Strategies for Responding to Climate Change-Induced Water Disasters : Seomjin River Basin in Korea

By

HWANG, Jeong Sik

CAPSTONE PROJECT

Submitted to

KDI School of Public Policy and Management

In Partial Fulfillment of the Requirements

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Committee in charge:

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Professor Shin, Byungho

Professor Liu, Cheol

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Contents

List of Tables

List of Figures

Abbreviations

CFI: Corporate Finance Institute

IPCC: Intergovernmental Panel on Climate Change

KHNP: Korea Hydro and Nuclear Power Co., Ltd.

KR: Korea Rural Community Corporation

K-water: Korea Water Resources Corporation

MAFRA: Ministry of Agriculture, Food and Rural Affairs

MoE: Ministry of Environment

MoIS: Ministry of the Interior and Safety

MoLIT: Ministry of Land, Infrastructure and Transport

MoTIE: Ministry of Trade, Industry and Energy

NGOs: Non-Governmental Organizations

NASA: National Aeronautics and Space Administration

NIMS: National Institute of Meteorological Sciences

OECD: Organization for Economic Cooperation and Development

SDGs: Sustainable Development Goals

UN: United Nations

UNESCO: United Nations Educational, Scientific and Cultural Organization

UNFCCC: United Nations Framework Convention on Climate Change

UNICEF: United Nations Children's Fund

WEF: World Economic Forum

WHO: World Health Organization

WMO: World Meteorological Organization

I. Introduction

A. Background

Water is an essential element in human life. Along with the origin of civilization, human growth and evolution are closely related to water (Hosseiny et al., 2021). Hallinan (2019) argues that those who occupy the river have power, but those who cannot secure water decline. Giosan et al. (2018) state that reduced precipitation caused by climate change affected Harappans, representatives of Indus civilization, to migrate to new areas. In recent years, a growing body of research has become interested in water disasters due to climate change (Campbell, 2022; IPCC, 2018; UN, 2022; WEF, 2021). The IPCC (2018, as cited in NIMS, 2020) predicts that if the global average temperature rises by 1.5℃ compared to the pre-industrial period, the likelihood of natural disasters such as floods and droughts will increase, and these changes will be affected by the rate and scale of warming. In addition, the WEF (2021) announced the top seven global risks facing the world. Among these, "Extreme weather" was selected as the first crisis of top global risks. Campbell (2022) states that water disasters will increase pests and diseases, cause economic stagnation due to reduced productivity in agriculture, forestry and fisheries, and further disrupt the fundamentals of society such as conflict and migration. As shown in Figure 1, the 13th task of the SDGs set jointly by all people around the world is to respond quickly to climate change and its effects (UN, 2022).

Figure 1. *SDGs (source: United Nations)*

B. The significance of the study

Korea is vulnerable to floods and droughts because 63% of its land is mountainous and the coefficient of flow fluctuation is very high at 70 to 243 (MoE & K-water, 2022). In other words, the rivers have steep slopes, so rainfall runs out quickly during the flood season, while the runoff volume is very small during the dry season. According to the MoE (2020), the frequency and intensity of torrential rains in Korea have been increasing since the 1990s, and extreme water disasters are expected to occur frequently due to increased precipitation variability. In the summer of 2020, the 54-day rainy season and the total precipitation of 687 mm caused significant damage to Korea (Jeong, 2020). In particular, it should be noted that 341mm of heavy rain, half of the total precipitation, poured for just two days, from August 7th to 8th, in the basin of the Seomjingang multi-purpose dam (K-water, 2020). This amount of rain was at a frequency that could only occur once in 500 years, so residents living in the area had to evacuate toward safe places. On the other hand, people had suffered an unprecedentedly severe drought from 2014 to 2017. Although the average annual rainfall in Korea is about 1,300 mm (MoLIT, 2016), it accounted for only 83% of the average precipitation during this period. Thus, 761,225 people faced water restriction (Chun, 2019). In August 2022, floods and droughts co-occurred in the Korean Peninsula. During this period, Seoul's cumulative rainfall was 453mm, the largest in 115 years (Chang, 2022; Han, 2022), while the precipitation in the Seomjin River basin was recorded as 70% of usual, lowering the storage rate of the Seomjingang Dam to 22% (K-water, 2022).

Figure 2. *Flood in 2020 (L) & Drought in 2015 (R) (source: news1)*

C. Purpose of the study

Most previous studies (e.g., Eom et al., 2017; Heo et al., 2012; Moon & Lee, 2014) have focused on post-recovery, but paid little attention to prevention. They have drawn attention to the designation of the damaged area and the reconstruction technologies. However, in order to preemptively cope with water disasters caused by climate change, effective water management must be implemented sustainably, away from the framework of traditional and structural measures. The purpose of this capstone is to investigate how climate change affects water disasters, and to propose sustainable water management strategies in the Seomjin River basin in Korea. This paper will be of interest to policymakers, central and local government officers, and residents living in the Seomjin River basin. Moreover, it will contribute to enabling governments and NGOs to design and implement policies for sustainable development in the future.

D. Research questions and overview of structure

The following research questions will guide this paper: First, what is the impact of climate change on water disasters? Second, what kind of interventions has the Korean government prepared to mitigate water disasters? Last, how much influence does citizen participation have in water disaster policy establishment?

The remainder of the paper is organized as follows: Section 2 reviews literature on the status of climate change and water disasters. Section 3 describes the methodology of the study. Section 4 analyzes the level of awareness and response of stakeholders to water disasters. Section 5 presents sustainable water management strategies and action plans for the Seomjin River basin. Section 6 concludes with findings and future research.

II. Literature review

A. Climate change

Over the years, a great deal of research has drawn attention to the climate change. One strand of research has established a definition of climate change (e.g., Broecker, 1975; Hansen, 1987; UNFCCC, 1992; Conway, 2008; NASA, 2022). As shown in Table 1, Broecker (1975) defined climate change as an increase in global surface temperature due to human emissions of greenhouse gases. Hansen (1987) translated climate change into the term 'global warming' (as cited in Weart, 2022). UNFCCC (1992) described climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods" (p. 4). Furthermore, Conway (2008) and NASA (2022) extended its meaning to include everything affected by global warming and the increasing amount of greenhouse gases.

Table 1. *Changing Definitions of Climate Change in Literature*

Authors	Focus	Summary points
Broecker (1975)	Temperature rise	Changes in Earth's surface temperature by greenhouse gases
Hansen (1987)	Global warming	Global warming due to the greenhouse effect
UNFCCC (1992)	Atmosphere variability	Changes in the composition of the Earth's atmosphere due to human activity
Conway (2008) NASA (2022)	Effects by changes	Everything affected by global warming and the increasing amount of greenhouse gases

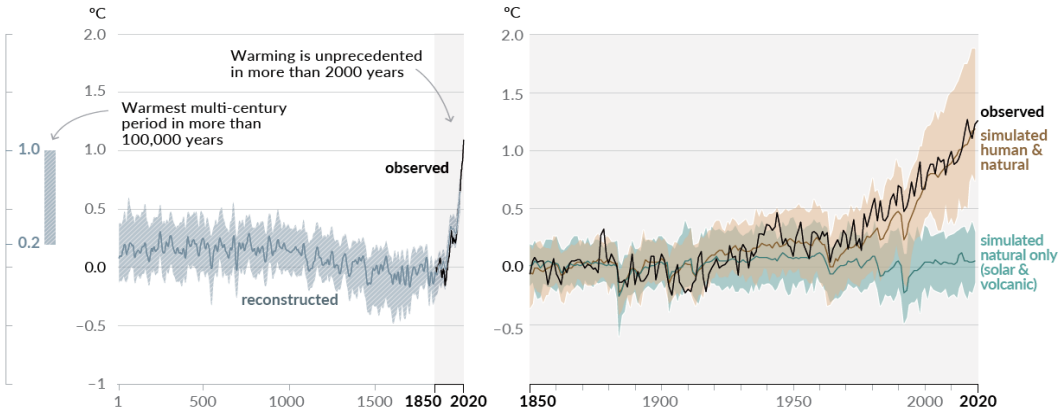
Note. This table presents the different focus given in definitions of 'climate change' in research since 1975 when the term was first used.

In previous studies, the term climate change is taken to mean the direct and indirect effects of global temperature changes due to increased greenhouse gases. Therefore, considering the

purpose of this capstone, this paper defines the term climate change as the effects caused by long-term temperature changes on Earth as it focuses on establishing countermeasures against the effects of climate change.

A second strand of research has observed climate change and predicted future prospects (e.g., IPCC, 2021; Lee et al., 2012; Smith et al., 2018; WMO, 2022). According to the IPCC (2021), the surface temperature of the Earth has increased rapidly since 1970, and the temperature over the past decade (2011~2020) is confirmed to be 1.09 °C higher than that of 1850~1900 (see Figure 3).

Figure 3. *Changes in Global Surface Temperature Relative to 1850~1900*



Note. From *Climate change 2021: The physical science basis* (p. 6), by IPCC, 2021, Intergovernmental Panel on Climate Change (https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM_final.pdf)

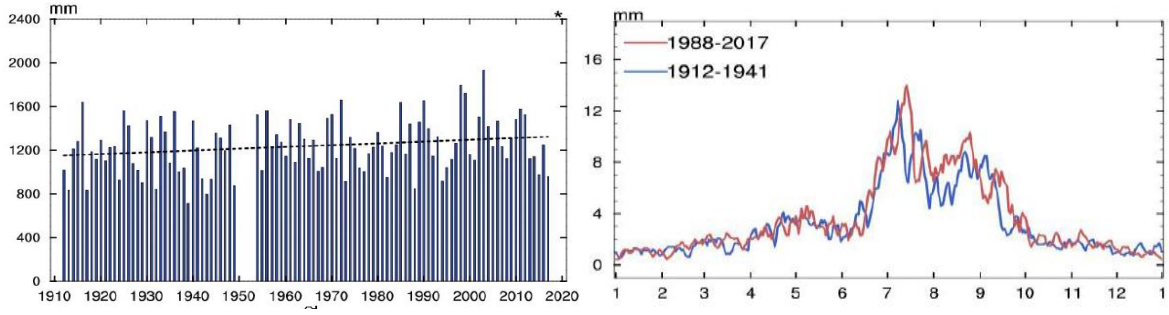
Similarly, many experts predict that temperatures will continue to rise due to climate change in the future (WMO, 2022; see also Lee et al., 2012; Smith et al., 2018). WMO (2022) states that there is a 50% chance for at least one of the next five years that the Earth's average annual temperature will reach 1.5°C higher than the pre-industrial level. The result of this study means that climate change is becoming more serious compared to the fact that the probability of exceeding 1.5°C was 10% between 2017 and 2021 (see Smith et al., 2018).

B. Climate change-Induced water disasters

As discussed about climate change, global average temperature has risen in recent years. Climate change changes patterns of rainfall, making it difficult to predict, and also affects the quality and quantity of water resources (UN-Water, 2019; see also Singh et. al., 2014; UNICEF, 2022). Singh et. al. (2014) suggested that climate change affects 1) changes in river runoff, 2) increases in floods and droughts, 3) decreases in groundwater, and 4) degradation of water quality due to decreased dissolved oxygen and algal blooms. According to UNICEF (2022), about 74% of natural disasters from 2001 to 2018 were water disasters such as floods and droughts, and the intensity and frequency of these phenomena are expected to worsen due to rapid changes in climate. Moreover, it warned that if water resources are extremely limited, competition for water could lead to conflict, and that one in four children would be under severe water stress by 2040. UNESCO et al. (2018) estimated that the number of people suffering from water shortages will reach approximately 6 billion by 2050, while about 1.6 billion will be exposed to flood risk. Meanwhile, water pollution further reduces the amount of clean water. Demand for water is constantly increasing, but the availability of water is decreasing. Currently, 12% of the world's population is drinking water from unsafe water sources, but water pollution will intensify (Boretti & Rosa, 2019).

For the past 106 years in Korea, the temperature and annual precipitation have steadily been increasing and the seasonal variation has continued to widen due to climate change (NIMS, 2018, see Figure 4). The study reported the annual average temperature has risen to +0.18°C per decade, and the seasonal temperature has increased a lot in the order of winter, spring, autumn, and summer. Likewise, the precipitation is also steadily increasing. Compared with the beginning of the 20th century, the average precipitation for the past 30 years has increased by 124.1 mm.

Figure 4. *Annual Precipitation and Average Daily Precipitation in Korea (1912~2017)*



Note. From *100 years of climate change in Korea* (p. 17, p 21), by NIMS, 2018, National Institute of Meteorological Sciences (http://energytransitionkorea.org/post/28649)

According to the announcement of the MoIS (2020), the floods that caused the most serious damage in the past 20 years were counted in the order of RUSA (2002), MAEMI (2003), and EWINIAR (2006). In other words, there have been several floods in the past that were stronger than the tragedy of 2020 described in the previous chapter. The cases of drought go back further. In the Annals of the Joseon Dynasty, which records the 500-year history of the Joseon Dynasty, the word “drought” appears about 12,800 times. Since 1990, drought has become more severe. Drought occurs every 2~3 years, and the occurrence of extreme drought has also been shortened from the previous 14-year cycle to 7 years (Bae et al., 2013).

C. Case study: Water disaster responses

Having provided evidence for the effects of climate change, I will proceed to investigate the responses against water disaster. Table 2 shows two ways to respond to climate change. One is 'mitigation' in which humans intervene to reduce greenhouse gas emissions or strengthen absorption sources (IPCC, 2014a). This means reducing and stabilizing the concentration of greenhouse gases that trap heat in the atmosphere. In contrast, the other is 'adaptation', which recognizes climate change and coordinates human and natural systems to mitigate damage or

exploit beneficial opportunities such as increased yields in some regions (IPCC, 2014b). Since this paper deals with water disasters caused or expected due to climate change, the 'adaptation' method is applied.

Table 2. *Mitigation and Adaptation*

Terms	Purpose	Summary points	Examples
Mitigation	Minimizing climate change	Reducing the flow of greenhouse gases in the atmosphere	· Decarbonization of energy sector · Forest management / Reducing deforestation · Cropland & grazing land management · Restoration of organic soils
Adaptation	Adjusting to life in climate change	Adaptation to actual or expected future climate	· Disaster prevention infra. (e.g., sea walls, etc.) · Water recycling & reuse / Water trading · Subsidized drought assistance; crop insurance · Biotechnology and genetically modified crops

Note. The table above shows two approaches to responding to climate change.

WHO (2021) pointed out the seriousness of water disasters caused by climate change as the most serious health threat facing mankind and made diverse recommendations to prevent the crisis. The recommendations included prioritizing health, social, and economic intervention in climate change, building resilient and nature-friendly health systems on climate, promoting stable food production, sustainable urban design and equitable transport systems. With the revision of the Korean Government Organization Act in June 2018, the existing distributed water management tasks were integrated into the Ministry of Environment (MoE, 2018). The Ministry of Environment et al. (2020) announced the five major strategies: 1) strengthening dam and river safety, 2) preventing steep slope collapse, 3) preventing urban flooding, 4) improving disaster response systems, and 5) strengthening support for damage recovery.

Along with this, a growing body of research has become interested in water-related fields (for recent studies on rainfall impacts and water resources management in Korea, see Kim &

Lee, 2021; Park et al., 2021; Seo et al., 2020). These studies can be evaluated positively in that they shed light on climate change adaptation programs related to water, but what is more important is to apply and practice the research results in reality. Cho et al. (2013) stated that many existing plans were often impossible because they did not match the field conditions, or that they were not implemented due to excessive budget. Additionally, it was argued that many plans could not be actually implemented due to overlapping or insufficient linkage (for examples of conflicts between plans or lack of linkage, see Cho et al., 2013). While much research has been conducted on post-recovery from an economic perspective (see Eom et al., 2017; Heo et al., 2012; Moon & Lee, 2014), little attention has been given to preemptive response (but see Kim et al., 2022; Koo et al, 2021). From the next section of this paper, I will consider effective measures to preemptively respond to water disasters.

III. Research Methodology

A. Solution approach

"Publications and presentations resulting from secondary analysis of qualitative research are less common than similar efforts using quantitative secondary analysis, although online availability of high-quality qualitative data continues to increase" (Chatfield, 2020, p.833). Kwon (2016) defines qualitative research as a methodology used to identify variables that cannot be easily measured numerically or to study problems that are deeply hidden in events. This study focuses on specific stakeholders exposed to various water use environments and issues in the Seomjin River basin. Thus, it is possible to judge the direction and priorities of policies based on their perceptions, and in this structure, decision-making supports the validity of qualitative analysis rather than quantitative analysis.

Focusing on qualitative data, this study analyzes 1) the expertise of water management institutions, 2) the level of acquisition and recognition of flood and drought information, and 3) the transparency, equity, and execution of the decision-making process. Preliminary modeling will be performed using experiments notes and secondary literature, and confirmatory modeling will be conducted after collecting primary data through expert interviews.

B. Preliminary modeling

Table 3 shows the solution approach steps of this study. The first step is to analyze and diagnose phenomena using three logical thinking tools: Stakeholder-Value Chain Matrix (SVM). Next, step 2 diagnoses the results derived from Step 1 and, devises solutions and subjects.

Table 3. *Steps to the Solution Approach*

Stage	Purpose	Major Finding
Step 1	Problem Analysis and Diagnosis	✓ Water management expertise: Competence of institutions ✓ Accessibility of information: Acquisition of information and recognition level ✓ Decision making/authority: Transparency, equity, executive power
Step 2	Prescription and Strategy	✓ **How** to solve? → **Who/What** to do?

To derive the problems of the current water management system, a spatial analysis of the Seomjin River basin and SVM are constructed. As shown in Table 4, stakeholders are classified into central and local governments, public institutions, local residents, and NGOs.

Table 4. *Stakeholder Organization for SVM Analysis*

Central Governments	Local Governments	Public Institutions	Residents	NGOs
MoIS MoLIT MoE MoTIE MAFRA	(Within the basin) Jeongeup-si, Suncheon-si, Hadong-gun, etc (Outside the basin) Gwangju Metropolitan City	K-water KHNP KR	(Downstream of the dam) residents (Upstream of the dam) residents	Environmental organization Civic group

C. Confirmatory modeling

Having analyzed preliminary, it is necessary to confirm the secondary data and export notes derived from that stage. Confirmatory modeling adopts interviews with stakeholders. One-on-one interviews are data collection methods commonly used in policy research. Frances et al. (2009) states that individual interviews are a valuable way to gain people's perception, knowledge, and experience of the phenomenon, and make it possible to collect in-depth data. Lee (2007) divides and defines interviews in three ways:

- Face-to-face interview: A method in which the researcher meets the interviewee
- Telephone interviews: a method of making phone calls to the interviewee and researching
- Written interview: A method in which the interviewee receives answers by fax or mail

Based on the theoretical framework mentioned above, a total of seven interviewees were selected in consideration of the specificity of this research topic. The interviewees consisted of one central government, one local government, one public institution, one local resident, and three academics (see Table 5). The reason for the difference in the number of samples between

different fields and academia is to obtain opinions from each expert in policy research, agricultural and environmental economy, and to balance the overall decision-making by focusing the perspective of third parties rather than direct stakeholders.

Table 5. *Interviewees Organization for Research*

Central Governments	Local Governments	Public Institutions	Residents	Academics
1 person	1 person	1 person	1 person	3 persons

Note. Academics: A policy research expert, an agricultural economy expert, an environmental economy expert.

Considering the circumstances of the interviewee, face-to-face and written interviews are conducted in parallel. As shown in Figure 5, the interview schedule is adjusted, and the questionnaire is shared with the interviewee in advance. Next, the interview is conducted, the contents of the interview are organized, and reconfirmed by the interviewee.

Figure 5. *Interview Process*

The questionnaire is composed based on the literature reviewed in the previous chapter and the preliminary modeling. Questions are divided into common questions and questions by professional field, and the main areas are classified into three categories as follows:

- Water management expertise: Competence of institutions
- Accessibility of information: Acquisition of information and recognition level
- Decision making/authority: Transparency, equity, executive power

The first category examines the perception for expertise and capabilities of institutions that manage dams, reservoirs, and rivers. MoIS, MoE, and local governments manage rivers according to relevant laws, and dams and subsidiary facilities are managed by MoTIE, MAFRA, K-water, KHNP, and KR, respectively, depending on the purpose. Table 6 shows facilities managed by each institution.

Table 6. *Status of Facilities Managed by Each Institution*

Water management institutions		**Management targets**
Central Government	MoIS	River (small)
	MoE	River (national), Multipurpose dam
	MoTIE	Hydro power generation dam
	MAFRA	Agricultural dam
Local Government	(In the basin) Suncheon, Hadong, etc	River (local/ small), Embankment
	(Outside the basin) Gwangju City	River (local/ small), Embankment
Public Institutions	K-water	Multipurpose dam
	KHNP	Hydro power generation dam
	KR	Agricultural dam

The second category is access to information. This step evaluates the level of acquisition of information about floods and droughts among stakeholders and recognition of disasters. In particular, it will focus on whether local residents are getting prompt information on water disasters. The third category analyzes the perception of transparency, equity, and authority in the decision-making process, and derives the positive and negative aspects of civic participation in the decision-making and stage. The final stage of the interview is to diagnose the results analyzed above and collect opinions for improvement.

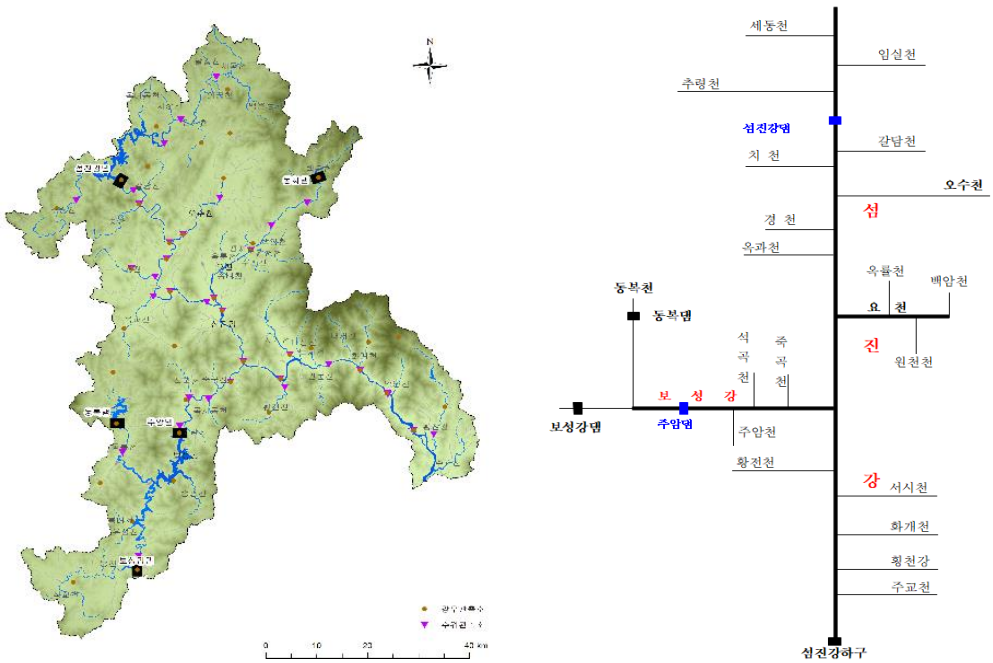
IV. Descriptive Analysis

A. Preliminary modeling results

Preliminary modeling was performed using expert notes based on work experience and knowledge, and secondary literature such as research and policy reports. First, a spatial analysis of the Seomjin River basin was performed. The catchment status is as follows:

- Basin area: 4,911.9 km^2
- River length: 223.86 km
- Status of rivers: 3 national rivers, 420 local rivers
- Local governments: 3 provinces, 4 cities, 11 counties
  - Jeonbuk Province: 2 cities, 4 counties (e.g., Jeongeup city, Imsil county, etc.)
  - Jeonnam Province: 2 cities, 6 counties (e.g., Suncheon city and Gokseong county, etc.)
  - Gyeongnam Province: 1 county (e.g., Hadong county)
- Major dams: Seomjingang/ Juam/ Boseonggang/ Dongbok/ Donghwa Dam

Figure 6. *Overview of the Seomjin River Basin*



The second step is to select stakeholders who are related to water management policies in the Seomjin River basin. As reviewed in Section 3, stakeholders were categorized into central and local governments, public institutions, local residents, and NGOs, and individual organizations or groups filled each category. This study selected five institutions as the central government. These organizations are MoIS, which supervises national disaster affairs; MoE, which manages water supply and quality; MoTIE in charge of operating hydroelectric dams; MAFRA, which is responsible for supplying agricultural water; and MoLIT, which has managed national rivers and dams until recently, although water management has been transferred to MoE. Similarly, public institutions are divided into K-water, which manages living water; KHNP, which operates hydroelectric dams; and KR, which manages agricultural dams. In the case of local governments, these are divided into areas located within and outside the watershed. Four cities and 11 counties, including Jeongeup, Suncheon, and Hadong, are located within the Seomjin River basin, while Gwangju Metropolitan City is located outside the basin. Residents were classified as people living upstream and downstream of the dam. Environmental groups and civic groups were selected as NGOs.

The third step is to organize a stakeholder value chain map (SVM) to discover the current status and problems. Diagnosis was performed on 1) Water management expertise, 2) Accessibility of information, and 3) Decision-making/Authority presented in section 3. In order to compare the results, each item was scored from 1 to 5 for analysis. A score closer to 1 means ‘insufficient’, and a score closer to 5 means ‘excellent’.

First, the expertise of each stakeholder in flood and drought management was compared (see Table 7). Except for MoLIT, the central government was interpreted as having expertise above the average level. In the case of MoLIT, since the water management function was transferred

to the Ministry of Environment in 2022, it was expressed as 'not applicable' in this item. Likewise, it was confirmed that all public institutions have expertise above the average level. The reason why each institution has a different level of expertise is that the goals of each institution related to water are different. Since this paper focuses on responding to floods and droughts, it gave high scores to MoE and K-water, which are in charge of tasks in the field. In contrast, the water management expertise of local governments was evaluated as lower than that of the central government and public institutions. The reason is the frequent personnel transfers of employees and the work environment that avoids water-related departments. Most residents and NGOs were also analyzed to have lower than average expertise due to a lack of water management experience and know-how.

Table 7. *Water Management Expertise Evaluation*

Stakeholders		**(Insufficient)← / →(Excellent)**					**Note: The reasons why?**
		1	**2**	**3**	**4**	**5**	
Central Govern.	MoIS				■		· Disaster and crisis warning department *Water resource-related business processing and data acquisition are supported through K-water
	MoLIT	N/A					
	MoE				■		
	MoTIE			■			
	MAFRA			■			
Public Inst.	K-water					■	· Water management specialized institution
	KHNP			■			· Possession of water-facility management know-how
	KR				■		
Local Govern.			■				· Frequent transfers, avoidance of water related departments
Residents		■					·Lack of experience/know-how (with some exceptions)
NGOs			■				·Lack of experience/know-how (with some exceptions)

Second, the accessibility of each stakeholder to flood information and drought information was compared (see Table 8). The ability of the central government, public institutions, and local governments to obtain information is on a mission to enforce or support disaster and crisis alerts, all of which are high with 4 to 5 points. On the other hand, it was analyzed that the information accessibility of residents and NGOs was relatively weak. Recently, various disaster-related portals have been operated through the Internet or mobile, but most of them lack publicity and are judged to be complicated for the public to use in real life. In particular, it was confirmed that most of the residents living in the area around the dam were elderly and had difficulty using the service. However, in the case of floods, as the regulations have recently been strengthened due to frequent damage, when river flooding or dam discharge is expected, residents living in the downstream of the dam are notified promptly, so flood information accessibility is judged to be high.

Table 8. *Accessibility Assessment of Flood and Drought Information*

Stakeholders		(Insuf.)← Flood →(Excel.)					(Insuf.)← Drought →(Excel.)					Note: The reason why?
		1	2	3	4	5	1	2	3	4	5	
C/G	MoIS					■					■	· Disaster and crisis warning department
	MoLIT					■					■	
	MoE					■					■	*Drought forecast/warning, flood warning, storm and flood crisis response, etc.
	MoTIE					■					■	
	MAFRA					■					■	
P/I	K-water					■					■	· Disaster response support/Disaster portal operation
	KHNP					■					■	· Water information management and sharing/Notification when discharged from gates (→ local governments, residents, etc.)
	KR					■					■	
Local Govern.					■					■		· Response according to disaster warning
R.	Upper		■					■				· Lack of awareness/Difficulty using the app.
	Lower				■			■				· Downstream R. are notified of water discharging.
NGOs			■						■			· Lack of water-related information

Note. C/G: Central Governments, P/I: Public Institutions, R.: Residents

Finally, an analysis of decision-making and authority was conducted (see Table 9). This part is divided into three categories:

1) Water management autonomy

2) Discretion to invest the budget

3) Possibility of the plan being realized.

Water management autonomy is a category that evaluates the level of how independently facilities managed by each institution can be operated for water supply and flood control. As a result of the analysis, it was found that the central government and public institutions had more than average water management autonomy. However, K-water's water management autonomy was evaluated to be lower than other institutions because the operation of dams, adjustment of water distribution, and construction of new infrastructure facilities were carried out in accordance with the direction of government policies and decisions of the Water Management Committee. For the same reason, local governments have low autonomy in water management.

Meanwhile, as national interest in disaster safety increases, it is confirmed that MoIS has the highest initiative for budget investment and the highest possibility of realizing the plan. In contrast, local governments implement most of the disaster budget with subsidies from the government, making it difficult to actively promote their work. It is noteworthy that residents and NGOs have a significantly high influence on the possibility of realizing the plan. The reason is that there are more opportunities to express opinions while participating in the residents' council and committees. Citizen participation is a positive method in that decision-making can be carried out democratically and conflicts can be reduced through consensus. However, it is necessary to examine the representativeness of the participants, the fairness of the procedure, and the appropriateness of the timing throughout the decision-making process.

Table 9. *Assessment of Decision Making/Authority*

Stakeholders		(Insuf.)←'A'→(Excel.)					(Insuf.)← 'D' →(Excel.)					(Insuf.)← 'R' →(Excel.)					Note: The reason why?
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
C/G	MoIS	N/A									■					■	
	MoLIT	N/A							■					■			· Due to high interest in disaster safety, MoIS' budget investment and execution power have increased.
	MoE				■				■					■			· Dam operation, water supply, and new infrastructure construction are promoted according to the decision of the Water Management Committee
	MoTIE				■				■					■			
	MAFRA				■				■					■			
P/I	K-water			■				■					■				· Dam operation, water supply, and new infrastructure construction are promoted according to the decision of the Water Management Committee
	KHNP				■			■					■				
	KR				■			■					■				
Local Govern.			■					■					■				· Most disaster budgets are subsidized by the government.
R.	Upper	N/A					N/A							■			· Increased opportunities to express opinions through residents' self-government councils, etc.
	Lower	N/A					N/A							■			
NGOs		N/A					N/A								■		· Increased opportunities to express opinions in committees, etc.

Note. 'A': Water management autonomy, 'D': Discretion to invest the budget, 'R': Possibility of the plan being realized.

Until now, preliminary modeling has been performed using experiments notes and secondary literature. By organizing the Stakeholder Value Chain Map (SVM), various problems of the current water management system could be derived as follows:

- Water management expertise: Compared to the central government and public institutions that manage water resources facilities, local governments lack of professional organizations due to frequent personnel transfers and a general tendency to avoid water management.
- Accessibility of information: While the central, public, and local governments that directly operate disaster portals have good access to information about floods and droughts, residents and NGOs lack awareness of the portals, and real-time information access is reduced if the sharing of disaster response situations is delayed.

- Decision-making/Authority: Due to the recent nationwide interest in safety (e.g., COVID-19, forest fires, Itaewon disasters, etc.), budget investment and implementation of MoIS are very high. However, the water-related fields are intertwined with complex interests such as residents, civic groups, and environmental groups, making it difficult to establish a rapid disaster prevention system due to the low autonomy, initiative, and possibility of realizing plans for water management.

B. Confirmatory modeling results

Confirmatory modeling was conducted with seven stakeholders and experts from July 26, 2022 to December 9, 2022. Interviewees were organized by one person each for central and local governments, public institutions, local residents, and experts in the fields of policy research, agricultural and environmental economics. Considering that this study is intertwined with various interests and deals with policy-sensitive matters, all interviewees were treated anonymously (see Table 10).

Table 10. *Interviewees Organization for Confirmatory Modeling*

Category	Notation	Details
Central Government	Interviewee 'A'	Infrastructure facility management
Local Government	Interviewee 'B'	Resident support management
Public Institutions	Interviewee 'C'	Dam operation and water supply
Residents	Interviewee 'D'	Person who live in the area around dam
Academics	Interviewee 'E' Interviewee 'F' Interviewee 'G'	Policy research Agricultural economy Environmental economy

The interview was divided into 1) Water management expertise, 2) Accessibility of information, and 3) Decision making/authority, and the following detailed questions were selected in consideration of the expertise of each interviewee.

● Water management expertise:

Q) In terms of preparing/responding to floods and droughts, what level of expertise do you think the following water management agencies have? If improvements are needed, to what level do you think it should be supplemented?

● Accessibility of information:

Q1) In terms of preparing/responding to floods and droughts, how easy do you think the accessibility of water management information provided by water management agencies is? If improvements are needed, to what level do you think it should be supplemented?

Q2) In terms of preparing/responding to floods and droughts, what is your level of self-risk awareness? If improvements are needed, how do you think the existing system should be supplemented?

● Decision-making/Authority:

Q1) Do you think the process of establishing water management policies is transparent and equitable? If improvements are needed, how do you think the existing system should be supplemented?

Q2) Do you think the process of establishing water management policies is efficient and effective? If improvements are needed, how do you think the existing system should be supplemented?

Q3) What is the appropriate proportion and authority of citizen participation in the policy decision-making process through citizen participation, and how do you think the existing system should be supplemented if improvements are needed?

Q4) What do you think about the participation in policy by civic groups in general? In particular, do you think the groups are properly reflecting the opinions of residents? If improvements are needed, how do you think it should be complemented?

As a first step, an interview on water management expertise was conducted. Interviewee ‘A’ belonging to the central government assessed that the current level of water management and scope of responsibility of the government and public corporations were at an appropriate level.

However, interviewee ‘B’ belonging to the local government stated that it is necessary to supplement the budget and manpower in order to perform public duties. Interviewee ‘C’ belonging to a public institution supplemented the opinions of interviewees ‘A’ and ‘C’. Interviewee ‘C’ stated that, although each water management agency has professionalism in its work, the local government assigns the task of managing all sections of the river to one or two persons in charge, making it difficult to manage facilities in detail. Interviewee ‘D’, a resident living near the dam, acknowledges that both the government and public institutions have expertise, but suggests that specialized institutions such as K-water take the lead in handling water supply and flood control for efficient water management. On the other hand, Interviewee ‘G’, an environmental economy expert, expressed a negative view of the water management expertise of public institutions. Interviewee ‘G’ emphasized the need for accurate forecasting of weather conditions and water demand/supply, citing repeated cases of drought damage as an example.

As a second step, an interview on accessibility of information was conducted. All interviewees were aware that information about floods and droughts was available on the Internet and on mobile devices. However, since most of the information requires specialized knowledge and the use of the system is complicated, it is difficult for ordinary people to easily acquire the information. To solve this problem, Interviewee ‘D’, a resident living around the dam, proposed to install an electronic signboard in the area near the dam where many elderly people live to provide real-time dam operation information such as dam level, water storage rate etc. The public's risk awareness level for floods and droughts was evaluated as low. Interviewee ‘C’ belonging to a public institution stated that there is a considerable gap between the disaster risk predicted by water management institutions and the level of awareness experienced by the public. Interviewee ‘D’, a local resident, argued that continuous efforts are needed to be aware of the dangers in everyday life through media such as news and radio.

As the third step, an interview was conducted on decision-making/authority. First, opinions on the transparency and fairness of the water management policy decision-making process were collected. Interviewees ‘A’ and ‘B’ belonging to the central and local governments evaluated that water management policies were established transparently and equitably. Interviewee ‘C’ belonging to a public institution insisted that the water management policy is carried out transparently and equitably, but that the new policy should be quickly disseminated to residents or citizens so that it can be applied appropriately. On the other hand, Interviewee ‘G’, an environmental economy expert, showed a negative position on the transparency and fairness of water management policy establishment. Interviewee ‘G’ insisted that there was still a tendency to exclude regional voices and stick to the top-down method at the policy decision-making stage. Next, interviews were conducted on the efficiency and effectiveness of the water management policy decision-making process. As a result, all interviewees responded positively to this question. In addition, Interviewee ‘F’, an agricultural economy expert, emphasized that in order to establish policies with high acceptance, the importance of economic analysis should be increased from the initial stage of review. Finally, a survey was conducted on the decision-making method through citizen participation. All interviewees also acknowledged the need for citizen participation in policy decision-making. However, interviewee ‘A’ belonging to the central government and interviewee ‘D’, a local resident, suggested that the percentage of citizen participation compared to the total members should be set to a level of about 30% when making decisions. However, Interviewee 'D' judged that some civic groups were entangled in interests and did not reflect citizens' opinions well. Similarly, Interviewee 'E', a policy research expert, took 'Six types (6S model) of representativeness as an example and raised the problem of over- and under-representation of citizen participants (For examples of representativeness, see Lee et al., 2021). Lee et al. (2021) divided representativeness into six types (see Table 11).

Table 11. *Six Types (6S Model) of Representativeness*

Type of representativeness	Summary points
Stake representativeness	Sharing the common stake with citizens
Stance representativeness	Sharing the same stance over public agenda
Service representativeness	Having public service motivation
Specialty representativeness	Having expertise or professionalism
Sovereign representativeness	Representing through legitimate procedure
Socio-econ representativeness	Representing demographic features

Interviewee ‘E’ evaluated that ‘Stake’ and ‘Stance’ were excessive, but ‘Specialty’ and ‘Service’ were insufficient for most citizen representatives participating in policy making. In order to solve these problems, interviewee ‘E’ proposed an alternative to encouraging the democratic participation of ordinary citizens and supporting them technically and financially rather than granting excessive representation to civic groups.

V. Prescriptive Strategy

A. Risk management

Risk means that decision makers know the probability and outcome of an event, whereas uncertainty refers to a situation in which no information is available or unknown (Park & Shapira, 2017). In other words, risk is the probability that actual results differ from expectations, but uncertainty is the lack of certainty about the phenomenon (Hasa, 2021). Therefore, it is necessary to make efforts to bring uncertainty within the scope of risk. This is called risk management. CFI (2022) states that effective risk management implies preemptive action rather than retrospective recovery, and offers the potential to reduce the likelihood and impact of risk. This section deals with measures to efficiently manage risk. In detail, each target level

was diagnosed for each stakeholder's water management expertise derived in Section 4, and strategies for achieving the target were presented.

In order to thoroughly manage risks, professionalism must be enhanced. For instance, it is necessary to strengthen the technology for accurate weather forecasting and detailed hydrological analysis. What scares climate change is its uncertainty. Up to now, all water resource facilities such as dams and embankments have been designed on the assumption that past meteorological phenomena will be repeated in the future. Therefore, historical rainfall and flow data over a long period of time have been considered very important. However, in the future these assumptions may no longer be valid. This is because a non-stationary pattern is being added to the hydrological phenomenon. In other words, there is an increasing possibility that water facilities designed in an existing way will not function properly. Expansion of observation points, actual measurement of water consumption, and technology development and application to acquire reliable data should be carried out in parallel. Furthermore, the use of existing facilities should be maximized through cooperation with each institution. Nowadays, developing the new water resource facilities is difficult to implement because there is a lack of space, a huge budget, and some unfriendly sentiments. Therefore, it is necessary to increase the efficiency of water management by sharing facilities operated by each water management institution. In the case of dams, multi-purpose dams have been operated by K-water, agricultural reservoirs have been controlled by KR and local governments, and power generation dams have been handled by KHNP (see Figure 7). As each institution responds to disasters individually, budgets can be overlapped and countermeasures can be often delayed. Each institution should periodically re-evaluate the climate change response capacity of its facilities. Then, depending on the evaluation results, various measures can be taken through mutual cooperation such as water movement between watersheds and redevelopment of existing dams.

Figure 7. *Dam Management Status by Institution*

Note. K-water (Left), KR (Middle), KHNP (Right)]

Table 12 shows the status of water management expertise (blue) and improvement goals (red) for each stakeholder.

Table 12. *Water Management Expertise Evaluation and Goals*

Stakeholders		(Insufficient)← / →(Excellent)					Note: How to solve?
		1	2	3	4	5	
Central Govern.	MoIS						· Reinforcing personnel training · Cooperation between departments and institutions
	MoLIT	N/A					
	MoE						
	MoTIE						
	MAFRA						
Public Inst.	K-water						· Reinforcing personnel training · Cooperation between departments and institutions
	KHNP						
	KR						
Local Govern.							· Incentives/Training/Recruitment of professional positions
Residents							· Participation in public hearings/ User-centered portals
NGOs							· Reinforcing personnel training

The government and public institutions need to raise their level of expertise to 4 points or higher. In order to achieve the goal, the central government and public institutions must strengthen the education of disaster managers and support the expansion of cooperation between departments and institutions. Local governments should expand incentives for those in charge of water-related tasks and strengthen training to enhance their expertise. In addition, when dealing with an in-depth field, there is also a method of employing specialized occupations specialized in that field. Residents can participate in various resident briefing sessions to improve their professionalism. The government and public institutions should operate a user-centered disaster portal so that residents can easily understand related fields. NGOs also need to improve their expertise for better policy participation, and it is desirable to strengthen education for this.

Until now, measures to strengthen expertise and capabilities for risk management have been dealt with. From now on, I would like to propose the subject in charge and actions for each measure. As shown in Table 13, the roles of the government and public institutions are important to enhance expertise in the disaster field. In order to increase the participation of disaster managers in education, it is desirable to operate it as mandatory as legal education. In addition, providing incentives such as expanding rewards and promotion points for excellent participants in education is another way to increase participation. To strengthen the cooperation system between institutions, joint workshops and training can be conducted. On the other hand, in order to strengthen the disaster response capabilities of residents and NGOs, experiential education on disasters can be helpful. The government and public institutions should endeavor to devise and expand effective education programs for water disasters.

Table 13. *Strategies for Improving Water Management Expertise*

Goal	How	Who	What
Professional Experience Ability	*《Governments/public inst.》* *· Reinforcing personnel training* *· Cooperation by institutions*	*C/G P/I*	*☞ Compulsory education, MOU (e.g., K-water-Meteorological Administration)* *☞ Implementation of joint workshops and disaster response training*
	《Local governments》 *· Incentives for water-related personnel* *· Expert education* *· Recruitment of experts*	*C/G L/G*	*☞ Expansion of reward, additional points for promotion, etc.* *☞ Compulsory training (penalty for non-participation)* *☞ Activation of programs linked to local universities*
	《Residents》 *· Participation in public hearing* *· User-centered public portals*	*C/G L/G*	*☞ Operation of disaster experience center (e.g., drought education experience zone)* *☞ Sharing real-time information (e.g., mobile phone weather information)*
	《NGOs》 *· Reinforcing personnel training*	*C/G L/G*	*☞ Operation of disaster experience center (e.g., drought education experience zone)*

Note. C/G: Central Governments, P/I: Public Institutions, L/G: Local Governments

B. Voluntary- and Information-based approach

Recently, interest in 'Voluntary- and information-based approaches (VIBAs)' to environmental management has increased (e.g., Hood and Markets 2007; Howlet 2019; Kotchen, 2014; OECD, 2000; Sullivan, 2001; Walker et al., 2020). The OECD (2000) defines 'voluntary approach' as a way for companies to work beyond legal requirements while carrying out public voluntary programs to improve the environment. This approach provides the flexibility to respond to problems more quickly than traditional 'command and control' regulations and achieves results at a lower cost (Sullivan, 2001). Another method is 'information-based policy'. It is used to provide knowledge or information to the public to improve their behavior (Hood and Markets 2007; Howlet 2019, as cited in Walker et al., 2020). Walker et al. (2020) explain that this method has positive effects such as quitting smoking or

refusing drugs in the public through advertisements or campaigns.

The two methods mentioned above are based on the active or passive participation of companies or the public. Participation is implemented through information and knowledge sharing. As analyzed in Section 4, it was found that the level of access to information on water disasters by residents and NGOs was significantly lower than that of governments and public institutions. In addition, the reliability of the government policy-making process was not high. However, information must be disclosed transparently. Water is a public good, not private property. Therefore, policies related to flood control and water use should be promoted after sharing with the public and forming a consensus. K-water revised the dam management regulations in 2021. The main content is to share information on the discharge of the floodgate through FAX, SMS, CBS, and warning broadcasts so that the residents of the downstream area can prepare in advance. Similarly, in the case of drought, the government provides support to minimize drought damage by implementing drought forecasts and warnings that inform the public of the current or expected drought situation in each region in real time. As in this case, only a water management policy centered on the region and the people will be able to further strengthen its execution power. Furthermore, water-related consulting and education should be promoted. When flood and drought occurred, small-scale local governments focused on repairing after the damage occurred rather than prevention due to limitations in financial conditions, professional manpower, and technology. As a result, the damage had no choice but to be repeated continuously. In the future, it is necessary for academia and professional institutions to participate in consulting so that effective countermeasures can be prepared according to local conditions, and the government should reflect it in the national plan, and support budget and manpower. In addition, education on flood and drought for the public should be conducted regularly at schools and specialized institutions so that they can recognize the importance of water and the dangers of disasters. Such a method will increase the

understanding of water management policies and make it possible to prepare reasonable policies by inducing active participation of the public. Table 14 shows the status of information accessibility by stakeholder (blue) and improvement goals (red). Local governments and residents need to raise the level of information accessibility to 4~5 points. In order to achieve the goal, it is necessary to shorten the acquisition path of complex data and make portal information easily accessible. And it is important to establish a communication channel between the government and residents so that information can be shared at all times.

Table 14. *Water Disaster Information Accessibility Assessment and Goals*

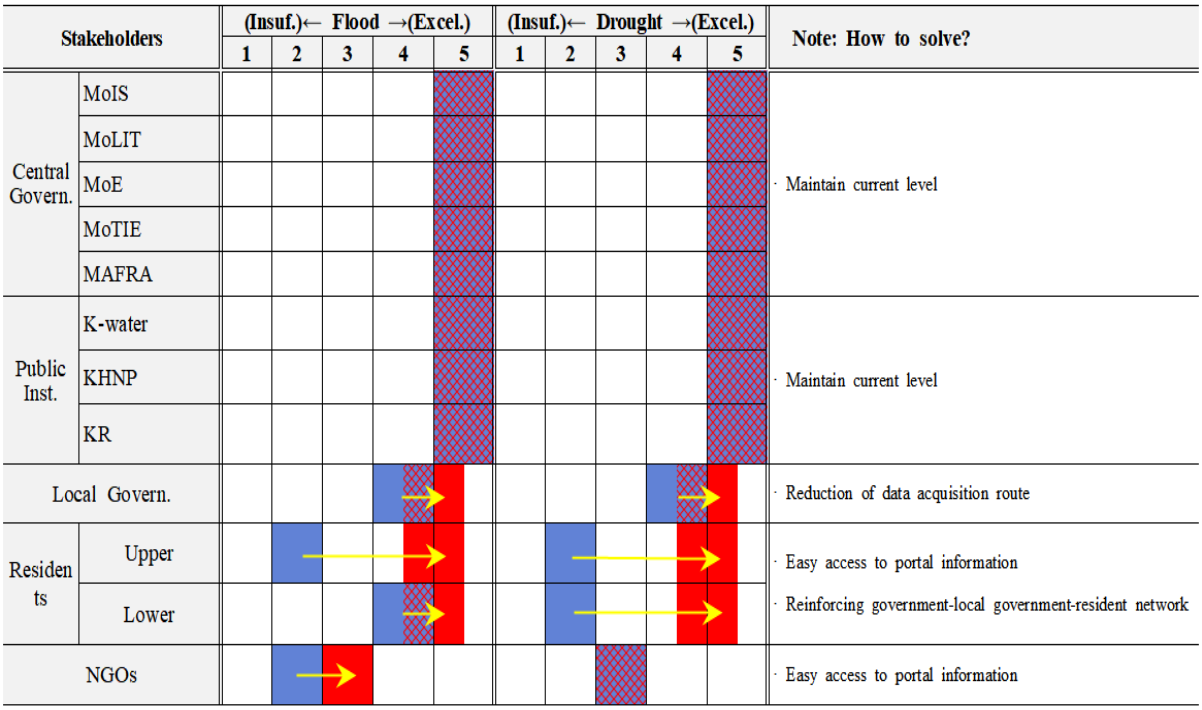


Table 15 shows the subject in charge and actions for each solution. The government and public institutions shall frequently disseminate disaster situations and activate disaster portals and portable applications so that information can be easily obtained anytime, anywhere. For example, the central government and public institutions can set up 'disaster status boards' within local governments so that local governments can compare the water holding capacity of dams

and the water consumption of consumers in real time. Alternatively, there is a consulting program of the central government and public institutions in areas where there is a shortage of professionals. Local governments should increase dispatch to government agencies to inform the situation of the region and communicate policy directions.

Table 15. *Strategies for Improving Information Accessibility*

Goal	How	Who	What
Information Risk awareness	《Local governments》 · Reduction of data acquisition path	C/G P/I	☞ Expansion of authority to access portal information ☞ Sever expansion (e.g. disaster board)
		L/G	☞ Expansion of dispatch channels to government agencies
	《Residents》 · Easy access to portal information · Reinforcing government-local government-resident network	C/G P/I	☞ Production and distribution of portable applications (e.g. fine dust) ☞ Promotion of disaster situation (campaign, broadcasting, etc.)
		C/G L/G	☞ Activate text messages and CBS (e.g., COVID-19 status) ☞ Regular workshops attended by resident representatives
	《NGOs》 · Easy access to portal information	C/G P/I	☞ Production and distribution of portable applications (e.g. fine dust) ☞ Promotion of disaster situation (campaign, broadcasting, etc.)

Note. C/G: Central Governments, P/I: Public Institutions, L/G: Local Governments

C. Decision making

Unlike the traditional administration model (PA), the newly introduced public management model (New PM model) since the 1990s requires more direct accountability of public managers in the process of providing public services to the public (Hughes, 2012). The unregulated plan can pass a heavy burden on the person in charge of the task and can make them passively handle

the work. The reason why studies on climate change response in various water fields are stopped at an early stage is that most of them have not been standardized or institutionalized. Limiting the autonomy of water management agencies to operate facilities and repeatedly establishing plans that are unlikely to be realized will make it more difficult to come up with effective measures against worsening water disasters. By specifying laws and regulations related to water disaster, discretion should be expanded as much as the responsibility assigned to public managers. Table 16 schematically illustrates the current status (blue) and improvement goals (red) of 'water management autonomy', 'Discovery to invest the budget', and 'Possibility of the plan being realized' by stakeholders. Central governments and public institutions aimed at four points for timely policy realization. Local governments need to raise it to three or more points in consideration of its relevance to government plans.

Table 16. *Decision Making/Authority Assessment and Goals*

Stakeholders		(Insuf.)←'A'→(Excel.)					(Insuf.)←'D'→(Excel.)					(Insuf.)←'R'→(Excel.)					Note: How to solve?
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
Central Govern.	MoIS	N/A															
	MoLIT	N/A															· Reestablishment of role relationship between the Citizen Engagement Committee and the government as partners
	MoE																· Timely decision-making
	MoTIE																· The Water Management Committee needs to operate freely away from political issues.
	MAFRA																
Public Inst.	K-water																· Guarantee authority as much as responsibility assigned to water management.
	KHNP																
	KR																
Local Govern.																	· Timely budget support for local river management · If the plan of the local government is feasible, reflect it in the government plan as soon as possible.
Residents	Upper	N/A					N/A										· Maintain the current level
	Lower	N/A					N/A										
NGOs		N/A					N/A										· Maintain the current level, but need to revise the composition/regulations of the committee so that unbiased and reasonable conclusions can be drawn

Note. 'A': Water management autonomy, 'D': Discretion to invest the budget, 'R': Possibility of the plan being realized.

Water management policies should be established away from political issues. Decision makers should listen to the opinions of residents, but be able to distinguish between what they 'need' and what they 'want'. In addition, decision makers must judge whether the civic group properly reflects the opinions of the residents. Therefore, responsibility and discretion must be given to the government and public institutions to fairly organize the committee and reasonably supplement the regulations.

For each solution, the responsible subject and actions are shown in Table 17. The National Assembly and the government should create an environment free from external pressure or interference for fair decision-making. The agenda presented by the committee should define decision-making methods and deadlines, reduce complex procedures, and increase concentration. In order to operate the committee fairly, personnel with approval/neutral/opposition disposition should be equally distributed and the democratic expression of opinions should be ensured. Experts in diverse fields should be allowed to participate for in-depth discussions, and experts should share the analysis results with the committee members without addition or exemption.

The person in charge of disaster management shall be given the authority to make decisions as much as the responsibility assigned to risk management. In particular, if damage caused by a natural disaster is inevitable, legal and financial protections should be set up for the person in charge to actively cope with the disaster. To this end, it is necessary for the government to intervene and reorganize the disaster insurance system. Lim (2022) proposed various support policies, such as sharing public-private losses, to supplement the limitations of individuals or the insurance industry against water disasters.

Table 17. *Strategies for Improving Decision Making/Authority*

Goal	How	Who	What
Professional Experience Ability	《Governments》 · Reestablishment of role relationship between the Citizen Engagement Committee and the government as partners · Timely decision-making · Operating freely away from political issues.	Assembly C/G	☞ Define and implement decision-making methods and deadlines (e.g., majority vote or unanimous vote, resolution within 1 month after the agenda is approved) ☞ Excluding external pressure or interference for fair decision-making ☞ Reducing the decision-making stage, legislating simple routines (e.g., number of committees ↓ ⇨ concentration ↑)
	《Public institutions》 · Guarantee authority as much as responsibility assigned to water management	C/G NGOs	☞ Participation in the committee as a specialized institution and guarantee of the right to speak
	《Local governments》 · Timely budget support for local river management · If the plan of the local government is feasible, reflect it in the government plan as soon as possible	Assembly C/G	☞ Budget deliberation within the deadline, timely budget support ☞ Define and implement decision-making methods and deadlines (e.g., majority vote or unanimous vote, resolution within 1 month after the agenda is approved)
	《NGOs》 · Maintain the current level, but need to revise the composition/regulations of the committee so that unbiased and reasonable conclusions can be drawn	C/G	☞ Organize appropriate personnel when organizing the committee (e.g., 1. Excluding biased members 2. Arranging pros/neutral/opposing personnel evenly 3. Balanced arrangement of pro-govern/pro-opposition parties, etc.)

Note. C/G: Central Governments, P/I: Public Institutions, L/G: Local Governments

VI. Conclusion and Future Research

This capstone aimed to analyze the causality of climate change and water disasters, and to propose sustainable water management strategies in the Seomjin River basin, which is safe for floods and droughts. To accomplish this, I reviewed the literature and explored the evolution of climate change definition, the current state and future prospects of climate change. In this process, it was confirmed that climate change has a close relationship on water resources. Climate change affects the quantity and quality of water. The influences are very negative, such as intensified typhoons and rains, inundation and landslides, shorter drought cycles, and unimproved water quality. This study focused on specific stakeholders exposed to various water use environments and issues in the Seomjin River basin. Using preliminary modeling and expert interviews, 1) the expertise of water management instruments, 2) the level of acquisition and recognition of flood and drooping information, and 3) the transparency, equality, and execution of the decision-making process were analyzed. There are three main problems that have been drawn. First, local governments that need primary response to disasters lack water management organizations, making it difficult to respond effectively. Second, residents have a low level of information and awareness about disaster situations such as droughts. Third, due to complex interests, the decision-making process for water management policies is not transparent and inefficient.

This paper proposed three solutions to the problems. The first is to strengthen expertise and inter-agency cooperation capabilities to manage thorough risks. In-depth research and expert training make it possible to more accurately predict changed rainfall patterns caused by climate change, and resource sharing between institutions helps to efficiently utilize limited water resources. Second, water-related education and information provision should be activated for the public. The government must provide information promptly in accordance with regional

characteristics and the level of the people and guarantee the people's right to know through various education programs. This method facilitates the public's understanding of water management policies and encourages their participation to come up with reasonable water management policies. Tietenberg and Lewis (2018) have drawn attention to the importance of information:

> Effective private action depends on good information on both the nature of risks and options for adapting to them. Much of this information about future risks is a public good, which means that it will be undersupplied unless the government supplies it or participates in its supply. (p. 417)

Lastly, a balanced and reasonable water management plan should be established away from political issues. At all stages of policy establishment, public opinions must be reflected and free participation must be guaranteed. The important thing is that all participants should try to make rational decisions so that the decision-making process is not distorted by a small number of biased people. Extensive research has shown a tendency towards short-sighted decision-making due to human selfishness (Healy & Lenz, 2014; Achen & Bartels, 2017; Han & Kim, 2022). Ostrom (1990) presented eight principles for managing common resources. These principles clarify the rules between those who use the resources, all stakeholders have the right to participate in making or revising the rules, and allows for monitoring and incremental sanctions against violations of the rules. Section 4 showed that the excessive representation of some civic groups does not properly reflect the opinions of residents who are close stakeholders. For sustainable water management in the Seomjin River basin, general residents should be encouraged to participate. To do so, discretion must be expanded along with the responsibilities imposed on the government and public institutions to fairly organize the committee and reasonably supplement the regulations without external pressure or interference.

There is a proverb that says “To lock the stable door after the horse is stolen.” As everyone knows, this proverb is often used to mean that it needs to be prepared before problems arise. However, in flood and drought management, it seems that there are many cases in which the horse is stolen but the stable door is still not locked. This is because, no matter how extreme the flood, the serious situation is forgotten after the flood season, and even if the worst drought is experienced, once the drought is somewhat relieved by rain, the person becomes indifferent again. We should not be stingy about supplementing the level of response and investment to overcome the wave of climate change. Furthermore, in order to achieve a regional consensus on water management policies, community awareness of the future water crisis must be accompanied. It is worth asking whether the results of this study apply only to the Seomjin River basin or more widely. I believe that the context under investigation is typical of most countries suffering from water disasters. These strategies will contribute to the design and implementation of sustainable policies for policymakers, central and local officials, residents and NGOs. Turning climate change into an opportunity, not an ordeal, can only be done through scientific and systematic water management policies. If we all become masters of water management and work together, the advanced water management country free from flood and drought will eventually be realized.

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