

우리나라의 농업용수에 대한 장기전망

National Water Vision for Sub-sector of the "Water for Food and Rural Development"

Summary

The agricultural water and farmland are two essential resources that should be conserved to ensure the sustainable agriculture and the sound rural society. The natural and socio-economic environments in Korea urgently require the conservation of agricultural and rural water in its quantity and quality.

The annual amount of total water consumption is estimated as 23.8%(30.1 billion m³) out of the total amount of annual water resources(126.7 billion m³) in Korea. Of this amount, 50%(14.9 billion m³) out of total consumption is used for agricultural production. Pollutants from point sources such as municipal sewage, industrial wastes and livestock wastes and from non-point sources such as fertilizers and pesticides applied over the agricultural system have deteriorated the quality of agricultural water. Its organic pollutant and highly concentrated nitrate and phosphorus known as the cause material for lake and reservoir eutrophication characterize contamination of agricultural water.

Four most significant national issues for the development and management of the water for food and rural development are identified as follows: The most significant issue is the development of agricultural and rural water resources under the spirit of environmentally sound and sustainable development. The construction of medium size multipurpose dams and irrigation reservoirs is recommended for supplying the increased water use. Enhancing existing reservoirs is advisable because of its fruitful merits. Linked operation of dams in a basin

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or transfer of water between different watershed areas is also the apparent method within some degree of limitations.

The second is water saving by a good water management and reasonable maintenance. The water saving is the most environmentally protective and sustainable conservation method for the sake of its advantages as well as its effectiveness on reducing the new construction needs to meet the increased water demand. The effective use of reservoir storage, water saving irrigation, construction of concrete canal, and water management by Telecontrol/Telemetry (TC/TM) system are therelevant methods fall into this category.

The third is protection of water from pollution. Watershed management is essential. Pollutant sources should be regulated by prohibiting the discharge of themselves. Fundamental environmental protection facilities must be broadened and enhanced. Water quality monitoring system should also be strengthened. Ground water should be conserved.

The fourth is the rearrangement of water management organizations and water laws. Many kinds of water laws must be unified and clarified. Two independent organizations for the agricultural and rural water development and for the management and maintenance of developed water, respectively, should be merged into one agency for more effective operation in the forthcoming 21st century.

1. Overview of National Policies and Development Plans

Korea is now being recognized as one of the most successful Asian countries in overcoming the recent economic peril. A strong and consistent policy mixed with fiscal and monetary policy instruments has been focused on increasing the efficiency of the whole economy and stabilizing the foreign exchange market. Several major macroeconomic indices, especially in the 1st quarter of 1999, show that Korea has remarkable potential for revitalizing its national economy. Although the world

economy is still stagnating because of the current recession of the advanced countries, Korean domestic business shows clear signs of recovery. According to recent studies performed by well-known research institutions, after the successful completion of the exchange management policy in 1998, the Korean economic growth rate is expected to increase by 2 to 5% in 1999, stimulated by aggregate demand. The current account surplus is expected to decrease due to revaluation but domestic consumption and investment will play a leading role in growth of the whole economy through the influence of low interest rates and affirmative expecta-

tions for economic recovery. Unemployment became one of the most urgent domestic problems during the recent peril. The unemployment rate is still tending toward increase but is expected to slow down from the second half of 1999. These expectations are strongly supported by the considerable rise in activity in capital and stock markets in the first half of 1999.

The recent economic situation has been the most severe crisis since 1960s. This economic peril was caused mainly by unfavorable domestic business environments including weakness of the financial market structure, fundamental weakness of the economic structure, and partly by the worldwide economic recession and lack of information on foreign financial markets. To cope with the economic crisis, the Korean government has proposed that IMF provides a rescue fund, and the IMF made US \$ 57 billion available in December 1997.

The agricultural sector was not excepted from the peril to the whole economy. The economic crisis led to a decrease in farm incomes because of high production costs, leading in turn, to an increase in farm debts for the individual farm household.

The new Government, launched in February 1998, has taken a series of countermeasures to overcome the economic crisis and thereby to revitalize the national economy. It was realized that restructuring the whole economy would be necessary and a deregulation of financial market would promote more efficient allocation of national resources and eventually improve the competitiveness of the financial

market. Increasing attention is being paid to encouraging new investment and creating employment simultaneously to cope with the recession and restructure the social safety net.

It is foreseen that within the agricultural sector in Korea in the 21st century the market will be open, and its competitiveness will be significantly developed. The government's agricultural policy would shift to a free open market system under the WTO system. As the world market for agricultural products is foreseen to be unstable due to the increasing world population and global climatic changes, there will be greater concern about food security for all. This was also noted at the World Food Summit held in November 1996. Internally, besides supplying agricultural products, non-trade concerns about agriculture and rural communities, such as food security, environmental protection and balanced regional development, which will not reflect in the market price, are expected to increase. As a result common interest in the economic and social safety nets would be widely expanded. A stable supply of agricultural products of high quality will be necessary due to the changes in consumer preferences in food products. Significant changes in the agricultural marketing system are also expected as technology develops in many areas. Nation- and region-specific farming will be accelerated in accordance with the development of world agricultural market system. A harmonious policy for the unification of South and North Korean agricultural sectors, which would contribute to a future unified

Korea, should be considered. These situations require continuous investment in the agricultural sector, but inefficient management of agricultural funds in the past becomes one of the problems, and therefore increasing investment efficiency and reforming the relevant organizations are strongly suggested.

Korea has a relatively high annual rainfall, which is 1.3 times of the world average. However, the average amount of rainfall per capita per annum is about one-ninth of the world average because of the high population density; this is the main reason for a possible water shortage. Large seasonal variations in rainfall frequently result in floods in the summer rainy season and drought in spring and winter. Korea also has difficulty in managing water resources because the amount of rainfall varies from region to region due to the varied geographical characteristics. A stable water supply for rice production is very important because rice is a staple food. Water resource development for agricultural needs therefore has priority among public investment plans.

Changes in farming patterns such as direct seeding for paddy rice and agricultural mechanization have led to increased demands for peak irrigation water. Value-adding efforts through crop diversification and high quality production have also increased needs for irrigation water. Moreover, urbanization and industrialization of rural areas require additional water demand for residential and industrial use.

Water contamination caused by residential, industrial, and livestock spills will make the water shortage problems worse in the 21st century. Water distribution will be a critical issue among the users, and the portion of agricultural users will decrease from its current majority.

In August 1996, the Korean government established the Committee for Water Resource Management and Policy under the Office of the Prime Minister (Chairman: the Prime Minister, members: ministers from the Agriculture and Forestry, Environment, and Construction and Transportation Ministries) to prepare a comprehensive plan for water resource management for the 21st century.

2. Present Status of Water

Korea has 1,274mm of average annual precipitation, which is estimated at 126.7 billion m³ of water in volume. Out of 126.7 billion m³ of water, 69.7 billion m³ discharges to rivers and streams showing a 55% runoff rate and 57 billion m³ evaporates or infiltrates as a direct loss. Total available surface and ground water is estimated at 47.2 billion m³ which includes 23.0 billion m³ of river flows during the non-flood season, 10.8 billion m³ of stored water in multipurpose dams and agricultural reservoirs and 13.4 billion m³ of ground water.

Water demand has been steadily increased for the last several decades due to the increase in population, irrigation area and industries, as well as the rapid expansion of urban areas. The water demand in 1994

amounted to about 30.1 billion m³ which comprises 6.2 billion m³ of municipal use, 2.6 billion m³ of industrial use, 14.9 billion m³ of agricultural use and 6.4 billion m³ of instream flow augmentation. Half of the total water demand came from agricultural use.

Approximately 32.5 billion m³ consisting of 17.2 billion m³ of river discharge, 2.6 billion m³ of ground water and 12.7 billion m³ of stored water in reservoirs were supplied in 1994. Total water supply slightly exceeded total water demand in that year.

The usable water potential is estimated at 83.1 billion m³. The water potential consists of 69.7 billion m³ of river discharge and 13.4 billion m³ of ground water.

Of the 69.7 billion m³ of surface water potential, about 27.5 billion m³ (17.2 billion m³ of river flows and 10.3 billion m³ of reservoir storage) is being used and the remaining 42.2 billion m³ is assumed to be the potential to be developed. Excluding 3.4 billion m³ of developed ground water (1997).

From the 13.4 billion m³ of total potential ground water. Therefore, the amount of water potential to be developed totals 53 billion m³, which are 42.2 billion m³ of surface water and 10.8 billion m³ of ground water.

According to the long-term plans for water resources development, approximately 5.1 billion m³ of surface water is scheduled to be developed by the end of 2011. The plan includes the construction of 28 multi-purpose dams with a storage capacity of 4.3 billion m³ and many agricultural dams with a total storage capacity of 0.8 billion m³. A

great number of small-scale ground water development projects will be executed by various sectors. However, water resources development has become more difficult in recent years due to an increase in construction and compensation costs, limited appropriate dam sites, and strong opposition from the inhabitants and environmental concerns.

About 18,000 agricultural dams together have 3.0 billion m³ of effective storage capacity and irrigate about 506 thousand ha of rice paddies. Most agricultural reservoirs have small storage capacities with less than one million m³ and only 377 reservoirs have more than one million m³ of effective storage capacity. The 35 existing large dams for hydro-electric power generation, municipal or industrial water supply and flood control have a total storage capacity of 13.5 billion m³ and effective storage of 9.3 billion m³. Seventeen large dams having a total storage capacity of 3.9 billion m³ are currently under construction.

Since approximately two-thirds of river water flows during the three months of the flood season, much of flood discharge flows directly into sea. Therefore, only 46.7 billion m³ from 69.7 billion m³ of river discharge can be considered available. River discharges show considerable variation from season to season. River's discharge remains low during dry season from October to June and runs high during the wet season from July to September. Monthly river runoff in billion m³ is measured at 1.5 (January), 1.6 (February), 2.6 (March), 4.8 (April), 4.2 (May), 5.1 (June),

11.5 (July), 12.9 (August), 9.9 (September), 3.3 (October), 2.3(November) and 1.5(December).

A total of 14.9 billion m³ of water for agricultural purpose is withdrawn from reservoirs(9.4 billion m³), pumping stations (2.7 billion m³), headworks(1.9 billion m³), tube-wells and other sources(0.9 billion m³). Most agricultural water is used for paddy rice and about 500 million m³ of water is applied for upland crops. The water for non-agricultural use amounted to 15.2 billion m³ which includes 6.2 billion m³ for municipal use(41%), 2.6 billion m³ for industrial use(17%) and 6.4 billion m³ for instream flow augmentation(42%).

In Korea, basin management to continue safe water supply mainly depends on the construction of multipurpose dams and agricultural dams as well as reforestation. The government is preparing an integrated basin management plan including water quantity and quality control in order to maintain a stable supply of clean and fresh water.

Used for domestic, industrial, agricultural and other purposes, total 3.4 billion m³ of ground water was mined from about 946 thousand wells in 1997. The ground water use consists of 1.6 billion m³(47.2%) for domestic use, 1.5 billion m³(43.9%) for agricultural use, 200 million m³(6.6%) for industrial use and 79 million m³(2.3%) for other uses. Domestic and agricultural uses of ground water cover about 91% of the total use. The use of ground water has sharply increased in recent years. Especially in coastal areas where main river systems do not pass nearby, ground water has

become a major water source.

Water pollution has accelerated since the 1970s and water quality improvement has become a major task in the 1990s. In order to monitor water quality, 1,698 water quality measuring stations are operated throughout the country: rivers (530), reservoirs (153), domestic water sources (589), agricultural water sources (300), and others (126).

Water quality measurements in BOD in the four major rivers in 1997 showed 4.1 mg/ℓ at Noryangjin in the Han River, 4.2 mg/ℓ at Mulgeum in the Nakdong River, 3.4 mg/ℓ at Buyeo in the Kuem River and 7.2 mg/ℓ at Najoo in the Yongsan River.

Ground water table drawdown and ground water contamination occurred in some areas and many small wells have been abandoned in urban areas.

Water pollution is caused mainly by domestic, industrial and livestock wastes. Domestic and industrial waste discharges amount 14.6 million m³ and 7.3 million m³ per day, respectively. A total of 398 wastewater treatment plants treat about 10 million m³ of waste discharge and many other plants are under construction or are planned. The basin areas, which produce water for domestic use, are protected by law such as the designation of streamside management zones, reserved forest and specified areas for the preservation of clean water.

Damages to crops by high salinity of irrigation water do not occur because irrigation water generally does not contain excessive salts and more than 1,000mm of yearly precipitation flushes salts in soils.

Efficiency of agricultural water use is reported to be 80~85% for rice irrigation and 60~85% for upland crop irrigation. The measure of efficiency in rice irrigation includes only seepage loss through canals while operational losses are not properly counted. Therefore, actual rice irrigation efficiency seems to be considerably lower than 80%.

Wastewater recycling is in an initial stage in Korea. At present 6 waste water recycling stations with a combined treatment capacity of 3.9 million m³ are being operated and other 6 stations with a treatment capacity of 23.2 million m³ are under construction.

Approximately 160 thousand m³ of seawater is desalinated at 16 stations for supplying drinking water, mostly on island areas.

The total volume of annual wastewater is estimated at 8.0 billion m³. About 45% (3.6 billion m³) is treated and the remaining 55% (4.4 billion m³) is discharged to rivers or reservoirs or seeps into ground water. The untreated wastewater is assumed to be the main source of water quality degradation. About 10 million m³ of wastewater per day such as domestic waste, livestock waste, industrial waste, and others is treated at some 282-treatment facilities. The number of treatment facilities has been increasing very rapidly in recent years.

3. Present Status of Food

The Republic of Korea had 99,373km² of national land in 1977, which included 64,413 km²(64.8%) of forest, 19,235km²(19.4%) of cultivated land, 2,822km²(2.8%) of rivers and

12,903km² of other types(13%). The average amount of cultivated land per capita was 0.042ha and the average farm household had 1.336ha including 0.808ha of rice paddy and 0.528ha of upland. The mountainous forest areas cover about two-thirds of the national land. The cultivated land is mainly composed of 7,607km² of uplands and 11,628km² of paddy fields. The uplands comprised 473km² of orchards and 511km² of pastures. The cultivated land and forest have been shown to bear a sharp decreasing trend since the 1980s by being converted into roads, houses, industrial sites and other purposes.

The cultivated land is utilized to grow food crops (1,314 thousand ha), vegetables (285 thousand ha), oil and cash crops (108 thousand ha), orchards (174 thousand ha), green house crops (92 thousand ha), some permanent crops (25 thousand ha), and other products (98 thousand ha).

A total of 2,096 thousand ha of yearly land use indicates a 107.8% land use rate by growing two or three crops on some parts of the cultivated land. The cultivated areas for food crops cover rice (1,052 thousand ha), barley and wheat (70 thousand ha), miscellaneous grains (30 thousand ha), pulses (122 thousand ha) and potatoes (40 thousand ha).

The climatic conditions in Korea allow one harvest of most crops except some vegetables and feed crops. The agricultural productivity of major crops is relatively high with high inputs of fertilizers and chemicals, applying advanced farming skills, intensive extension

and farm mechanization. The yields of paddy rice, barley, wheat, potato, maize and pulse in 1997 recorded 6,950kg, 3,820kg, 4,040kg, 5,000kg, 4,110kg and 1,570kg per ha, respectively.

The yield of rice in Korea is the highest among all the food crops and indicates a high level in the world as well. Chinese cabbage is the most widely grown among the vegetables and yields 65,210kg per ha each season. Apples are one of the major fruits and harvests are 16,300kg per ha.

The production of major crops in 1997 were 5,449,561 tons of rice; 195,495 tons barley and wheat, 218,369 tons of potatoes, 97,402 tons of miscellaneous grains, 181,738 tons of pulses, 588,686 tons of vegetables, 2,451,653 tons of fruits and 33,393 tons of cash crops.

Rice, a staple food in Korea, was grown in more than half of the total cultivated land. In southern part of Korea barley and wheat were grown as second crops in rice paddies after harvesting the rice in November until the early 1980s. However, imported barley and wheat have replaced domestic products and nowadays only a small number of farmers grow these for their family's consumption.

The number of livestock and poultry in 1997 comprised 2,785,000 native beef cattle, 544,000 dairy cattle, 7,652 horses, 7,096,000 pigs, 1,455 sheep, 127,826 deer, 603,905 goats, 197,197 rabbits, 88,251,000 chickens, 2,709,000 ducks, etc.

Cattle, chickens and pigs are major meat products in Korea. The numbers of native beef cattle, pigs and chickens had sharply increased during the five years from 1992 to

1997. During that period, native beef cattle increased by 38% from 2,019,000 heads to 2,785,000 heads, pigs increased 30% from 5,463,000 heads to 7,096,000 heads and chickens increased 20% from 73,324,000 heads to 88,251,000 heads.

The numbers of livestock and poultry farms were sharply reduced during the same period. Native beef cattle ranches were reduced by 21% from 585,000 to 465,000, pig farms reduced by 72.5% from 99,000 to 27,100 and chicken farms reduced by 14% 188,000 to 162,000. The reduction of livestock and poultry farms and increase in numbers of livestock mean an increase of the number of cattle, pigs or chickens raised in a single house. For example, the farms raising more than one thousand pigs increased from 527 in 1992 to 1,663 in 1997.

The raw feed for livestock and poultry are grains, bran, vegetable protein, animal protein, inorganic substances, etc. Of the 15,885,000 tons of total raw animal feed in 1997, grains were a major element recording 9,169,000 tons and most of this amount was imported.

A total of 882,000 tons of chemical fertilizer (421kg per ha) was used in 1997. The chemical fertilizers can be classified by active ingredient nitrogen(411,126tons), phosphorus (172,095tons) and potassium(197,182tons). Chemical fertilizers have been overused and it has caused harm to soil and waters through residues. Some 24,814tons of agrochemicals, including 7,332tons of fungicide, 9,161tons of insecticide, 6,043tons of herbicide, 923tons of plant growth regulator and 1,355tons of

other types were used. Agrochemicals were mainly used for rice, fruits and vegetables. However, overuse of agrochemicals has caused problems for human health, ecosystems, water quality, etc. Therefore, the government plans to reduce the use of chemical fertilizers and agrochemicals by promoting natural, organic fertilizer use.

The number of households adopting environmentally favorable farming was 13,056 and the area of environmental farming reached 10,718ha in 1996. Environmentally favorable farming can be classified as organic farming, farming without agrochemicals or low input farming. Furthermore, the number of households adopting environmentally favorable farming is continually increasing.

A large portion of farm work, which was previously done by laborer or cows, has been replaced by agricultural machinery such as the power tiller, farm tractor, rice transplanter and combine. Major agricultural machinery owned by farmers in 1997 were 945,844 power tillers, 131,358 farm tractors, 68,903 binders, 74,258 combines, 703,383 power dusting equipment, 397,417 water pumps, 95,790 threshing machines, and 13,202 sowing machines.

The number of farm households was 1,437,000 in 1997. Most of the rice farming work from nursing to harvesting has been mechanized and the rate of mechanization with the exception of drying rice has reached 98%.

The four major agricultural cooperatives in Korea are the Agricultural Cooperative,

the Forestry Cooperative, the Livestock Cooperative and the Ginseng-Tobacco Cooperative. The Agricultural Cooperative is the largest one having 1,286 local cooperatives with 1,953,000 members. The Forestry Cooperative and the Livestock Cooperative have 143 and 181,738 local cooperatives with 474,420 and 588,686 members, respectively. The government plans to merge these cooperatives into a single cooperative.

Average annual food consumption per capita in 1996 amounted to 172.9kg of cereals, 10.8kg of starchy roots, 16.8kg of sweeteners, 13.5kg of pulses, 152.2kg of vegetables, 36.9kg of fruits, 34kg of meat, 8.7kg of eggs, 41.7kg of dairy, 44.3kg of fish, 14.6kg of oils, and some other products. Average nutrient consumption per capita per day showed 2,957kcal, which included starch (61.1%), sweeteners (6.0%), animal food (14.3%), oils and fats (12.1%), and other materials (6.5%). Average protein consumption per capita per day was 98.4g with 41.3g(42.0%) of animal protein. Average fat consumption per capita per day was 78.7g in which oils covered 50.8 percent.

A total national cereal production of 5,081,000 tons compared to 18,673,000 tons of domestic consumption in 1996 showed a self-sufficiency rate of only 27.2%. The self-sufficiency rates of rice (89.9%) and barley (73.5%) were relatively high, self-sufficiency rates of wheat (0.4%) and maize (0.8%) were extremely low. Low national production and dependence on imported wheat and maize caused an overall low

self-sufficiency rate for cereals. A large portion of imported wheat and maize were used for livestock and poultry feed so that the self-sufficiency rate of cereal excluding animal feed reached 52.4%.

The self-sufficiency rates of pulses (11.7%) and oil crops (42.1%) were relatively low. But the self-sufficiency rates of starchy roots (99.6%), fruits (92.6%), vegetables (98.7%), eggs (100%), fish and shellfish (95.1%), and seaweed (126.7%) were high.

4. Present Status of Rural Development

As a result of concentrated efforts in agricultural water resource development by Korean government, 882,000 ha of the rice production area was converted into irrigated paddy fields by 1997, which accounts for 76% of total rice production area. However, about 50% of the irrigated paddy fields are still subject to possible damage from the drought with 10-year frequency because of poor irrigation facilities. Besides these problems, 10,000 reservoir (55% of the 18,000 existing reservoirs) do not function well due to this deterioration.

The energy sources are electricity, petroleum and natural gas. Consumption in 1997 by energy source was 200 tera Watt hour for electricity, 670 mega Bbl for petroleum, 7 giga cubic meter for natural gas and 29 mega tons for coal.

Major physiographic constraints are large mountainous areas, which are prone to erosion due to steep slopes and high intensity rainfall. These conditions limit

development in the mountain area. Similarly the absolute shortage of flat plain area has led to the conversion of farming areas into industrial and urban areas. The recent development of industry as well as urbanization due to the increase of population is the major causes of the reduction in farmland.

The population as of 1997 is about 46 million, with a growth rate of 0.98%, population density of 463 persons per km², birth rate of 1.6 per female and death rate of 5.4(male 6, female 4.7) per 1,000 persons. The male-female ratio is 101.5%.

The farm population consists of 4.47 million(male 2.15 million; female 2.32 million) which is 9.7% of total population.

The composition of employment for adults as of 1996 was 22.5% in manufacturing, 11.6% in agriculture and fisheries, and 66% in service and other sectors. Unemployment ratios were 2.4~2.8% during the early 1990s, and about 2% from 1995 to 1997, but the rate increased sharply in 1998.

The human development index of Korea is 0.89 based on the average life span of 71.5, the literacy rate of 97.9% and the percentage of school attendance at 82%.

The Korean national economy has been steadily developed since the 1960s. The Gross Domestic Product (GDP) was US\$ 480.2 billion in 1996, and dropped to US\$ 437.4 billion in 1997. Gross National Product (GNP) per capita decreased from US\$ 10,543 in 1996 to US\$ 9,511 in 1997. The economic growth rate was 8.7% in 1995, 6.9% in 1996, and 4.9% in 1997. The gross saving ratio in 1997 was 34.6%. 24.3% in the private sector

and 10.3% in the government sector.

Export volume increased sharply from US \$ 1.0 billion in 1970 to US \$ 63.0 billion in 1990, and it reached US \$ 136.2 billion in 1997.

Household energy has been changed from coal to oil and gas during the last decade. For cooking, imported natural gas and propane gas are major energy sources. For heating, natural gas is used in the city areas and oil in the rural areas.

The share of passenger traffic by mode of transportation as of 1997 is 81.7% by road, 11.7% by subway, 6.3% by railway, 0.2% by air and 0.1% by ship. The total length of roads including express highways (1,889km) is 84,968km. Motor vehicles per km length of road are 122.6 and the percentage of paved road is 74%.

As of 1995, the percentages of school attendance were 95% for primary and secondary schools, and 54.8% for universities and colleges. Primary school starts at the age of 6 and has a 6-year term. Middle school has a 3-year term and High school lasts 3 years and university 4 years.

An autonomous system in local government was adopted in 1990, whereby local governments have increased power in administration and financing. Local governors and local assembly members are selected by direct election by the people.

5. Future Scenarios and Aims

Water demand increases continuously, requiring that development is sustained in respect in water quantity as well as water

quality. Self-sufficiency in food is very low. The national goal is to attain self-sufficiency in staple food production, and this requires irrigation water development and preservation of farmland.

Also, rural development for farm production as well as rural living conditions is necessary to achieve equitable regional living standards and to prevent a concentration of the population into the urban areas.

The Ministry of Agriculture and Forestry (MAF) has established two programs: known as the First Program (1992-1998) and the Second Program (1999-2004). The First Program consisted of conducting rural infrastructure improvement with a total investment of KRW 42 trillion (US\$ 3.4 billion). The Second Program consists of investment/loan programs requiring ₩45 trillion (US\$ 3.6 billion). A unique characteristic of the Second Program is the transition into investments in software-based marketing, natural environment and information as opposed to the hardware-based investments of the past. Agricultural consulting systems were additionally incorporated to increase management efficiency. The specific purposes of the Second Program aimed at (1) a stable food supply and preservation of productive land resources, (2) environmentally sound agriculture, (3) reforming agricultural marketing systems, and (4) improvement in agricultural exchange and cooperation between South and North Korea.

After successful completion of Second Program, farm income is expected to rise to ₩29.5 million (US\$ 23,500) in the year

2004, from ₩22.6 million(US\$ 18,000) in 1998. Although the GDP portion of the agricultural sector is decreasing, value-added industries related to agriculture such as food processing and food industry will be expanding. The added value will be ₩48,791 billion(US\$ 38.9 million) in 2004, from ₩ 36,398 billion(US\$ 29.0 million) in 1998. In addition, the rate at which rural roads are paved will be increased to 51% in 2004 from 32% in 1998. Rate of water supply facilities is also expected to rise up to 71% from 48%. Living conditions and welfare will be improved. For example, medical benefits will be improved in terms of the ratio of population to medical doctors, from 515 in 1998 to 373 in 2004.

Considering the increase in water demand, water resources development is seriously needed. However, most of proper dam sites have been developed, and planning for new dams is difficult because of national conservation supported by environmentalists as well as because of high development costs.

Water consumption for agriculture utilizes 50% of totals the available water resources. Therefore, water saving farming needs to be developed to reduce water use in the agriculture sector and convert more water to other sectors. The on-going government plan for rural water development, which started in 1994, will be finalized in 2004. The plan aims to increase the ratio of irrigated paddy fields to the total, from 76% in 1997 to 88% in 2004. For this purpose, a total of 14,420 billion won (US\$ 11.5 billion) will be invested.

The government expects that rural water development will also be achieved after 2004, and that most of the paddy fields, except those in mountainous areas, will be provided with irrigation facilities, attaining 94% irrigation in paddy fields.

Agricultural water resource development in the 21st century should aim at (1) transition of single purpose development for agricultural use into the multipurpose development, (2) site-specific and systemized water resource development, (3) developing harmonized systems of existing and newly-built facilities, (4) developing efficient water management systems, (5) expanding systems for repairing and improving the existing facilities to increase safety and use efficiency, (6) developing technology and systems for scientific and efficient water management structure (such as Telecontrol/Telemetry, or TC/TM), preparing for a decrease in the farm population and aging in rural areas, and (7) water resource development related to rural village development and agricultural infrastructure projects.

For these reasons, the Ministry of Agriculture and Forestry is planning a project for rational and efficient agricultural water use, for the purposes of developing limited water resources, managing existing water facilities efficiently, and distributing water resources rationally. This project intends to develop and manage irrigation areas in terms of units of irrigation (a unit of 20,000~30,000ha). MAF established 464 irrigation units in rural areas in 1991, and completed a water resource survey at the nationwide level in 1998. This survey data

will be used to plan the agricultural water resource development project in 1999.

As a subsequent program for agricultural and rural development after 2004, Korean Government is planning mid- and long-term projects with a duration of 2004~2031. The objectives of this program will be similar to the previous programs except that it introduces an environmental viewpoint into the development of water for food and rural development.

Inter-basin water resources development along the major rivers has been studied as a solution for regional water distribution, but different interests among Government agencies and local governments make it difficult to realize. However, this solution will be further studied in the future to cope with the problems of national water shortage.

For the efficient use of water and savings in management labors, automation of water management has been studied, and some pilot schemes are being executed. The automation will be expanded in response to the need for water savings and higher labor costs.

Also, the communication network, Agri-Net, will be established to give and exchange information between concerned agencies and farmers. The Agri-Net will become a useful tool for training farmers, the dissemination of new technology and the marketing of agricultural products.

Farmland consolidation as an on-farm development has provided square, level plots, irrigation and drainage canals and farm

roads for 56% of the total paddy field area (658,000ha) until 1997. A total of 800,000ha will be consolidated by 2004.

On-farm drainage improvement has been implemented for approximately 81,000ha, which is equivalent to 39% of the total proposed drainage area and will be continued on a small-scale basis.

Operation and maintenance of irrigation systems and water management have been performed by Farmland Improvement Associations (FIA), autonomous irrigation organization with a 90-year history. All the farmers who have irrigated farmland are members of these FIAs. They have elected a president and a managing board, making very effective participation in the association's activities possible. A similarly effective participatory system must be a goal when the government company takes over these associations next year.

In the year 2000, a government corporation will merge all Farmland Improvement Associations, ending the 90-year history of these autonomous farmers' organizations. This change causes about after a decade in which the FIAs have lost most of their independent sources of income and seen a reduction in water charges while dependence on government subsidies has increased. While this shift in structure will produce changes, encouraging participatory management will be an important issue to resolve in the future.

From the beginning of the installation of modern irrigation systems around 1910, The irrigation association has acted as an owner

of irrigation projects although under government guidance and supervision. Therefore turning over the system to the government was not necessary.

There is no private water resource and irrigation development except a number of tideland reclamation areas that were developed by private companies. All the investment costs and a part of operational and maintenance costs have been borne by the government budget since 1988.

Historically, community water rights have been recognized, and as such, water was owned by the community and not by individual farmer. Water was a social good in those days, even if self-help works were needed. After establishing Irrigation Associations from the 1910s to the 1950s, farmers have had to pay water charges and part of the construction costs, changing the concept to be more closely tied to the economy.

Since the last decade, the concept of water had changed again from economic back to social, as a result of on the increase of subsidies.

Water charges had been based on operational and maintenance costs along with long-term loans for part of the initial construction costs. Since 1988 under the policy changes farmers have started to pay certain fixed amounts depending on the area irrigated (5kg paddy per 10a). Any shortage in operational and maintenance costs is subsidized through the government budget. As a result, farmers and the operating organization have little interest in water pricing.

The Republic of Korea shares several

rivers and watersheds with North Korea. Some experts propose joint study and development for the basins, but politically it has been difficult to proceed.

6. Challenges for the Future

Investment in water for food and rural development has increased remarkably in Korea, where the total investment since 1945 has amounted to US\$ 17.5 billion. The corresponding increase in irrigated areas for example, was 0.188 to 0.882 million ha. Although there is evidence that investment in irrigation has declined in recent years, irrigation development will continue to receive a high priority due to limited land and water availability for further expansion.

As regards the agriculture and rural development policy, Korea has become a newly industrialized country, which means that is no longer the most important economic sector. However, increased food production and self-sufficiency in food are still important agricultural policy objectives. Even though the irrigated agricultural area has substantially increased, there remains a high proportion of farmland (usually over 50% on the basis of a 10-year drought recurrence interval) which is non-irrigated or rainfed.

The main policy objectives for water for food and rural development in Korea are (1) to establish an agricultural production structure that ensure a stable supply of staple foods and paddy rice, and (2) to create a better rural living environment with coexistence among the primary, secondary, and

tertiary industries in rural areas.

In line with the mid-and long-term projects with a duration 2004~2031, to consolidate the stable foundation of rural agricultural areas for the coming 21st century, Ministry of Agriculture and Forestry is planning to prepare the basic foundation for agricultural production so as to develop more productive and profitable agriculture by effective and stable cooperatives. Moreover, to attain the establishment of amenities in rural areas, the living environment project will be extended together with the agricultural production infrastructure improvement projects. Several national visions within the planning projects will be identified as follows.

1. To strengthen the development of the agricultural production infrastructure, particularly that of paddy rice for stable self-sufficiency in staple foods. This will include: the development of water resources for agricultural and rural use as a provision against drought, drainage improvement projects, the completion of un-finished large scale farmland reclamation projects for ensuring high quality farmland.

2. To establish agriculture's production base early on to make mechanized farming possible. This will include an agricultural road improvement project, a farmland consolidation project and the development of upland production base.

3. To scale up the investment for the efficient management of water resources and related structures and facilities. This will also include the reorganization of agencies in

charge of development and management of agricultural and rural water as well as rehabilitation and modernization of hydraulic structures and facilities.

4. To shift the development method for the preservation and conservation of national land and the environment. Disaster prevention and the conservation of farmland are also important from the viewpoint of national land conservation.

5. To pursue rural development where the primary, secondary, and tertiary industries coexist in rural areas. This will include the village sewage projects and integrated rural development projects.

6. To strengthen international cooperation and to study the North Korean agricultural production infrastructure as a provision for reunification.

Within the framework of "proposed programs" during the period 2004 to 2031, the agricultural production infrastructure will be improved and developed to secure the farmland and water resources necessary for agricultural production and to increase agricultural productivity. Self-sufficiency in staple foods will be achieved through to the stable agricultural production. Living conditions in rural areas together with production infrastructures will improve as well for the creation of attractive living environments. In the 21st century, rural areas in Korea will be brought into the complex society where urban and rural populations are mixed and where areas function as a supporting background to large metropolitan areas.

Major rural water development projects

are significant investments, when considered on a per-unit cost or a total cost basis. The current average cost per hectare for new development schemes in Korea range from a low of US\$ 5,000 to a high of US\$ 8,300 per ha. With these prices, investment in irrigation is difficult to justify if benefits are projected on the basis of present prices. With today's domestic rice prices, in order to provide a 5.5% discount rate of return on investment costs of US\$ 8,000 per ha, a production increase of in excess of 5.3 tons per ha would be needed. Improving or rehabilitating an existing system is less costly, ranging from US\$ 2,000 to US\$ 5,000 per ha, but in both cases, irrigation projects are well known for their tendency to cost more and provide fewer benefits than originally planned.

Rainfall is one of the constraints to water resources development. Seasonal distribution of rainfall is concentrated in summer season (about two thirds of the yearly rainfall), causing flood damage along the rivers and in low land. And water shortage is common in the spring and winter season. Because of such hydrological conditions, reservoirs are a major source of water and supply irrigation water to 58% of all irrigated paddy fields. Unfortunately there are almost no more appropriate sites for reservoirs, and this is one of the constraints in water resources development.

Water pollution is also serious. Population increases, urbanization, industrialization and higher living standard have brought water quality problems. Yearly sewage water is

estimated to be about 8 billion m³, of which 55% is not treated. Of 150 reservoirs for irrigation purposes included in the quality monitoring network, 31% of the reservoirs showed COD levels higher than 8mg/ℓ. Water quality improvement is as important as water quantity is.

Until 1988 and 1989, part of the farmers' contribution to the investment costs was made in the form of long-term loans and their yearly repayment. Upon political consideration, farmers were exempted from sharing investment costs and part of the operation and maintenance (O & M) costs. So, all the investment costs and part of the O & M costs were borne by the Government budget. This new policy limited the availability of funds for water resources development. More interest was bestowed on social and political costs than economic costs.

In Korea, the public have the impression that there is enough water, because they experience floods very often. When there is long drought, the government and the public realize the importance of water. Spring droughts are especially important to overcome by national efforts to transplant rice in its due season. In recent history, investment in water resources development has been heaviest just after drought years.

Water management in the irrigation sector has been done by Farmland Improvement Associations. Irregular rainfall requires irrigation at one time and drainage at other times. This makes good water management and saving water very difficult.

Public awareness of water development was

very high about two decades ago. New irrigation systems were welcomed by farmers and local communities, because irrigated farming resulted in great increase in yield. Also, agriculture was a major industry then, which many people depended on.

Recently public awareness of the environment has increased and has lessened the public support for water resources development. Now, several reservoir sites are planned, but are caught in disputes between the government and environmentalists. Governmental efforts to persuade and guide the public are urgently very needed in order to meet future demands for water.

Korea has no international boundaries on land except with North Korea. However, the air masses which bring cloud, and rain also

can bring pollution. A large amount of weather comes from the west and so air pollution in China can affect the quality of rainwater in Korea. Acid rain is found all over the Korean territory indicating that cooperation between Korea and China would be indispensable. Mitigating air pollution in China would positively effect the Korean water resources.

Overseas agricultural and rural development cooperation has been implemented by Korea's KOICA (Korea International Cooperation Agency). Recently, international cooperation in agricultural and rural development is becoming more important than ever. The Korean Government will pay more attention to international cooperation.