WATER RESOURCE SUPPLIES AND EFFICIENT UTILIZATION FOR BIOPRODUCTION AND THE ROLE OF AGRO-ENVIRONMENTAL EDUCATION IN KOREA

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INTRODUCTION

The Republic of Korea (Korea) like many countries in the Asia-Pacific Regions has faced continuing challenges for securing more water resources and efficiently utilizing them for sustainable bioproduction. In 1998, the total amount of water being used for agriculture was estimated to be 15.8 billion m^3, or 48 percent of the total uses (MOCT, 2001). The agricultural water uses have been increased during the past three decades of the economic development at such a remarkably rapid rate that the water uses now are 3.5 times greater than that in 1965. Most of the agricultural water is used for paddy irrigation for rice, the stable food of Korea, and water demands for vegetable cropping and other bioproduction are also increasing.

It is reported that nearly 45% of Korea renewable water resources are now in use, in a level that sustainable water resource development is no longer possible without significantly deteriorating ecosystems. Efforts should be made to control water demands and to utilize the valuable resources more efficiently in all sectors. It is no exception for agriculture; water saving efforts should be made by improving irrigation efficiencies or by any other means..

This paper presents the current status of water resource development and water conservation efforts in agricultural sectors. Results from a recent case study will be presented to pinpoint issues of efficient agricultural water uses. It will be followed by presenting possible roles of educations, research and development for utilizing water more competently.

LAND AND WATER RESOURCES

Cultivated Lands

The total area of Korea is 99,373 km^2, and about 64% of the land is mountainous, leaving little land resources. As of 2003, the cultivated land is 18.5 thousand km^2, among which 11.27 thousand km^2 or 61% is paddy field and the rest 7.19 thousand km^2, upland, orchards, and other farm lands.

Precipitation

The annual precipitation of Korea is 1,276 mm in the part of the Korean Peninsula, and 1,283mm when the Jeju Island is included. It fluctuates considerably from year to year. During the past 94 years, the recorded minimum annual precipitation was 754 mm in 1939 and the maximum was 1,782mm in 1998. Annual precipitation tends to increase recently and so does the variability (MOCT, 2001).

Uneven distributions and great fluctuations of monthly precipitation are the features of our water resources. During the monsoon and typhoon seasons from June to September, nearly the two-third of annual precipitation (65.7%) is recorded. Mean monthly precipitation other than the four months is 58.3mm, and rain-fed farming may be vulnerable to drought damages.

Water Resources

Figure 1 summarizes the availability and use of Korea water resources (MOCT, 2001). The total annual water resources are 127.6 billion m^3. The renewable water resources which are defined to be the available water minus evapotranspiration losses are 73.1 billion m^3 or 57 % of the total. The total annual water uses were estimated to be 33.1 billion m^3, or 45 percent of the renewable water. The water demands are balanced by the supply from streamflow (48.6%), reservoirs and dams (40.2%), and groundwater (11.2%). The water demands will be increased, and the water shortage up to 1.8 billion m^3 (5.4 % of present water uses) is expected by 2011 even after substantial water saving efforts are put into practice (MOCT, 2001).

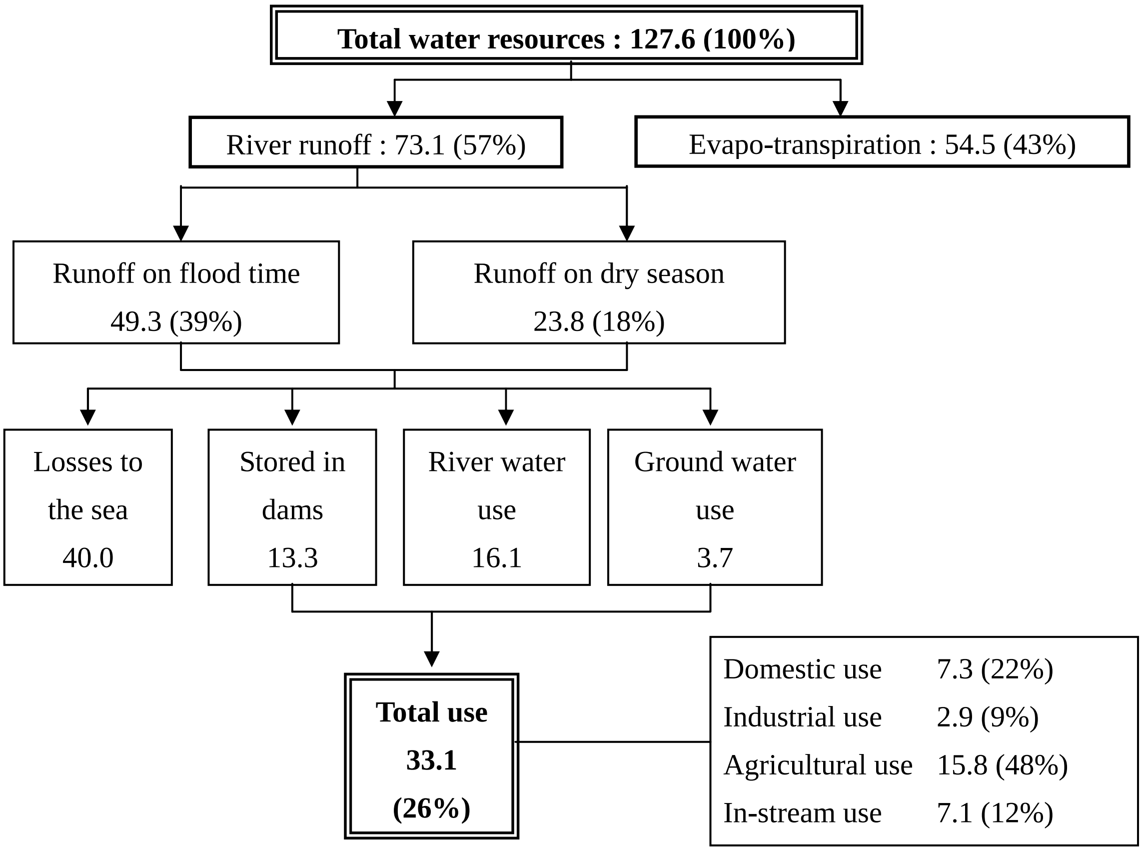

Figure 1 Annual average water resources in Korea.

AGRICULTURAL WATER USES

Irrigation Development

The Korea government has made great efforts to continuously develop irrigation water resources for ensuring stable rice production. A total of 8.8 thousand km^2 of paddy was converted to the irrigated areas, as of the end of 2002, which accounted 77%

of the total paddy fields (Table 1). The rest 2.58 thousand km^2 of paddy fields remains to be rain-fed areas. However, about 49 % of the irrigated paddy field is subject to possible damages from 10-year recurrence drought because of insufficient water resources. More than half of existing irrigation reservoirs were built before 1945, and many are filled with too much silt to function properly. The half (49%) of the pumping stations are older than 20 years, and irrigation facilities are also deteriorated.

Table 1 Irrigated Paddy Field Areas in Korea (as of the end of 2002).

Year	Total Paddy Field (10^3 ha)	Irrigated Paddy Field Area (10^3 ha)	Partially Irrigated Paddy Field (10^3 ha)	Percentage of Irrigated Paddy Field (%)
1970	1,284	745	No data	58.0
1980	1,307	893	No data	68.4
1990	1,345	988	357	73.4
2002	1,138	880	258	77.3

Integrated Water Management

Significant changes in irrigation practices have been taken place in recent years. Conventional paddy irrigation during growing seasons is being changed to year-round water supplies for the bioproduction. The peak water supply period for paddy fields has been shortened due to the mechanized rice transplanting. Water demands in rural regions increase with more acreage of irrigated vegetable crop planting. And the manual on-farm irrigation management is not well carried out as aging farmers become the majority.

To cope with the changing irrigation practices, Ministry of Agriculture and Forestry (MAF) has encouraged and supported financially many water saving efforts like 1) the maximization of water utilization, 2) the direct seeding of rice on paddy, 3) the repair and reinforcement of existing dams and canals, and 4) the installation of telemetering (TM) and telecontrol (TC) instrumentation systems, 5) the networking of adjacent water resources, and 6) the automation of on-farm water management for large irrigation districts of 3 km^2 or more.

A pilot study on the TM/TC and the centralized integrated irrigation management systems at the Seongju district (having 3,530 ha of irrigation areas) has shown that significant water saving has been achieved through better irrigation scheduling and more uniform water distribution. The saved water is now being used to irrigate additional areas outside of the original district, and to be taken for domestic water supply. The cost of the integrated water management system has been paid off from the water saving.

Institutional Aspects

Korea has dual institutional systems to operate and manage the irrigation facilities.

Korea Agricultural and Rural Infrastructure Corporation (KARICO) takes in charge of larger irrigation districts over 50ha of the duty areas, while local governments (city or county) manage small-size duty areas of 5 to 50 ha. KARICO was founded by consolidating regional independent Farmland Improvement Associations (FIA) and Agricultural Development Corporation (ADC), both of which were responsible for the operation and management of irrigation systems. Such institutional changes could help improve overall irrigation systems performance. No concrete findings, however, have been available to justify the institutional change.

Other Features of Irrigation Systems

The author (2001) reported that some features of Korea paddy irrigation systems are 1) small duty areas for each irrigation water resource, 2) not enough capacities of the water resources and aging problems of the delivery systems, 3) low irrigation efficiencies in conveyance and on-farm management, and 4) the water quality degradation in irrigation reservoirs. Some of those may be unique, and others are found everywhere throughout the world. Further discussions may also be found in references like MAF (2004).

ROLES OF EDUCATION AND RESEARCH

Education and Professional Development

Educational programs for irrigation are provided in agricultural high schools, junior colleges, and universities. And technical training and continuing professional education programs of various levels are offered to irrigation systems administrators, operators and managers. Professional engineer programs are also established to accredit irrigation engineering program.

Some technical high schools offer irrigation technical courses. High school graduates from those programs are eligible to become assistant technicians and, after due training, work as operators for irrigation facilities such as agricultural dams and pumping stations. There are three junior colleges which offer agricultural technology curricula. Several technical junior colleges also offer irrigation courses in civil engineering programs.

Eleven universities offer agricultural engineering (or soil and water major) curricula. All the universities offer graduate programs toward master and Ph.D degrees. College graduates are eligible to become qualified civil engineers accredited by an agency authorized by the Korea government. Professional engineer certificates in areas of irrigation are also issued by the agency to qualified engineers who have minimum six year careers in irrigation engineering, and pass qualification tests.

On-job training programs for irrigation system design, operation and management are currently offered by the Education and Training Center, KARICO. The short courses on pumping station operations and irrigation scheduling are developed for field operators. The Center also initiates a web-based self-training course for many field operators. Government Office Training Center, MAF also offers short courses for government employees.

It is clear that irrigation engineering curricula in higher educational programs play an important role of developing new technology for and promoting the efficient operation and management of irrigation systems. Professional career development programs offer opportunities for engineers in practice to learn new and advanced technologies for integrated irrigation system management.

Research and Development

Like in many engineering disciplines, research and development programs are important to the technical advances in irrigation engineering. For instance, integrated irrigation management systems based on TM/TC technology have been developed at universities and research institutes. Other recent achievements worth noting are: 1) Wastewater reuse researches to make use of reclaimed water from domestic sewer treatment plants (MOST, 2004), 2) field investigation of irrigation return flow (Im et al., 2002), 3) decision support systems for irrigation water management (MAF and RDC, 1999), and 4) multifunctionality of irrigated rice culture (MAF, 2002). Such roles should be appreciated and more R&D programs supported to ensure continuing efforts of efficient water utilization for bioproduction in Korea.

SUMMARY AND CONCLUSIONS

This paper presents the current status of the water resource supplies and utilization for agriculture and the roles of agro-environmental education in Korea. The water resources become a limiting factor for sustainable economic development as water withdrawal rates increase to a marginal level. The agricultural water uses have been increased by 3.5 times during the fast three decades. Yet, nearly one-quarter of paddy lands remain rain-fed, and irrigation water supply is needed for increasing bioproduction. Water conservation measures and rehabilitation of existing irrigation facilities are important to improve irrigation efficiencies at on-farm and irrigation district levels. Education and professional career development as well as research and development efforts have been proven to play important roles on the development of irrigation technology.

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