

**A STUDY ON THE COOPERATION OF WATER-ENERGY TRADE IN
TRANSBOUNDARY RIVER OF SOUTH AND NORTH KOREA**

By

CHA, Jongman

CAPSTONE PROJECT

Submitted to

KDI School of Public Policy and Management

In Partial Fulfillment of the Requirements

For the Degree of

MASTER OF PUBLIC MANAGEMENT

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Committee in charge:

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Approval as of December, 2018

.Executive summary

Water has been an invaluable economic resource that has been closely linked to human right to life since its inception. So there has always been a battle to preoccupy the value of water at the heart of conflicts between nations. In recent years, disputes between shared rivers and countries around the international rivers have increased and disputes have become more serious.

The problem of shared rivers according to geographical characteristics has not been solved for a long time in both Koreas. One of the problems in North Korea is the severe lack of electricity. The power shortage in North Korea is very serious. To overcome this problem, North Korea built a Hwanggang Dam in Tohsan-gun, North Hwanghae province in 2008. Moreover In order to increase hydropower generation using high water head, North Korea changed the waters of Imjin River, which had originally flowed to the South, to Yesung River. On the other hand, problems in South Korea are reduced flow and deteriorated water and ecosystem. North Korea decided to change diversion scheme from Imjin River to Yesung River. As a result, flow rate of Hwanggang Dam was not supplied to the South Korea side. There are so many problems such as shortage of flow rate, destruction of river ecosystem etc.

Under these circumstances, there are three reasons why we need cooperation in a shared river between the two Koreas. First, it can be a solution to reduce the military tension mode. Second, two Koreas can achieve water security and economic community together through cooperation. Lastly,

river maintenance flow for conservation of natural ecosystem should flow.

As a solution about this problem, I proposed 'Water-Energy Trade Cooperation Project' in Hwanggang Dam in North Korea as a cooperation model. One of the most notable points is that South Korea will invest to construct floating photovoltaic power plant on the reservoirs of Hwanggang Dam and it will supply electricity to North Korea. Instead, South Korea will be able to receive the flow to the Imjin River basin corresponding to the electricity generated by the floating photovoltaic power plant.

Water-Energy Trade Cooperation Project's key to researching operational management methods in shared rivers between two Korea is to conduct institutional and economic analysis on cooperative projects that are intermediaries. First is the institutional point of view about Joint Water Management Committee's Structure. Two Korean should first formulate laws and guidelines related to the water resources. Moreover it is desirable to operate sustainable water resources management through the Joint Management Committee which is a permanent organization, on the river basin scale. Second is the institutional point of view about Hwanggang Dam Photovoltaic Cooperation Project Agreement. This study established the Joint Management Division of Inter-Korean Water Resources under the Joint Management Committee of the Inter-Korean of the New Government's Top 100 National Agenda, and set up the Hwanggang Dam Water Status Cooperation Project (tentative name) as a medium of Water-Energy Trade cooperation. Third is the economic point of view about Water-Energy Trade Cooperation. In order to maintain the sustainability of inter-Korean water cooperation projects, the economic feasibility of the Hwanggang Dam

Photovoltaic Cooperation Project should also be considered. And economic analysis results of this study has good economy feasibility as follows. Capacity : 40 MW, Annual Energy Production : 50,818 MWh (14.50% utilization rate), Economic Analysis : B/C 0.91, IRR(%) : 3.15 etc. It is also important to consider the economic value of water in terms of economy. The economic value of the water flowing back to the south of the Imjin River by the Water-Energy Trade shows the quantitative value of measurable water as well as the effect of water quality improvement and ecosystem protection. Furthermore, this water cooperation will strengthen the trust between the two Koreas and lead to the détente of the DMZ. We have to know that the social value of this water is very large.

Finally, we must bear in mind that when East Germany-West Germany before the unification had a conflict in the river shared by the Elbe River, the problem was resolved in the center of West Germany. This means that South Korea is a downstream shared river country and should be considered to be a better developed country than North Korea. West Germany continued to provide economic incentives to the East Germany, bringing East Germany into the field of dialogue, and the long-established trust was the key to solving the problem. Even if the cooperation project for Hwanggang Dam has not economic feasibility(B/C), we have to provide technical and economic incentives to North Korea preemptively, which will lead to dialogue for river management and economic community formation. I want to emphasize that it is more important than economic value.

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A Study on the Cooperation of Water-Energy Trade in Transboundary River of South and North Korea

1. Introduction

In Water has been an invaluable economic resource that has been closely linked to human right to life since its inception. So there has always been a battle to preoccupy the value of water at the heart of conflicts between nations. In recent years, disputes between shared rivers and countries around the international rivers have increased and disputes have become more serious. The problem of shared rivers according to geographical characteristics has not been solved for a long time in both Koreas of the Korean peninsula. Therefore, we would like to understand the concept and characteristics of these shared rivers, and to find ways to cooperate with each other in the shared rivers on the Korean Peninsula through case studies on disputes in shared rivers. Furthermore, I am trying to derive a long-term and efficient management plan for shared rivers on the Korean peninsula.

Since the launch of the new government, Moon Jae-in in 2017, efforts to improve relations between the two Koreas have continued. The blueprint for the resumption of Inter-Korea economic cooperation is as follows. First, president Moon's pledge is that expansion of Gaesung Industrial Complex and promotion of various economic cooperation projects. Second, Minister of Unification, Cho, said that Gaesung Industrial Complex will be reopened until period of Moon government in an interview with the press. Finally, new government's process of peaceful unification has announced 'Moon's peace initiative' at Berlin Germany, in June, 2017. It is consist of four steps such as principal of peace, denuclearization, economic

cooperation and establishment of a peace regime. 'Moon's peace initiative' can be founded through the Moon's policy road map. Among 100 tasks, establish Joint Management Committee and operate Special Economic Zone are the good sign of resuming economic cooperation between North and South Korea. The international situation of the Korean Peninsula is rapidly changing into a reconciliation and cooperation mood due to recent inter Korea Summit (April 27, September 18, 2018) and the North-US Summit (June 12, 2018). In particular, discussions on the utilization of border areas including the demilitarized zone (DMZ), which is the central area of the country, are being activated.

The existing agreements of the two Koreas' shared rivers so far are as follows. "Joint Press Release of the Second Inter-Korean Ministerial Talks" (September 1, 2000) - "We will jointly promote the flood prevention project in Imjin River in the near future". We concluded the "Agreement on the prevention of flood Damage on the Imjin River" (March 22, 2004) for the construction and operation of the "Imjin River Water Pollution Prevention Committee" and the "Imjin River Water Pollution Prevention Joint Investigation Group". However Since 2005, the implementation of the agreement has not progressed due to deteriorating inter-Korean relations.

Under these circumstances, I would like to study the Water-Energy Trade promotion plan which located at the Hwanggang Dam in the Imjin River Basin, trans-boundary river. First, I will investigate limitations and problems of the existing agreement on the trans-boundary river between North and South Korea. Secondly, I will examine the characteristics of benchmarking shared river management on the

Korean peninsula by examining the best cases of international river dispute settlement. Lastly, I will study the institutional and economic aspects of the Water-Energy Trade project using the floating photovoltaic power plant. I will also present a gradual and progressive business strategy. I would also like to help K-water establish a basis for the North Korean water business after the unification.

A. Key Issues / Problems

(Definition of Shared Rivers) International River or shared river means that flow across the boundaries of two or more countries (Lee J,P 2017). The International Law Association (ILA) defines a shared river as an area determined by the watershed including land and underground water, extends to more than one country and spans the geographical range downstream of the community ". Shared Rivers are classified into three types as shown below. Trans-boundary River is that it is clearly distinguish upstream and downstream countries by shared river. When a shared river forms the boundary between two countries, it is called a boundary River. When a shared river is difficult to distinguish between an upstream country and a downstream country, it is called a shared river.

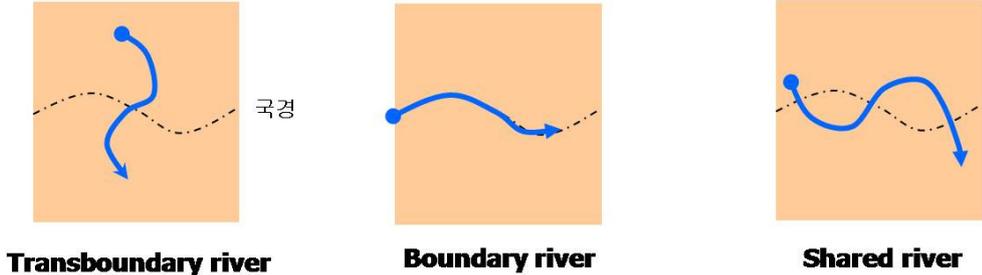


Figure 1 Types of shared river (Choi D,J 2005)

(Problems in the Shared River of two Koreas) The shared rivers Imjin River and Bukhan River located in the border region of DMZ and belong to the North and

63% and 23% of the watershed, respectively. Among them, Imjin River originates from Dukwon-gun, South Hamgyong Province, and flows into Gyeonggi via Gangwon and Hwanghae Province. After joining Hantan River, it flows into Kanghwa Bay. The topography is generally a rapids river that forms a rugged valley, and there are many bends. The watershed area is 3,709.6km² (including 8,897km² in North Korea) and the extension of the river reaches 244.0km. The main tributaries include various streams including Gomitan, Pyeongan, Yucgok, Hantan, Sami, Munsan and Sa. (Kim, I,J 2009).



Figure 2 Status of Trans-boundary River inter Korea (Hankyoreh, 2018)

Problems in North Korea are as follows. The power shortage in North Korea is very serious. Many North Korean has suffered from lack of electricity. This is due to the closed energy policy of self-help, the aging of facilities, the reduction of energy supply, and the instability of power generation and transmission-distribution systems. The core of the North Korean power industry is the hydro power plant. It accounts for 60% of the total electricity in North Korea. According to study, strategies for hydro power business of North Korea (Feb,2005, K-water), status of hydro power facilities is that most of them are built in the period of Japanese colonial, and the degree of aging is severe and the operation rate is low due to the lack of proper maintenance or reinvestment of facilities. To overcome this problem, North

Korea built a Hwanggang Dam in Tohsan-gun, North Hwanghae province in 2008. In order to increase hydropower generation using high water head, North Korea changed the waters of Imjin River, which had originally flowed to the South, to Yesung River.

Problems in South Korea are as follows. North Korea decided to change diversion scheme from Imjin River to Yesung River. As a result, flow rate of Hwanggang Dam was not supplied to the South Korea side. There are so many problems such as shortage of flow rate, destruction of river ecosystem etc. Lee Kwangman also said that water shortage is serious situation in the Imjin River, due to the construction of the Hwanggang Dam. The depth of water has been rapidly lowered through continuous sedimentation. As a result the river has being lost its function. And Analysis of the Imjin River flow regime before and after the construction of the Hwanggang Dam showed that six month flow decreased by 18% and minimum flow except ten days decreased by 44%. It is expected that the amount of inflow to the downstream will be cut off and 100 million tons will be reduced annually (Lee 2010). In the case of the Imjin River, water depth is rapidly lowered by continuous sedimentation due to lack of water, and it is losing its function as a river. In addition, as mentioned above, North Korea operated the Hwanggang Dam reservoir at a high water level to increase the amount of hydroelectric power generated using the difference of high and low water head. Unfortunately, however, when unexpected floods and heavy rains came, North Korea discharged an enormous amount of water to the South. Because of this, South Korea has suffered human accidents and property Damage (6 people were killed, 21 cars were flooded, September 2009). In other words, North Korea, which is an upper country, is unilaterally using water, and South Korea, which is a downstream country, is

suffering from the Damage.

(Limitations of the existing water related inter-Korean Agreement) The inter-Korean talks on the inter-Korean shared rivers, which began in September 2000, revealed various limitations and problems. First, there was no permanent organization to implement the difficult agreements. In the case of East and West Germany, it was not easy to cooperate on the Elbe river problem, but it was able to continue the dialogue through the institutionalized 'Joint Border Commission'. On the other hand, the inter-Korean channel has been interrupted whenever there is a political problem between the two Koreas because there is no organization to jointly manage the shared river. And when it resumed after that, it was difficult to guarantee continuity because of the disagreement about the composition of the dialogue channel and scope of the agenda. This eventually did not reach the institutionalization of inter-Korean trades around the shared rivers.

Second, these Agreements focused solely on preventing floods. I think that it was right to solve the urgent issue because at that time, the Damages occurred by the unauthorized discharge from the Hwanggang Dam of the North Korea. However, not only the flood Damage but also the problem of water quality deterioration due to lack of flow in the dry season was a limited subject and the subject of cooperation was very limited. As a result, it was limited to expanding into the overall water resource sector.

Third, it was central government-centered approach. The nature of inter-Korean relations makes it obvious that there is a primary discussion among the

authorities. However, one of the best cases of shared river disputes is the Elbe River in East and West Germany, The opinions of local governments and residents as well as the central government are reflected and sustainability is maintained and the expansion of the project is guaranteed.

2. Research Design / Methods

A. Literature Review

(The case of dispute in the shared river) Because of the geographical characteristics of rivers, there have been many events of water conflicts and conflicts in many parts of the world. Moreover, many experts predict that shared river disputes will be a major issue in the 21st century, due to uneven distribution of water, increased water usage and increased drought due to climate change. This is why cooperation in international shared rivers is becoming important. Figure 3 shows the major conflicts in the international shared rivers.

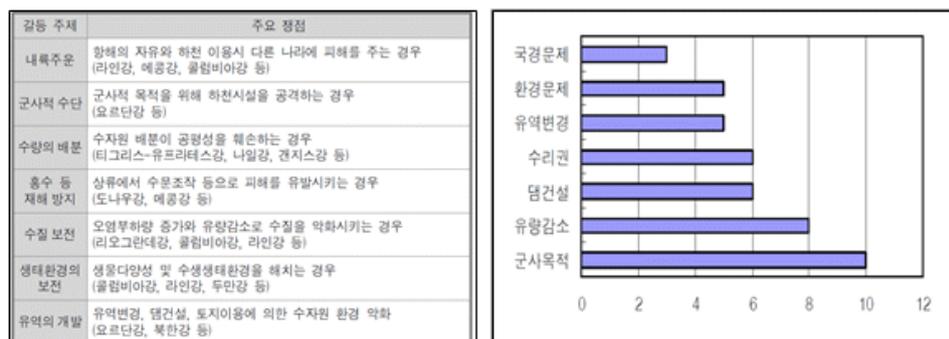


Figure 3 The case of dispute in the shared river (Son K,U 2006)

First point of these disputes, there is a great deal of implication for us in case of disputes on the Elbe River, which is similar to the circumstances of our two Koreas, before the unification of Germany and East Germany. The shared rivers and

water resources cooperation between East and West Germany were caused by the water pollution problem in East Germany. However, after World War II, East Germany lacked the financial and technological capabilities to protect rivers and solve pollution problems. As a result, East Germany was not able to accept West Germany's claim of "polluters pay principle" as a polluter and was forced to rely on West Germany's financial and technical support. In this process, the role of the Joint Water Management Committee was great. It was at the center of cooperation among various related organizations such as East and West German government to solve various problems.

Second point of these disputes, the Rio Grande River conflict in the United States and Mexico, is a good model for resolving shared river disputes in the process of cause and resolution about the conflict. That dispute included quantity, quality and environmental issues. And the process of moving from the initial confrontation to the cooperation stage for common management of rivers is a case that gives us many implications. In addition, examples of positive conflict resolution around shared rivers in the world have been found in many countries. The 1964 Columbia Agreement between the United States and Canada is a good example. And the West African Senegalese watershed is a case of mutual cooperation between the coastal nations in terms of "sovereignty bargain". And Orange in southern Africa, The Senkyu River is considered a successful example of cooperation between South Africa, Lesotho, Botswana and Namibia (Lee S,H 2015).

B. Research Questions

(Why do we need cooperation in the shared river between two Koreas?) When

conflicts arise in shared rivers, until now, three following principles have been applied such as Absolute Territorial Integrity which was called 19th century Harmon Doctrine and Absolute Riverine Integrity, and Limited Territorial Integrity. These principles have evolved into the Reasonable and Equitable Utilization Principles in order to avoid harming other coastal states in accordance with the Helsinki rules of 1975 (Vinogradow, Wouters & Jones, 2003). In general, the upstream countries prefer "absolute territorial sovereignty" and the downstream ones claim "Preemption Principle" and "Absolute Territorial Integrity"(Son, 2006). In other words, if conflicts arise in relation to the use of shared rivers, there is no universally applicable principle among these principles, and it can be seen that it depends on the interests and national power of the Parties.

However, the shared river management in the North and South Korea is one of the cases that conflict dominated rather than cooperation. The process of resolving conflicts has followed the political logic of both countries, rather than applying the principle of international shared river management. As a result, any cooperation between the two Koreas related to the shared river's problem is perceived as a bigger problem because there is no sustainability.

(In the economic and institutional point of view, respectively, what should we do in order to maintain the sustainability of inter-Korean water cooperation projects?)

Considering the special political situation, tense mode, and international sanctions conditions of the two Koreas, it is difficult for the delegation and the environmental groups to participate independently, like as the cases of East and West Germany. Moreover in the economic point of view, Even if the cooperation project has not good economic feasibility(B/C), is it right that we have to provide technical and economic incentives to North Korea preemptively so that maintain the sustainability

of inter-Korean water cooperation projects? It is very difficult and complex problems.

(How do we get the North Korea's data required to analyze economic feasibility?) We cannot access a lot of data needed to analyze economic feasibility. We need to think about what data is appropriate as an alternative. One of the most important dependent variables in the optimal design of solar power plants is the solar radiation. It is available from the Resource Map of Korea Institute of Energy Research (KIER). However, as with all North Korean data, the Hwanggang Dam data is not available, so an alternative is needed. However it is considered that a more accurate review can be made later when effective data can be acquired later such as unification.

C. Research Methods

Case studies can be a practical solution when a big sample population is difficult to obtain. It is also considered useful in research as they enable researchers to gain better insights into the detailed characteristics of the subjects of interest.

Sampling of the case study was chosen to ensure the reliability and generality of the research topic. In particular, we focused on the case of successfully resolving conflicts in the case of dispute in the shared river and ICPR and ICPEP were selected. One of the limitations and problems of the existing water-related inter-Korean agreements is that there is no sustainability and there is no permanent organization. In this regard, I think ICPR and ICPEP, which are known as best practices for resolving shared river conflicts, will be one of the best sampling. Regarding data gathering, I reviewed the ICPR and ICPEP interviews I

visited during this summer field trip and could obtain useful data by carrying out additional document analysis such as related papers.

3. Analysis and Findings

A. Analysis Frame

The key to researching operational management methods in shared rivers between North and South Korea is to conduct institutional and economic analysis on cooperative projects that are intermediaries. I think this will help to ensure the rationality of the project and help to shape the governance of the Cooperation Committee that both Koreas can accommodate. As a solution to this problem, I proposed 'Water-Energy Trade Cooperation Project' in Hwanggang Dam in North Korea as a cooperation model and benchmarked the cases of international agreements and governance operations through domestic and overseas advanced cases and literature review. In particular, I will focus the case of China-North Korea hydroelectric power company, which is famous for the cooperation between North Korea and China, and the another case of the International Commission for the Protection of the Elbe River (ICPER) that solved the problem of water pollution in East and West Germany. Through this, I would like to propose a basic framework of agreements required for joint management operations

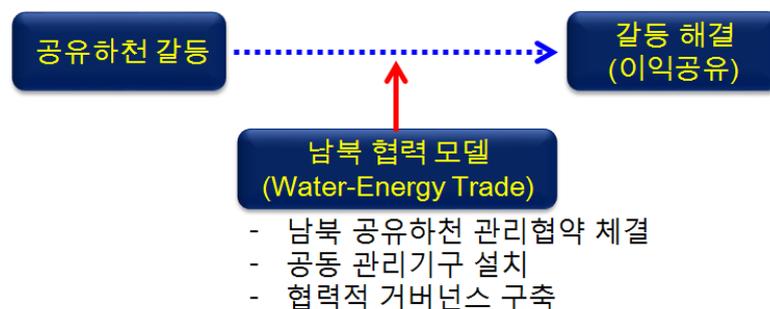


Figure 4 Analysis Frame

B. Field Research (Characteristics of ICPER / ICPR)

As mentioned earlier in the case of shared river conflicts, it is important to conclude a convention with legally binding power and to rationalize the governance of the committee to operate it in order to secure the sustainability of Water Resource Cooperation Projects. When we formulated a governance system for shared river management, the Elbe River Border Commission, which was established by the East and West Germany to solve the river pollution problem in the Elbe River, and the Rhine River Border Commission, where Germany and France participated, the cases give us a lot of suggestions. It is clear that comprehensive and long-term transnational cooperation is needed in the management of shared rivers and water resources facilities, rather than claiming regional selfishness and political logic. In addition, we can see that the above cases lead governments, governments, residents, and NGOs to form governance and lead to conflict. The governance characteristics of the Elbe(ICPER¹) / Rhine(ICPR²) International Committee are as follows.

① Overview

- | | |
|---|---|
| ○ 설립 : ICPER ¹) (1990년) | ○ 설립 : ICPR ²) (1950년) |
| ○ 목적 : 생태계보호, 수질개선, 홍수방지 | ○ 목적 : 생태계보호, 수질개선, 홍수방지 |
| ○ 길이 : 1,094 km ○ 유역 면적 : 148천 km ² | ○ 길이 : 1,320 km ○ 유역 면적 : 168천 km ² |
| ○ 국가 : 독일, 체코, 오스트리아, 폴란드 | ○ 국가 : 독일, 프랑스 등 총 9개국 |

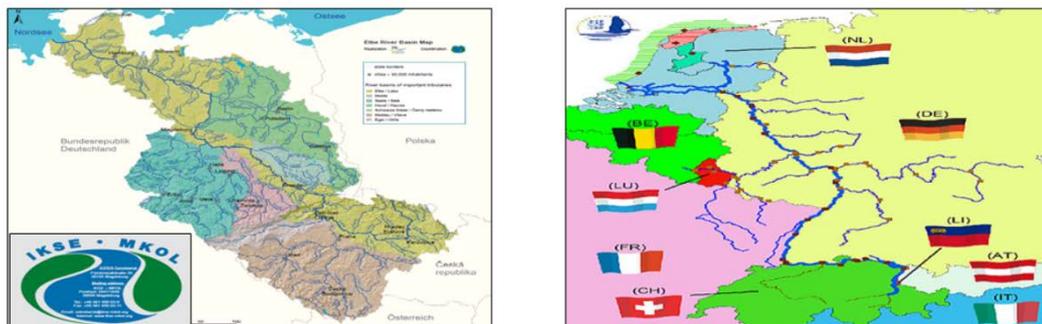


Figure 5 Status of ICPER(left) and ICPR(right)

¹ International Commission for the Protection of the Elbe River 엘베강 국제위원회

² International Commission for the Protection of the Rhine River 라인강 국제위원회

② Structure

- 사무국 : 8명
- 실무자그룹 : 3개 그룹(15명)
- 전문가그룹 : 120명
- 최상위 정책기구 : 총회, 조정위원회, 각 연안국 대표(전략그룹의 자문을 받음)
- 실무자그룹 : 4개 그룹

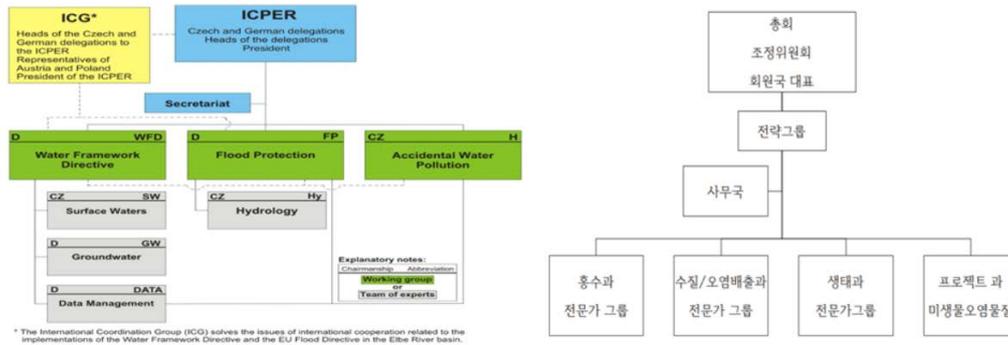


Figure 6 Structure of ICPER(left) and ICPR(right)

③ Example of governance cooperation (Elbe River, Brandenburg, Germany)

The intergovernmental cooperation mechanism in Germany is the Elbe River Basin Committee (FGG Elbe). The Elbe International River Basin District is divided into nine watershed districts, five of which belong to Germany. A representative of the state governments in the lower watershed coordination district is selected (for example, the state representative of the Havel watershed district in the State of Brandenburg) and the remaining provinces form a partnership. In addition, a particular state constitutes an organic organization by participating in other watershed-coordinating districts as well as representing the watershed-coordinated district (Walsh C. 2012)

체계	담당기관	주요 업무
연방	환경부(Federal Ministry of the Environment)	• EC에 보고, 법체계 마련 및 국제 사회에서 독일 대표
국제 유역 지구	ICPER	• 국제강 유역관리 계획 조정 및 준비, 관련 이해집단 간 분쟁 해결 및 정보 공유
주정부 간 협력	엘베 강 유역 위원회 (FGG Elbe)	• 지역경계 관련 문제 해결, 유역경계 개념, 전략 마련, 경험 공유 및 데이터 조율
주정부	브란덴부르크주 환경, 보건 및 소비자 보호기관	• 정책 및 법제 개발, 주정부 간 및 국제 공청회 참여
	브란덴부르크주 환경청	• 강 유역관리 계획 실행-하천 개발 개념(GEKs) 및 사업 개발
지역 및 지방정부	주환경청, 컨설턴트, 지방정부, 이해관계자	• 이해관계자 및 공공 참여를 통한 GEK 발전, 지역 정보 공유

Table 1 Governance System of Elbe river basin district (eg. Brandenburg)

C. Necessity of Cooperation in the Shared River of Inter Koreas

Why do we need cooperation in the shared river between two Koreas? I think there are three reasons why we need cooperation in a shared river between the two Koreas. First, it can be a solution to reduce the military tension mode. South and North Korea must conclude and cooperate with the principle of common management of shared rivers, considering the special situation between the two Koreas, rather than sticking to international principles that benefit their own countries. Second, through cooperation, the two Koreas can achieve water security and economic community together. The modernization project of hydropower Dam in North Korea through water resources cooperation is one of the merits that North Korea can gain through this project. In addition, it will come to North Korea's great advantage in regenerating the potential energy value of numerous Dam reservoirs. Lastly, river maintenance flow for conservation of natural ecosystem should flow. It is because the second peace Dam and the civilian casualties of Imjin River will not occur if the river utilization system and the management system that have common principles and common sense are established. This is why we need special cooperation for both South and North Korea in order to fully protect the South-North shared rivers and to use the water efficiently

The international situation of the Korean Peninsula is rapidly changing into a reconciliation and cooperation mood due to recent inter Korea Summit (April 27, September 18, 2018) and the North-US Summit (June 12, 2018). In particular considering the follow-up of high-level talks and practical contacts after the inter-Korean summit, it seems that there is a sufficient power to cooperate in the field of water cooperation between the two Koreas in shared rivers.



Figure 7 Summary of the necessity for cooperation

D. Overview of Water-Energy Trade

I selected the "Hwanggang Dam Floating Photovoltaic Power Plant Project" as one of the cooperation projects between the two countries in the Imjin River Shared Stream. This is because the Hwanggang Dam is located about 42.3km upstream from the DMZ and has an excellent advantage of easy accessibility of the North and South Korea such as Gaesong Industrial Complex. And the Floating Photovoltaic Power Plant Project has the advantages of South Korea's related source technology, low investment cost, and short construction period. Therefore, it is possible to obtain an effective effect through the exchange of power production and flow rate. The facilities of Hwanggang Dam are shown in Table 2.

구 분	제 원	구 분	제 원	
위 치	황북 토산군 황강리	유역 면적	2,803 km ²	
댐 형식	복합댐(콘크리트 중력식댐 + 사력댐)			
댐마루고	EL.114 m	총저수용량	약 354백만 m ³	
댐바닥고	EL.74 m	유효저수용량	약 273백만 m ³	
		여수로 정고	EL.101 m	
댐높이	40 m	수 문	15m(B)×15m(H)×7조	
		홍 수 위	-	
댐길이	콘크리트댐	300 m	최고홍수위	EL.112.5 m
	필 댐	810 m		
도수터널표고	자연방류	저 수 위	EL.97.3 m	

Table 2 Facility Status of Hwanggang Dam (K-water, 2005)

The purpose of this project is to provide financial and technical incentives to North Korea and jointly manage shared rivers. One of the most notable points is water trade with floating photovoltaic power plant at the Hwanggang Dam. South Korea will invest to construct floating photovoltaic power plant on the reservoirs of Hwanggang Dam and it will supply electricity to North Korea. Instead, South Korea will be able to receive the flow to the Imjin River basin corresponding to the electricity generated by the floating photovoltaic power plant.

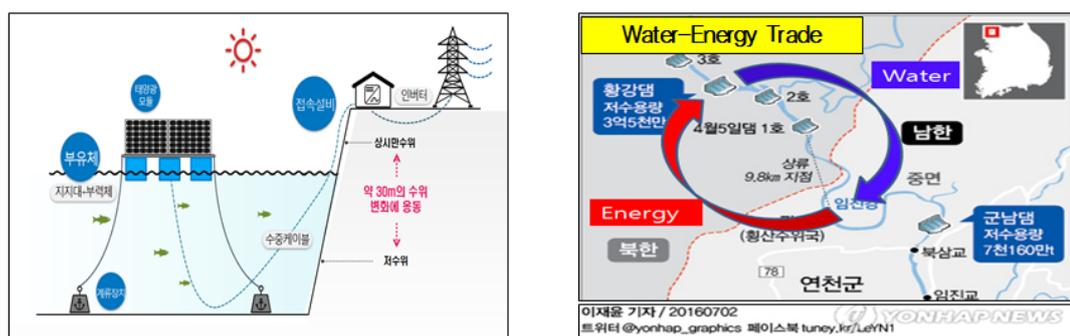


Figure 8 Concept of Floating Photovoltaic Plant and Water-Energy Trade

4. Policy or Administrative Recommendations

A. (Proposal) in the institutional point of view

a. Establishment of the Inter-Korean Joint Management Committee

We can see the case of conflicts in international shared rivers and the cases of interception of flood prevention projects between South and North Korea. In order to ensure the sustainability of water resource cooperation projects between countries in shared rivers, it is important to establish river management committees, legislative agreements, and governance, which are composed of concerned parties based on "benefit sharing". We can see that these factors are key roles for cooperative problem solving. For this purpose, this study established the Joint Management Division of Inter-Korean Water Resources under the Joint Management Committee of the Inter-Korean of the New Government's Top 100 National Agenda, and set up the Hwanggang Dam Water Status Cooperation Project (tentative name) as a medium of Water-Energy Trade cooperation

However, considering the special political situation, tense mode, and international sanctions conditions of the two Koreas, it is true that it is difficult for the delegation and the environmental groups to participate independently, like as the cases of East and West Germany. However, as can be seen from the case of the Elbe River and the Rhineland International Commission in Germany, the Korean peninsula should first formulate laws and guidelines related to the water resources of the Korean peninsula. And I think it is desirable to operate sustainable water resources management through the Joint Management Committee, which is a permanent organization, on the river basin scale. Among the organizations of the Inter-Korean Joint Management Committee, the General Assembly and the Coordination Committee, which are the highest-level policy organizations, consist of three members each from the North and the South, and will be advised by the Strategic Group. The secretariat of the committee, which is a permanent organization,

has four expert groups: the Water Energy Group, the Flood Group, the Water Pollutant Discharge Group and the Ecology Expert Group. In addition, the composition of the expert group is considered to be governance by participating in local governments, delegates from local residents, and NGOs.

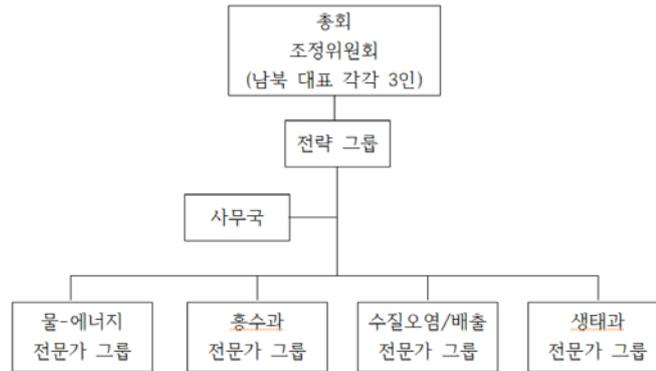


Figure 9 Organization of Inter-Korean Joint Management Committee (proposal)

b. Agreement for Hwanggang Dam Floating Photovoltaic Power Plant

Proposal inter-Korean Joint Management Agreement, in accordance with the International River Law, will propose the following regarding the institution, organization and operation sector considering the specificity of inter - Korean relations.

The composition of the inter-Korean Joint Management Committee was based on the Articles of Association of the China-North Korea Hydroelectric Company (Lee, 2006). It consists of six directors dispatched by the two governments in accordance with the principle of equality, and president and vice president are elected among the directors. The president and vice president should alternate between the two directors, but it is reasonable to replace them once every three years. The Hwanggang Dam floating photovoltaic power plant's board of directors will lead and supervise the power plants on behalf of the governments of the two Koreas. The Board of Directors shall discuss and resolve all matters pertaining to the Board's

authority based on the spirit of consultation. It was considered that the committee should be operated as a cooperation project that both Korea can accommodate.

제 1조 (자산)	南·北 황강댐 수상태양광발전소의 모든 재산은 南·北 양국의 공동 소유이다.
제 2조 (제도)	南·北 양국 정부는 南·北 황강댐 수상태양광발전소를 공동 경영하기 위하여 南·北 집경지역 공동관리위원회 산하 수자원공동관리 분과를 설치하여 황강댐 수상태양광발전소를 운영한다.
제 3조 (이사회 설립)	南·北 양국정부는 평등원칙에 따라 파견인원으로 南·北 황강댐 수상태양광발전소 이사회 및 감사회를 조직함으로써 南·北 양국정부를 대표하여 발전소를 지도/감시하게 된다. 이사회 및 감사회의 권한과 임무는 별도로 협약서 세부규칙에서 규정한다.
제 4조 (이사회 조직)	이사회 정기회의는 매년 2회 소집한다. 이사회는 공사의 최고 지도기관으로 양국정부가 각각 파견하는 이사 6인으로 구성하며, 이사 중에서 이사장과 부이사장 각 1명 선출. 이사장과 부이사장은 양국 이사가 교대로 담임하되 3년에 한번 교체한다.
제 5조 (이사회 운영)	이사회 회의는 협의정신에 근거하여 이사회 권한에 속하는 모든 문제들을 토의·해결하며 어느 일방이 반대하는 결의는 통과시킬 수 없다.
제 6조 (발전소 운영)	南·北 황강댐 수상태양광발전소에서 생산하는 전력은 원칙적으로 北 정부가 소유 분배한다.
제 7조 (발전소 운영)	北 정부는 수상태양광 발전소에서 생산되는 전력에 상용하는 전수비 ¹⁾ 발전수량을 납축 하류 하천으로 공급하고 南 정부는 이를 공유하천 하류의 이·치수에 활용한다.
제 8조 (발전소 운영)	발전소에 소속되는 발전·송전·배전설비 등 일체 시설의 유지보수는 南·北 양국이 공동관리 한다.
제 9조 (발전소 운영)	저수지의 홍수조절, 저수 등 종합적 기능을 발휘하고, 임진강 하류의 무단방류로 인한 南측 주민의 안전을 보장하기 위하여 양국 정부는 저수지 운영규정을 합의하여 위원회에서 운영하도록 한다.
제 10조	南·北 양국은 상호 합의하여 본 협정과 부소 문건을 수정/보완할 수 있다.
제 11조	본 협정은 20**년 *월 *일부터 효력을 발생한다.
대한민국 정부 전권대표	조선민주주의인민공화국 정부 전권대표

Table 3 Agreement for Hwanggang Dam Floating Photovoltaic Power (proposal)

B. (Proposal) In the economic point of view

a. The result of economic analysis for 40 MW capacity

In order to maintain the sustainability of inter-Korean water cooperation projects, the economic feasibility of the Hwanggang Dam water conditional heating project should also be considered. Using the Hwanggang Dam optimal design, the site capacity and site research and the optimal capacity of the power plant were estimated. Based on this, an economic analysis of the business should be carried out. The main independent variables of a water-state power plant optimal design are as follows.

(Solar radiation quantity per unit area per day [kWh / m² / day]) One of the most important dependent variables in the optimal design of solar power plants is the solar radiation. It is available from the Resource Map of Korea Institute of Energy Research (KIER). However, as with all North Korean data, the Hwanggang Dam data is not available, so an alternative is needed. Therefore, the data of Yeoncheon Gun Jung myeon (longitude: 126 degrees 59 minutes 27 seconds, latitude: 28 degrees 10 minutes and 21 seconds) which located in South Korea nearest Hwanggang Dam can be used as an alternative. This is because, as in all North Korea data precedent studies, there is a problem in reliability, but it is considered that a more accurate review can be made later when effective data can be acquired later such as unification.



Figure 10 Replacement point of Hwanggang Dam's solar radiation quantity (Yeoncheon-gun, Gyeonggi province), Source KIER Resource Mapping System]

(Water level) Depending on the water level of the reservoir, the floating photovoltaic power plant facilities are moving, so it is necessary to consider the equipment Damage due to the water level drop, such as drought. Therefore, it is necessary to select the place more than 5m higher than the low water level of Dam. In addition, locations where the ground is exposed at low levels should also be avoided.

For the proper development of the Hwanggang Dam, the review should be

based on the data of the Hwanggang Dam's Sedimentation Survey Report. However, this also requires an alternative because there is no report on the available Hwanggang Dam's Sedimentation Survey Report in North Korea. The following figure shows the satellite images of the Hwanggang Dam reservoir before and after 2015 in KBS News. As you can see in the photo, indirect development reviews can be made to areas other than the areas where the ground is exposed due to the drop in water level (red).

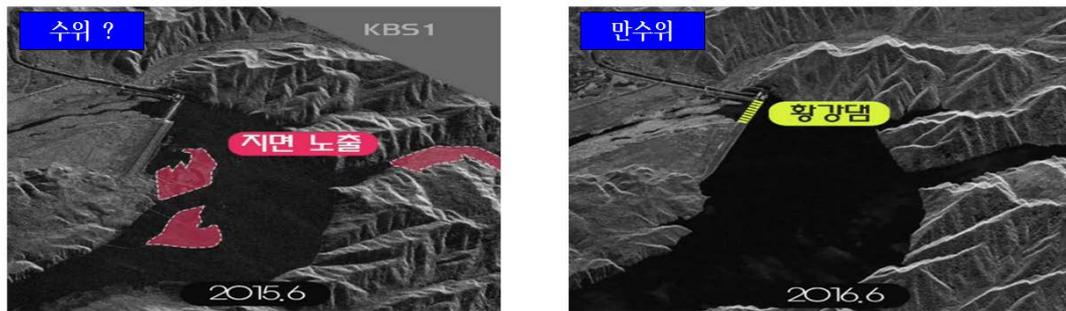


Figure 11 Satellite picture of Low Water Level(left), High Water Level(right)

(Water intake facility) Water intake facility: The water intake facility should not be installed in the Protection Area of Source Water and the water intake which located in the 15Km upstream and 1Km downstream.

(Power system) It is selected as the place where the grid connection of the distribution line and transmission line is easy.

(Selection of power generation capacity) selected based on the population of Icheon-gun, North Gyeonggi Province, near Hwanggang Dam.

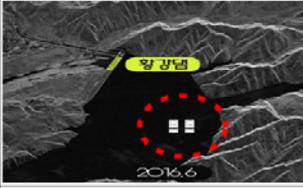
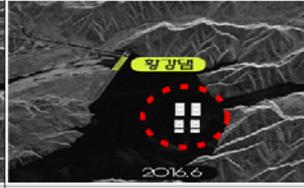
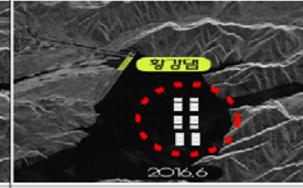
구분	년간 10,000 명 ¹⁾ 전력소모량 규모	년간 20,000 명 전력소모량 규모	년간 40,000 명 전력소모량 규모
규모	북한 강원도 (이천군 + 철원군) 인구의 약 5.5 %	황해북도 (토산군+개성시+장풍군) 인구의 약 10 %	황해북도 (토산군+개성시+장풍군) 인구의 약 20 %
용량	10 MW	20 MW	40 MW
설치 위치 (예상)			
개략 사업비 선정	283억원 ²⁾ + 알파 (접속설비비 포함)	560억원 + 알파 (접속설비비 포함)	1,130억원 + 알파 (접속설비비 포함)

Figure 12 Capacity comparison³

The economic analysis results for the facility capacity of 10 MW are as follows.

- Capacity : 40 MW standard *
- Annual Energy Production : 50,818 MWh (14.50% utilization rate)
- Economic Analysis

(Unit : Million Won)

Total Cost	Benefit	Cost	Net Benefit	B/C	IRR(%)
113,000	123,092	135,979	-12,887	0.91	3.15

* K-water 신재생에너지사업 재무성분석 가이드라인(에너지처-2810, '16.07) 참조

※ Annual Energy Production(kWh) = Capacity(kW) × Utilization(%) × 24h × 365일

$$\Rightarrow \text{Utilization ration (\%)} = \frac{3.47^{1)} \text{ kWh/m}^2/\text{day}}{24\text{h/day} \times 1\text{kW/m}^2} \times 75.2\%^{2)} \times 121\%^{3)} \times 110.24\%^{4)}$$

1) Average annual solar radiation quantity : 3.47 kWh/m²/day(cite : KIER, YeonChon-Gun)

2) PV Design coefficient : 75.2%

3) Slop(30 degree) solar radiation quantity : 121% of the horizontal plane

4) Increase efficiency of floating PV : 110.24% of the Land PV

Table 4 Equation of Annual Energy Production

³ 전력소모량 : 2012년 OECD 전력보고서 기준, 1인당 연간 평균 전력사용량 1,278 KW / year 참고

※ 공사비 : 2,732천원/KW ⇨ 2016 K-water 충주댐 청풍호, 수어댐 수상태양광 투자심사 평균 공사비

※ 계통연계 : 1억원/Km ⇨ 22.9 KV 가공선로 한전 표준건설비

The Second, it is important to consider the economic value of water in terms of economy. As mentioned earlier, the core of the project is South Korea's facility investment in North Korea, while North Korea discharge water from the Hwanggang Dam downstream of the Imjin River. Because of the watershed change in the North, about 900 million cubic meters of water which must be flowed to the Imjin River in the south, is being sent to the Ye Sung River. At this time, the economic value of the water flowing back to the south of the Imjin River by the Water-Energy Trade shows the quantitative value of measurable water as well as the effect of water quality improvement and ecosystem protection. Furthermore, this water cooperation will strengthen the trust between the two Koreas and lead to the détente of the DMZ. We have to know that the social value of this water is very large.

- 경제성 분석의 수익(Benefit) 측면
 - 전력생산량에 상응하는 물을 남한에서 받을 때의 **물의 사회적 가치**
 - (1) 정량적 가치 : 수질 개선비용 절감 등의 측정 가능한 물의 사회적 가치
 - (2) 정성적 가치 : 수자원 협력으로 남북신뢰가 형성되고 휴전선 대치 지역에 긴장완화를 이끌어 낼 수 있는 매개체로의 사회적 가치 역시 큰 비중을 차지
- 북한 핵문제 해결 후 남북간 **교류협력이 활성화 되는 시점에 실효 DATA 취득 가능**

Figure 13 Social Value of Water

C. Government - there is a sufficient executive ability between the two Koreas in shared rivers

Considering the balanced development aspect of the country and the area adjacent to the metropolitan area, the Imjin River basin is a region with a high potential for water resources development. However, the biggest problem in inter - Korean shared water - energy cooperation project is the political environment. Over the past few years, the situation on the Korean peninsula has continued to be sanctioned by the international community because of the North Korean nuclear test

and missile launches. Fortunately, however, after the South-North Korean summit and the North-US summit, the denuclearization of the Korean peninsula and the declaration of the end of the war are being discussed, and the international sentiment on the Korean peninsula is likely to change into a reconciliatory mood. Also, considering the follow-up of high-level talks and practical contacts after the inter-Korean summit, it seems that there is a sufficient executive ability between the two Koreas in shared rivers.

D. K-water - Establish foundation for entering of North Korea's water resources business

I think this study can give K-water some help. First, thanks to pre-emptive technology exchange, it can take a favorable position to preoccupy the business for the modernization project of North Korea's water resources facilities after unification. This will be a preliminary study that will provide a basis for entering the water resource business in North Korea. Second, it is also expected to be used as one of the implementation tasks of 'North Korea Hydroelectric Power Plant's Modernization Project M / P (K-water, 2017)'.

5. Limitations of the Proposed Research

One of the things that I missed while studying this project is the fact that it has not been examined more effectively due to the specificity of North Korean business and the limitation of information access. In particular, it was very difficult to obtain data on North-China hydroelectric companies. In order to increase the reliability of the research, experts' articles were mainly used. If the inter - Korean relations enter the dialogue mode after the inflationary period and the reciprocal

technology exchange begins, additional and effective empirical studies will be possible.

6. Conclusion

The key to researching operational management methods in shared rivers between North and South Korea is to conduct institutional and economic analysis on cooperative projects that are intermediaries. I think this will help to ensure the rationality of the project and help to shape the governance of the Cooperation Committee that both Koreas can accommodate. So, in this study, three solutions are suggested.

First, Institutional point of view about Joint Water Management Committee's Structure, we have examined limitations and problems of the existing water related inter-Korean Agreement. We also reviewed the best practices of resolving overseas shared river conflicts and examined the characteristics of benchmarking in the organization of the Joint Management Committee on the Korean Peninsula. Considering the special political situation, tense mode, and international sanctions conditions of the two Koreas, it is true that it is difficult for the delegation and the environmental groups to participate independently, like as the cases of East and West Germany. However, as can be seen from the case of the Elbe River and the Rhine River International Commission in Germany, the Korean peninsula should first formulate laws and guidelines related to the water resources of the Korean peninsula. And I think it is desirable to operate sustainable water resources management through the Joint Management Committee, which is a permanent organization, on the river basin scale. Among the organizations of the

Inter-Korean Joint Management Committee, the General Assembly and the Coordination Committee, which are the highest-level policy organizations, consist of three members each from the North and the South, and will be advised by the Strategic Group. The secretariat of the committee, which is a permanent organization, has four expert groups: the Water Energy Group, the Flood Group, the Water Pollutant Discharge Group and the Ecology Expert Group. In addition, the composition of the expert group is considered to be governance by participating in local governments, delegates from local residents, and NGOs.

Second, Institutional point of view about Hwanggang Dam Photovoltaic Cooperation Project Agreement, This study established the Joint Management Division of Inter-Korean Water Resources under the Joint Management Committee of the Inter-Korean of the New Government's Top 100 National Agenda, and set up the Hwanggang Dam Water Status Cooperation Project (tentative name) as a medium of Water-Energy Trade cooperation. One of the most notable points is water trade with floating photovoltaic power plant at the Hwang gang Dam. South Korea will invest to construct floating photovoltaic power plant on the reservoirs of Hwang gang Dam and it will supply electricity to North Korea. Instead, South Korea will be able to receive the flow to the Imjin River basin corresponding to the electricity generated by the floating photovoltaic power plant.

The composition of the inter-Korean Joint Management Committee was based on the Articles of Association of the China-North Korea Hydroelectric Company. It consists of six directors dispatched by the two governments in accordance with the principle of equality, and president and vice president are

elected among the directors. The president and vice president should alternate between the two directors, but it is reasonable to replace them once every three years. The Hwanggang Dam floating photovoltaic power plant's board of directors will lead and supervise the power plants on behalf of the governments of the two Koreas. The Board of Directors shall discuss and resolve all matters pertaining to the Board's authority based on the spirit of consultation. It was considered that the committee should be operated as a cooperation project that both Koreas can accommodate. This Agreement, in accordance with the International River Law, proposed the following Hwanggang Dam Photovoltaic Cooperation Project Agreement regarding the institution, organization and operation sector considering the specificity of inter-Korean relations.

Last, economic point of view about Water-Energy Trade Cooperation, In order to maintain the sustainability of inter-Korean water cooperation projects, the economic feasibility of the Hwanggang Dam water conditional heating project should also be considered. And economic analysis results of this study has good economy feasibility as follows. Capacity 40 MW, Annual Energy Production 50,818 MWh (14.50% utilization rate), Economic Analysis B/C 0.91, IRR(%) 3.15 etc.

It is also important to consider the economic value of water in terms of economy. As mentioned earlier, the core of the project is South Korea's facility investment in North Korea, while North Korea discharge water from the Hwanggang Dam downstream of the Imjin River. Because of the watershed change in the North, about 900 million cubic meters of water which must be flowed to the Imjin River in the south, is being sent to the Ye Sung River. At this time, the economic value of the

water flowing back to the south of the Imjin River by the Water-Energy Trade shows the quantitative value of measurable water as well as the effect of water quality improvement and ecosystem protection. Furthermore, this water cooperation will strengthen the trust between the two Koreas and lead to the détente of the DMZ. We have to know that the social value of this water is very large.

Finally, we must bear in mind that when East Germany-West Germany before the unification had a conflict in the river shared by the Elbe River, the problem was resolved in the center of West Germany. This means that South Korea is a downstream shared river country and should be considered to be a better developed country than North Korea. West Germany continued to provide economic incentives to the East Germany, bringing East Germany into the field of dialogue, and the long-established trust was the key to solving the problem. Even if the cooperation project for Hwanggang Dam has not economic feasibility(B/C), we have to provide technical and economic incentives to North Korea preemptively, which will lead to dialogue for river management and economic community formation. I want to emphasize that it is more important than economic value.

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