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National Water Resources Planning in Korea: Experiences and Perspectives

1. Introduction

The limitations of the water resource policy used in Korea since the 1960's are now surfacing. Although water demand continues to increase, the development of water supply by traditional methods has become politically and socially difficult to sustain. As a result, the discrepancy between supply and demand is beginning to appear, and disputes concerning preferential allocation of limited water resources are occurring. To add to the problems, Korea has endured three years of drought from 1993 to 1996 and three years of floods from 1996 to 1999. If the multipurpose dams and their flood control function is opposed due to extreme floods, and prior methods of flood control are used, the possibility of abandoning usable water supply from the dams must be faced. This manuscript presents the difficult state of the water resource policy in Korea and explores the alternative proposals to deal with this sensitive issue.

2. Rainfall Fluctuation

Rainfall is the principle variable that determines the water resources of Korea. The supply and demand of water resources is very sensitive to small fluctuations in rainfall. Evapotranspiration account for approximately half (depending on the watershed and an average of 45%) of the water loss. The remaining water volume is available for human use. However, the amount of evapotranspiration is less sensitively affected by the amount of rainfall so a small fluctuation in precipitation can drastically affect the amount of water available for use. For example, if rainfall decreases by 30% from average annual precipitation, the amount of water available for use decreases by 60% since the amount of evapotranspiration remains relatively constant. Consequently, the water resource supply is affected significantly by rainfall fluctuation.

Large differences exist in annual rainfall in Korea. When one of the world's longest annual rainfall record from Seoul of 213 years from 1770 to 1990 is examined, the large fluctuations are apparent (Kim et al., 1993). Since the standard deviation of the annual precipitation accounts for 31% of the mean, 95% confidence lower limit is 1.65 times of 31%, 51% less than the mean. To satisfy water usage demand with 95% confidence level, the supply volume must be guaranteed with approximately 50% of an average annual rainfall. As described before, approximately half of the rainfall in Korea is lost to evapotranspiration. The amount of water lost to evapotranspiration is assumed to not be affected by rainfall volume and as a result, if rainfall decreases by half, the amount of water available for use would be decreased by 1/4. As a result, in Korea, a reservoir capable of storing rainfall over a long period of time is needed. In other words, to ensure water supply, Korea needs to maintain at least one years supply of usable water.

Table 1. Characteristics of Annual Rainfall Data from Seoul

Period of Data Collection	Years of Continuous Data Collection	Average Rainfall	Standard Deviation	Maximum Annual Rainfall (Year)	Minimum Annual Rainfall (Year)
1770-1990	213	1216mm	376mm	2582 mm	370 mm

				(1821)	(1901)

The representative water resource supply, the multi-purpose dams of Korea, currently operate under the standards established during the drought from 1967 to 1968. Also, the national water resources plan (Korean Ministry of Construction and Transportation, 1996) established after 1985 follow the standards developed from the 1967-68 drought. Most of the large scale water resource projects developed in the 1970s used the criteria set from the 1967-68 drought because the data were readily available and the experience of the drought were fresh in the mind of the developers. However, as Figure 1 clearly shows, the drought of 1967-68 is far from an extreme drought. Korea experienced an extreme drought in the early 1900s from 1884 to 1910, a period of 27 years. For 27 years, the average rainfall did not exceed 70% of the average annual rainfall for the 213 years recorded. As a result of the drought period, insurrections and extreme social unrest occurred and even the Korean monarchy crumbled. Even the drought of 1939, although not as severe as the drought from 1884-1910, had much lower rainfall and lower river flow than during the drought of 1967-68. When the river water level during the 1939 drought period is observed, most of the rivers in Korea had relatively low flow even during flooding season.

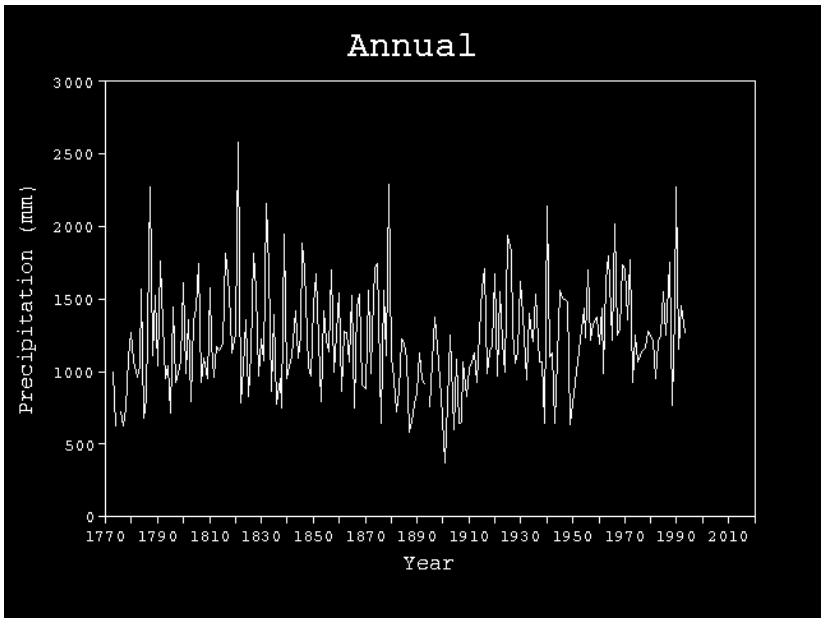

Figure 1. Annual Rainfall Recorded in Seoul.

The 1967-68 drought condition standard used to establish the water resource policy for usable water supply does not sufficiently reflect Korea's drought characteristics. This policy was established considering the insufficient financial conditions of the 1970s. In addition, this policy, created for a population of 20 million Seoul Metropolitan people, is insufficient to provide usable water supply for the current population. This fact is the most serious problem facing Korea's water resource policy.

3. Usage of Renewable Water Resources

The water available for use is the quantity that remains after evapotranspiration. If more than the remaining amount is used, whether from groundwater or surface water, the ultimate result is the drying up of water resources. As a result, the usable water quantity is referred to as renewable water resources and is used as an index to represents water scarcity of a country. In

Korea, the national water resources plan states the renewable water sources to be 69.7 billion m^3/year. When the volume is divided by the population, the total annual volume available for use per person is 1,546 m^3. United Nations Economic and Social Commission for Asia and the Pacific (1992) estimated for 26 countries in Asia the average available annual water to be 4,143 m^3. The water available to Koreans is only 37% of the average for Asia.. Among the 26 surveyed counties in Asia, the only two nations below 2,000 m^3 are Korea and Singapore. Excluding Singapore, Korea is considered as the country with the most serious water shortage problem in Asia and the Pacific. National Geographic magazine from October 1998 also showed the available water resources for countries around the world. Unfortunately, excluding the desert countries of western Asia, Korea was shown to be the country with a serious water shortage problem.

Korea's heavy water use contributes to the water shortage problems. According to the national water resources plan from the Ministry of Construction, Korea uses 30.1 billion m^3 of the 69.7 billion m^3 available for use annually. Because 6.4 billion m^3 is used for in-stream flow, the actual water use becomes 23.7 billion m^3. Accordingly, approximately 34% (23.7/69.7) of the renewable water resources are being used currently. United Nations Department for Policy Coordination and Sustainable Development (1997) used this percentage to determine the "water stress" of a nation. Water usage under 10% does not result in water stress. Water usage between 10-20% is considered normal. Water usage between 20-40% results in water stress above normal and requires intensive management of supply and demand. If water usage percentage rises above 40%, a serious water shortage problem may result. In this scenario, water resources depend more and more on depleting groundwater and desalinization. Accordingly, to manage supply and demand, a special plan is needed. Water usage above 40% could be not sustainable and the water shortage may work to limit essential economic progress. The average water use is 34% in Korea and as a result, an asserted effort to regulate supply and demand is needed. It is important to keep in mind that 34% is only an average and in some watersheds, the water usage percentage far exceeds the 40% limit. In most of these watersheds, the environmental quality continues to degrade.

As mentioned before, the water resource problems facing Korea stem from the fact that the available usable water is at the level of a water famine country. Water use is high with 34.7% of the renewable water resources being used. Without a decrease in water use, such a high percentage of water use makes the management of a sustainable water resource very difficult. Also, the shortage of water supply limits economical development. Especially in the areas where water usage exceeds 40%, the continual use without constructive water saving measures through resource management will result in worsening degradation of water resources and environment.

4. Extreme Floods

In the last 10 years, Korea has experienced large-scale floods never recorded before. In 1987, a large flood in the Kum river watershed caused 1 trillion won (about two billion US dollars) worth of property damage. In 1990, an intense rainfall recording 400mm in the southern Han river basin caused break of levee near Seoul and resulted in a large flood. In 1996 at the Hantan river basin, a concentrated rainfall measuring over 600mm overwhelmed the Yonchun dam's flood control volume and flooded the downstream region. Shortly thereafter, the dam collapsed. In August 1998, a surprising record rainfall fell across Korea. As a result, in the Chiri mountain range, flash floods occurred, a reservoir in Kangwha-do collapsed, and in Chungrang stream and mid-and-small river basins, property damage as well as loss of lives occurred. In 1999 at the Imjin river basin, a rainfall event over 700mm

destroyed Yunchun dam once again, and caused severe flood damage in Moonsan and Yunchun.

The recent flood damage can be attributed to the change in rainfall characteristics. It is worth noting that rain events in 1998 broke the old records, such as the 118.6mm rainfall in one hour in Seoul. In one year, all the rainfall records were broken.

As stated before, the serious problem Korean water resources policy faces today is how to counteract the extreme floods. The recent flood events are new conditions never dealt with before. Accordingly, the construction methods established during different circumstances are no longer effective. Extreme rainfall events have increased compared to before and as a result, flood policy has also increased. In contrast, the flood control ability of multi-purpose dams have declined. Questions about the effectiveness of flood control facility properties such as flood frequency, safety factors, and clearance are beginning to arise. Questions are also arising about the flood control ability of multi-purpose dams. To maintain the flood prevention level like before, the flood control volume must be increased and the water supply volume must be decreased.

5. Alternative Proposal

Korea's water resource policy needs to be revised. The current policy focused on water supply needs to be changed to a policy that focuses on the management of water resources as a priority. This shift in policy does not mean the abandonment of water resource development. The conversion to a policy of management should consider water supply guarantee, flood safety guarantee, and the improvement of the environment as priorities.

The Creation of Maximum Limit of Water Use

To advance a stable usable water supply policy, Korea must first determine the Limit of maximum water use. The limit of maximum water use is the actual maximum water use and does not indicate potential capacity nor supply volume. The principle on which water resource development in Korea has been based on is the unavoidable increase and development of water resources due to increase in population, industries, and standard of living. However, this type of policy logic is now facing limitations because increasing dependence on surface waters for water supply. Korea is already using large quantities of the available surface water. Approximately 34.7% of the river flow is being used for water resource use. This approximation is the average for the nation and if Seomjin and Han rivers are excluded, the percentage increases. The United Nations' Committee on Sustainable Development report warns that if water use surpasses 40%, continual sustainable management of water resources becomes difficult. If Korea's usage is considered to be greater than 40%, the continual water use increase may not be the most economic policy from the country's environmental preservation point of view. The continuous management of water resources requires establishing the limit of maximum water use.

Guarantee of Stable Water Supply

Korea uses the drought from 1967 to 1968 as the reference to calculate water supply plan. However, when the supply plan is appraised, the weakness of the plan can be seen. Although the reference drought of 1967 and 1968 was nation-wide, there was considerable variability among the various regions. The Nakdong river basin suffered severe drought while the drought in the Han river was not as severe. As a result, the planned water supply volume, as well as supply guarantee, according to the current plan are not stable for each region and

may result in social unrest during extended periods of drought. It is commonly known that the United States, Australia, Africa, and Japan have suffered intense droughts from climate anomalies. From the Korean perspective, our country has experienced 27 years of severe drought around 1900 and consequently, the stability of water supply guarantee is critical. The method used currently was applied when the economy was weak, urban population was low, and failure of water supply did not result in large economic loss. Now, the failure of water supply and its effect on the economy as well as the society cannot be compared to the past. As a result, a national plan to guarantee water supply needs to be advanced. The first step must be to raise the efficiency of water resource management and if needed, develop new water resources to improve water supply. Korea should not overlook the history of extreme droughts and the existence of a large population in a relatively small country.

Living with Floods

1999 brought record floods like in 1996 and 1998. Luckily, the floods concentrated in the Imjin river basin and not in the Han River basin and the capital, Seoul, was not in danger. However, if the flooding had concentrated in the upper Han River basin, there was potential for national danger. As the recent extreme flood event demonstrated, Korea's flood defense ability is progressively getting weaker. This is because the flood defense ability is based on a premise that statistical characteristics do not change over time: a premise that is becoming less credible. However, to accomplish the national objective of improving quality of life, it is necessary to protect the nation and its citizens from floods. To do this, Korea must advance the flood defense level. However, due to climate anomalies, the nation's flood defense ability is deteriorating. A new paradigm of flood management is needed. The floods experienced recently are events that have never been experienced before. Accordingly, the design plans from the past may no longer be effective. Compared to before, the increase in rainfall amount has resulted in an increase in flood plans and a decrease in the ability of multi-purpose dams to control floods. Design components for flood control such as flood frequencies, safety level, freeboard and others need to be revised.

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