comprehensive evaluation system, policymakers can consistently implement long-term and sustainable policies that are satisfied by developers (public/ private), local governments and residents. In addition, such a user-based evaluation system can not only complement the effect of financial input but also form a cooperative policy platform by minimizing controversy with local governments and residents and eventually increase the satisfaction of the whole society.

5.2 Policy recommendation and Limitation

The main purpose of the urban water cycle restoration policy is to maintain the sustainability of ecosystems and human activities by restoring the water cycle distorted by indiscriminate urban development. It should be a priority to form a consensus with various stakeholders along with technical efforts. The public policies are ensured sustainability when social consensus and stakeholder needs are adequately met, and continue to be complemented and developed with this agreement (Kang et al., 2008). Therefore, our policy evaluation tools need to put more weight on governance that creates public consensus rather than the one-sided government system. Acceptance of the policy can naturally be shaped by continuous interactions with stakeholders in the long term Perspective, and policy drivers should be patient to engage with them through the endure communication processes.

This study classified indicators related to the urban water cycle, which had been dispersed from “Sustainable urban planning standards”, and suggested a systematic, comprehensive and balanced evaluation model for the overall water cycle system. This may be meaningful in terms of presenting diversified perspectives to improve the practicality of urban water cycle restoration policy including motivations to encourage the changes in stakeholder actions. However, the adoption of a new evaluation model can cause not only the financial burden of urban development projects but also many changes in procedures and periods (Kang et al., 2005). This study is a kind of pilot study that combines the technical evaluation indicators defined in the many previous studies with the vision & goals, urban planning and governance system to improve social acceptability. Whereas, there is a limit to the detailed review of the legal, financial and institutional changes anticipated from adopting this model.

Nevertheless, it is effective to link with legal evaluation systems such as the environmental impact assessment. In particular, I strongly suggest that the post-environmental impact assessment reflects the monitoring and feedback process emphasized in this study and institutionalizes the verification of its effectiveness. Besides, it might be considered to introduce an official certification program using the evaluation model to actively participate in developers and to raise public awareness. For example, the Barrier-Free Certification program for improving pedestrian rights for the disabled has been controversial due to financial issues at the beginning of its introduction. However, the ratio of certification has been continuously increasing in 2015, by steadily expanding the willingness of policy such as mandatory to obtain certification of public buildings and supporting incentives (Park & Lee, 2016). Nevertheless, improvement of the existing system or legislation should be based on sufficient discussion and research by project operators, academia, and local governments, rather than the top-down approach of policymakers. I hope that this study will be a small turning point in establishing a more desirable urban policy, and further research will be conducted on the detailed method of evaluating indicators and analyzing the effects of the evaluation model.

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Appendix

I. SPSS Statistical Output

1) Independent Samples Test

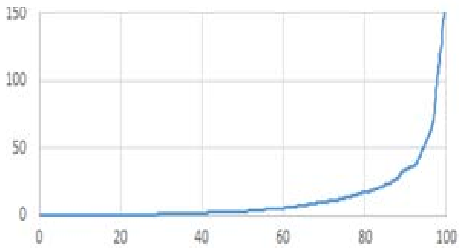
Item		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Awareness	Equal variances assumed	3.716	.058	8.082	76	.000	1.8425	.2280	1.3884	2.2965
	Equal variances not assumed			8.172	75.078	.000	1.8425	.2255	1.3933	2.2916
Necessity	Equal variances assumed	5.207	.025	3.517	76	.001	.6223	.1769	.2699	.9746
	Equal variances not assumed			3.593	69.256	.001	.6223	.1732	.2768	.9678
WTP (Willingness to pay)	Equal variances assumed	.140	.709	3.068	76	.003	.7785	.2538	.2731	1.2840
	Equal variances not assumed			3.080	75.958	.003	.7785	.2527	.2752	1.2819
Effectiveness	Equal variances assumed	6.606	.012	4.110	76	.000	.8016	.1950	.4131	1.1900
	Equal variances not assumed			4.175	72.982	.000	.8016	.1920	.4190	1.1842
Satisfaction	Equal variances assumed	1.772	.187	3.666	76	.000	.8853	.2415	.4043	1.3663
	Equal variances not assumed			3.696	75.772	.000	.8853	.2395	.4082	1.3624

2) **Correlations**

Item		Awareness	Necessity	WTP (Willingness to pay)	Effectiveness	satisfaction
Awareness	Pearson Correlation	1	.506**	.565**	.562**	.422**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	78	78	78	78	78
Necessity	Pearson Correlation	.506**	1	.339**	.638**	.319**
	Sig. (2-tailed)	.000		.002	.000	.004
	N	78	78	78	78	78
WTP (Willingness to pay)	Pearson Correlation	.565**	.339**	1	.585**	.312**
	Sig. (2-tailed)	.000	.002		.000	.005
	N	78	78	78	78	78
Effectiveness	Pearson Correlation	.562**	.638**	.585**	1	.332**
	Sig. (2-tailed)	.000	.000	.000		.003
	N	78	78	78	78	78
Satisfaction	Pearson Correlation	.422**	.319**	.312**	.332**	1
	Sig. (2-tailed)	.000	.004	.005	.003	
	N	78	78	78	78	78

II. Status of Water Cycle Management Target by the Projects

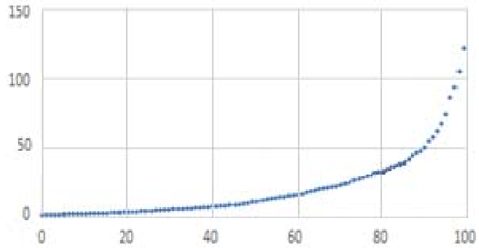
Song-san green city project



Percentile	Ranifall / day (mm)
80	17.5
85	23.0
90	34.5

Rainwater management tarket:21mm

Busan Eco delta city project



Percentile	Ranifall / day (mm)
80	33.5
85	40.4
90	50.5

Rainwater management tarket: 26mm

Item		Song-san green city project			Busan eco delta city project		
		Overall Area	Target area	Target amount	Overall Area	Target area	Target amount
total		3,403,988	1,760,707	21	1,439,951	865,065	26
Residence	Apartment	610,483	366,290	12	98,517	59,110	13
	Row house	105,986	68,891	13	-	-	-
	single house	421,658	252,995	10	105,511	52,756	6
	Neighborhood Commercial	24,739	19,791	-	24,739	19,791	9
Commercial		44,134	35,307	-	323,521	258,817	9
Public facilities	school	64,869	38,921	-	21,731	13,039	13
	Public	7,001	4,201	-	2,807	1,684	13
	welfare	11,640	6,984	-	898	539	13
	supply	1,132	792	-	900	540	13
Park & Green space	Park & Green space	1,319,924	263,985	22	450,955	90,191	5
	Plaza	6,424	6,103	-	6,005	5,705	-
	parking space	11,561	6,937	-	19,933	11,960	3
Road		466,403	443,083	53	289,245	274,783	60
Other (eco-farm)		308,034	246,427	-	95,189	76,151	23

* Calculation method by item

1) Target area for rainwater management: Target area × ecological area exclusion area (40% joint, 35% coalition, etc.)

2) Rainwater Management Targets

- Residential, commercial: Rainfall treatment capacity according to district unit plan by land
- Parks and roads: Rainfall treatment capacity or LID facility capacity reflected according to the district unit plan by land

III. Reflection of District Unit Planning Guidelines

Item		Reflection
Residence	Apartment	✓ Rainwater management area (㎡) × Low impact development (LID) technique or green infrastructure (GI) facility that can manage the capacity (㎥) of 0.02 (m) or more and the total impervious surface area of 80% or more are linked ✓ When a reservoir or installation facility for rainwater and spilled groundwater with a building area (㎡) × 0.02 (m) or more is planned
	Row house	
	single house	✓ When rainwater management area (㎡) × 0.02 (m) or more capacity (㎥) can be managed, low impact development (LID) technique or green infrastructure (GI) facility installation and total impervious surface area of 80% or more are linked ✓ When a reservoir or installation facility for rainwater and spilled groundwater with a building area (㎡) × 0.02 (m) or more is planned
	Neighborhood Commercial	-
Commercial		-
Public facilities	school	-
	Public	
	welfare	
	supply	
Park & Green space	Park & Green space	✓ LID channel: 34,916㎡ × 0.12㎥ / ㎡ = 4,190㎥ ✓ Ecological pond: 14,391㎡ × 0.12㎥ / ㎡ = 1,727㎥
	Plaza	-
	parking space	-
Road		✓ Penetration block: 94,000㎡ × 0.25㎥ / ㎡ = 23,500㎥
Other (Eco-farm)		-