

韓國의 논灌漑施設 維持管理 및 물管理

Maintenance of Paddy Irrigation Facilities and On-Farm Water Management in Korea

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摘 要

지난 40년간 韓國에서는 농업生産 특히 쌀 生産의 가속화를 위한 노력으로서 灌漑事業에 큰 비중을 두어 왔다. 따라서 灌漑施設과 農地改良에 대한 投資는 괄목할 만큼 伸張되어 1960년대 이래 총투자액은 美貨 61억불에 달하고 있다. 그 결과 灌漑에 대한 잠재력과 灌漑面積은 크게 확장되어 지난 40여년간 純灌漑面積은 1945년의 188,200ha로부터 1988년의 975,750ha로 증가 되었으며 이 숫자는 한국 총 畝面積의 73%에 이르는 면적이다.

韓國에는 농업수자원의 開發과 管理를 計劃, 실시하는 임무가 부여된 國家機關이 있다. 그러나 이에 관련되는 국가수준의 機關이 하나이상이므로 관련되는 機關間의 統合이 문제로 제기되고 있다. 이러한 문제는 얼마간 인식되고 있기는 하지만 아직도 심각하게 남아 있다.

農地改良組合은 農村近代化促進法에 의하여 조직되고 운영되고 있다. 각 組合에서는 灌漑管理에 대한 政策, 灌漑水 分配計劃, 水資源管理 등을 담당하는 管理課가 있으며 또한 각 조합내에는 末瑞水路 및 團場의 물管理를 위한 農民灌漑團體인 홍농계가 조직되어 있다.

農家水準에서의 灌漑開發 및 管理에 관련되는 問題點 및 주요爭點은 다음과 같음을 확인할 수 있었다.

1. 灌漑組織 및 물사용의 低效率
2. 農리구역내의 不均衡한 물分配
3. 水稅의 부과 합리화 및 징수방법
4. 現存의 낡은 灌漑組織
5. 灌漑施設을 效率적으로 운영, 유지관리 하기위한 훈련된 人力
6. 관련 機關間의 統合

韓國의 現 經濟成長 단계에 비추어 볼 때 물의 수요와 水資源의 汚染이 증대되고 있으며 새로운 水資源의 開發은 점점 어려워지고 또 高價이다. 따라서 더 이상의 발전을 위해서는 토지와 수자원의 효율적이고 경제적인 이용은 물론 現存 灌漑組織의 개선과 집중적인 管理가 강조 되어야할 것으로 생각된다.

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I. Introduction

Paddy irrigation in Korea has a long history. However, the construction of modern irrigation and drainage works was substantially initiated and accelerated by the Rural Modernization Promotion Act in 1970. Despite the tremendous investment towards land improvement projects over the last 20 years, the derived results have sometimes been less than expected. One important reason for this is the lack of integration of engineering and agricultural practices in which proper water management at the farm level would play an important role. Rather the engineering undertakings and related agricultural activities are separated from each other, this has resulted in slow returns from investments in land improvement projects.

Emphasis placed on the solution of major engineering problems during the planning and construction phase, coupled with the lack of recognition of the important on-farm water management are the major constraint for irrigated paddy in Korea. Consequently, there exists a gap between the irrigation potential created and the full exploration of that potential. Although significant progress has been made in engineering undertakings, the majority of farmers can not fully visualize the importance of water management at the farm level.

In order to solve some of present problems in irrigated agriculture and to create a situation conducive to modern irrigation development, a change in approach based on the integration of engineering undertakings and various agricultural activities is needed. Such a change calls for more attention to the water use concept in connection with a set of planning and design criteria which may place emphasis on the farm level water management.

II. Present Status of Irrigation Development

The total land area of the Republic of Korea,

hilly and mountainous country, is about 99, 170km². Of the total area, 21.6% or 2.14 mha is now being cultivated, 67% for forestry, grazing or other extensive land uses, and 11% for urban and industrial use. The paddy land, about 13.5% of total area, is located mainly along the river and in small plains along the western and southern coasts. Upland areas, about 8.1% of total area are located on sloped and hilly land. Due to the rapid urbanization and industrialization, a considerable portion of farmland has to be converted to non-agricultural uses such as industrial complex, road and housing site and other purposes. The farmland area has accordingly decreased by 0.16 mha from 2.3 mha in 1970 to 2.14 mha in 1987 in spite of the newly established land by both the tide and hilly land reclamation.

The population in 1987 was about 42 million with a recent annual growth rate of 1.3%. However the farm house population was decreased from 14.4 million in the year of 1970 to 7.3 million at the present time. Agriculture contributes 11.3% of the total GNP and the rural population occupies 17.2% of the total population.

The average annual precipitation ranges from 900mm in Kyung-Buk Province in the east central part of the country to 1,400mm in the southern and western coastal areas. During the year, however it is poorly distributed, with two third falling during the rainy season for 3 months. Therefore the amount of rainfall in the growing season of paddy rice is not enough. It is especially so during the critical period of rice transplanting and the early stage of rice growing. In addition, shortage of water due to droughts occurs sometimes even in the rainy season.

Irrigation was essentially developed for rice cultivation in Korea. It began in the first century B. C. The early development was on a small scale, diverting directly stream water to paddy fields through small headworks and conveyance structures. During the period from 1910 to 1945, the existing systems were remodeled, consolidated, and

expanded. A number of new irrigation systems were constructed using relatively modern technology.

Since 1945, the irrigation development in Korea has been carried out in three stages.

In the first stage(1945~1962), efforts were made to modify the irrigation and drainage systems, and flood control works that have been damaged during the World War II and subsequently during the Korean War. Through these efforts, most of the irrigated area was improved.

In the second stage (1963~1970), single purpose new irrigation projects were implemented. Land consolidation projects were also initially implemented to efficiently utilize the existing land and water resources. Investigations and planning of multipurpose integrated large scale water development were also initiated during this period.

In the third stage(1971~present time), new development and economical utilization of water resources were carried out in connection with the comprehensive rural development project. The new development covered large scale irrigation, multipurpose reservoirs, groundwater development and construction of large estuary dams including the intensive development of land consolidation, drainage, and tidal land reclamation projects.

Until the 1960's most of the land improvement projects were in a category of small scale irrigation water development project, farmland consolidation, and farmland development at the individual project basis. After 1970, however, because one of the major objectives of the government economic development plan, based on the extensive development of rural sector, the government expenditure for the rural sector became a substantial part out of the total government investment. In accordance with its policy change, the government has planned to formulate and implement the comprehensive agricultural development of land and water resources on a large scale. Integrated large scale projects have provided a key momentum achieving agricul-

tural modernization and establishing a sound foundation for the rice crop production in this country.

Fig.1 shows the location of total 16 comprehensive agricultural development projects. By the end of 1988, nine projects covering 88,000ha of irrigated paddy have been completed and the rest of seven projects covering 89,000ha are now under construction. Total cost of the project amounts to U. S. \$ 3.3 billion.

At present, there are 18,463 reservoirs, 5,201 pumping stations and 19,962 headworks utilizing surface water as important agricultural water resources in Korea.

The net irrigation area during the last four decades, after the base year 1945, has increased from 188,200 hectare to 975,750 hectare. Out of letter, 517,175 hectare(53%) have been irrigated through reservoirs, 171,363 hectare(18%) through pumping stations, 118,514 hectare(12%) through headworks and 38,263 hectare(4%) through infiltration galleries and tube wells (Table-1)

The total expenditure for the development of irrigation potential through different water sources is U. S. \$ 6.1 billion given in Table-2. It is observed that the annual total expenditure has increased considerably with the comprehensive agricultural development after 1970. From these figures, it is noted that the cost of creating irrigation potential, especially of major and medium irrigation projects was increasing at a meteoric pace. The cost of irrigation potential will escalate further in the years to come because of the unavailability of good sites for the construction of reservoirs and headworks for major and medium irrigation projects along with other factors. According to the present estimates of the Ministry of Agriculture, Forestry and Fisheries (MAFF), the cost of developing irrigation potential through large scale irrigation projects varies from U. S. \$ 17,140 to \$ 28,750 per hectare. If the cost of consolidating the land for reciving irrigating water is also added, the total cost would be about U. S. \$ 25,710 to \$ 40,180 per hectare. If the irrigation efficiency

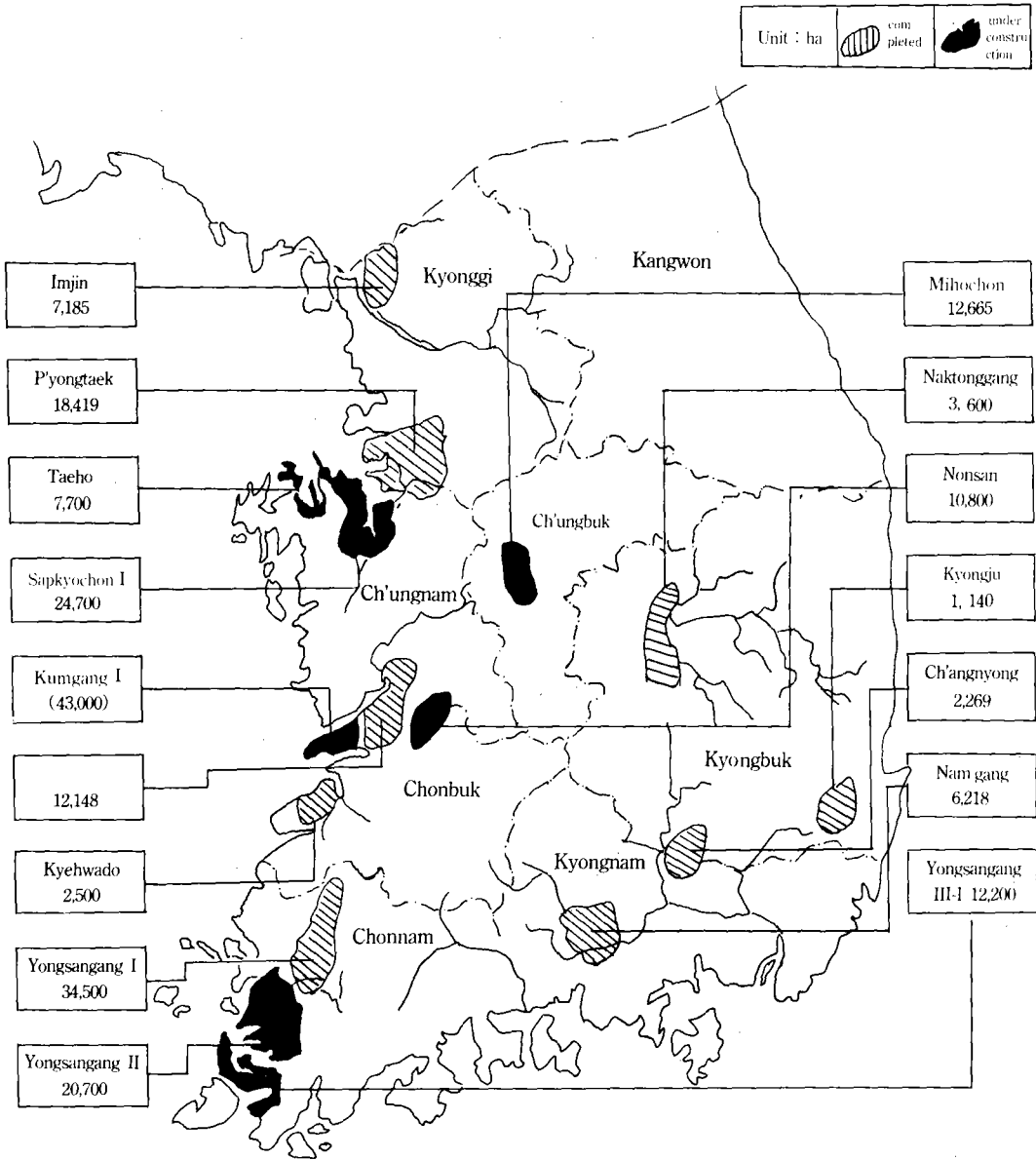


Fig. 1. Location of Comprehensive Agricultural Development projects with the benefited areas developed.

factor is considered, then the cost of effective irrigation potential per hectare rises, which is prohibitive and the farmers cannot afford to receive the cost without ensuring the efficient and economic use of irrigation water with high productivity of rice. For this consideration, higher emphasis has been laid on the on-farm water management since

1980.

The yield capacity is sometimes greatly influenced by the supply of inputs such as irrigation, seed and fertilizer. The development of irrigation systems in Korea has resulted in large increases in rice production from 1.83 million metric tons in 1945 to 6.05 million metric tons in 1988 with

Table-1. Present status of irrigation area under different facilities of water source.

Name of facilities	F I A		non-F I A		Total		
	No. of place	Area covered (ha)	No. of place	Area covered (ha)	No. of place	Area covered (ha)	%
Reservoirs	2, 578	357, 323	15, 885	159, 851	18, 463	517, 174	53
Pumping stations	2, 039	117, 732	3, 162	53, 631	5, 201	171, 363	18
Headworks	3, 308	11, 615	16, 654	106, 899	19, 962	118, 514	12
Infiltration galleries&tube wells	1, 391	2, 967	12, 971	35, 296	14, 362	38, 263	4
Others	—	—	—	130, 437	—	130, 437	13
Total	9, 316	489, 637	48, 672	486, 114	57, 988	975, 751	100

Remark : FIA(Farmland Improvement Association)

Table-2. Input to agricultural water and land development project during last 40 years.

Period of Years	Total investment (million Won)	Converted to present value of 1985 (million US \$)	Annual expenditure (million US \$)	Index
1940's ¹⁾	9	36. 2	9. 1	
1950's	9, 691	449. 9	45. 0	
1960's	62, 270	818. 4	81. 8	100
1970's	768, 805	2, 486. 6	248. 8	304
1980's ²⁾	1, 953, 938	2, 284. 4	380. 7	465
Total	2, 794, 713	6, 075. 5	765. 3	

Remark 1) 1946~1949 2) 1980~1985

the highest production record. Needless to say, such progress can be attributed to technology advancement including farmland improvement and high yield rice varieties.

III. Planning and Financing of Water Resources Development.

There are altogether four main agencies which are involved in the development of water resources for agricultural purpose and operation of irrigation systems under the Korean government. These are Ministry of Agriculture, Forestry and Fisheries (MAFF), Agricultural Development Corporation (ADC), local autonomous body, and Farmland Improvement Association(FIA).

Rural Development Bureau (RDB) of MAFF is a major governmental body for policy-making on various land improvement and water resources development for the agricultural use. Other major functions of this agency are supervision and guidance for planning and financing to local autonomous bodies, ADC and FIA.

The ADC, a semi-autonomous agency operating under the MAFF is a prime organization for medium and large scale irrigation projects implementation. The ADC was established in 1970 by combining the Union of Land Improvement Association (ULIA) and the Ground Water Development Corporation (GWDC) by the Rural Modernization Promotion Act. The primary goal of ADC is to realize amelioration of the rural area and to create

all weather farming lands. In order to secure these goals, ADC involves with various agricultural land improvement projects, comprehensive farm mechanization and rural housing development. However, the main activities of ADC are the promotion of rural areas through the development of land and water resources and the provision of technical assistance to FIA which is basically responsible for the operation and maintenance of land improvement projects established by ADC.

Local autonomous body would usually be city or county (Gun) office under the provincial government. Small scale water development and farmland improvement including the groundwater development and the land expansion are sometimes implemented by these agencies. After completion of projects, they will be responsible for the operation and maintenance job with assistance from irrigation group organized by farmers. We often refer to this area as non-FIA or communal systems aside from FIA based on large scale irrigation system.

Even though its primary purpose is to operate, manage and maintain farmland improvement facilities, limited extension of medium scale water development can be implemented by FIA.

The financial sources for the development of water resources and irrigation systems may be classified into subsidies by the government, long term loan, ADC Fund, and FIA fund. In addition, foreign loans sometimes can be used for the project implementation especially for the large scale comprehensive agricultural development projects.

The proportion of subsidies and loan for the total project cost and the rates of subsidies are different according to the type and purpose of a project as shown in Table 3. Generally the highest rate of subsidies is applied to the small scale irrigation improvement project and it reaches up to 90%.

The project cost borne by farmers through long term loan would be repaid by the benefited farmer over a period of 30 years with a low rate of interest

Table-3. The financial source of the land improvement project.

Unit = %

Type of project	Type of facilities		Subsidies rate			Rate of borne by farmers		
			National government	Provincial government	Total	Longterm loan	One yer borne	Total
Irrigation development	Large scale	Reservoirs	70	-	70	30	-	30
		Pumping stations	85	-	85	15	-	15
	Medium scale	Reservoirs	70	-	70	30	-	30
		Pumping Stations	85	-	85	15	-	15
	Small scale	Reservoirs	70	-	70	-	10	10
		Pumping Stations	70	-	70	-	10	10
		Head works	70	-	70	-	10	10
		Infiltration galleries	70	-	70	-	10	10
Tidal land development			80	-	80	20	-	20
Drainage development			85	-	85	15	-	15
Farmland development	Large scale		50	30	80	-	20	20
	Medium scale		60	20	80	13.3	6.7	20

(5.5%). However, in case of the irrigation development, the benefited farmers are allowed to repay at a maximum rate of 30% of the direct project cost.

As stated earlier, the project facilities implemented by ADC are usually transferred to FIA for the operation, management and maintenance. For the projects implemented by the local autonomous body, the city or county office itself would be directly responsible for O & M and is called non-FIA which usually comprises of small irrigation system on village basis. (see Fig. 2)

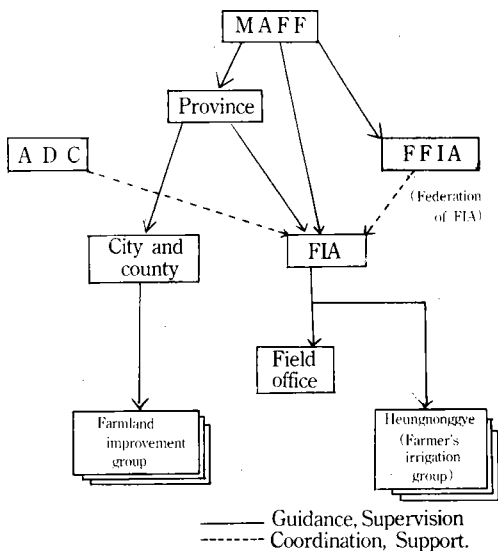


Fig. 2. Organizational relationship among involved agencies in the operation and management of irrigation systems.

IV. Organization, Operation, Management and Maintenance of Farm Level Irrigation Systems.

Farmland Improvement Associations (FIA) in Korea are corporate bodies organized by farmers to improve irrigation systems and farm land and to supply irrigation water to farm fields in their individual designated service areas. They also assist the government in the planning and develop-

ment of new irrigation projects altogether with ADC. The FIAs are organized and operated in accordance with the Rural Modernization Promotion Act.

The development of FIA is essentially for paddy irrigation. Through several decades, the original 432 FIAs were recombined and gradually reduced in number. At present, there are 103 FIAs, the largest one being the Tongjin FIA, covering an area of about 42,000 ha southwestern part of the country and the smallest one is the Cheju FIA, covering an area of only 120 ha in the Cheju island. The total service area of the 103 FIAs is about 489,637 hectares.

The organizational set-up of a typical illustration shown in Fig. 3 is for a large association with an irrigated area of more than 16,000 ha. For a smaller association with an irrigated area less than 16,000 ha, the number of assistant managers, the number of divisions or sections may be decreased depending on the size of irrigated areas.

Each FIA has a management division to handle irrigation management policy, planning of water distribution and management of water sources. In a typical FIA, there are several branch offices for field workers. The field worker's offices are responsible for the management of water resources and the operation of main and lateral canals for water control and supply. Field water distribution planning and execution are also the main responsibility of a branch office, which has a number of irrigation supervisors or attendants to take care of 300 ha to 500 ha of paddy fields. At the farm level, five to ten irrigation groups (called Heungnonggye) for an irrigation supervisor may carry out the water distribution and maintenance work of irrigation systems.

The irrigation groups called Heungnonggye in Korea are organized by association members on village basis for the on-farm water management. One Heungnonggye covers an area of 30 to 100 ha. It includes several teams each with ten to fifteen members to maintain irrigation and drainage dit-

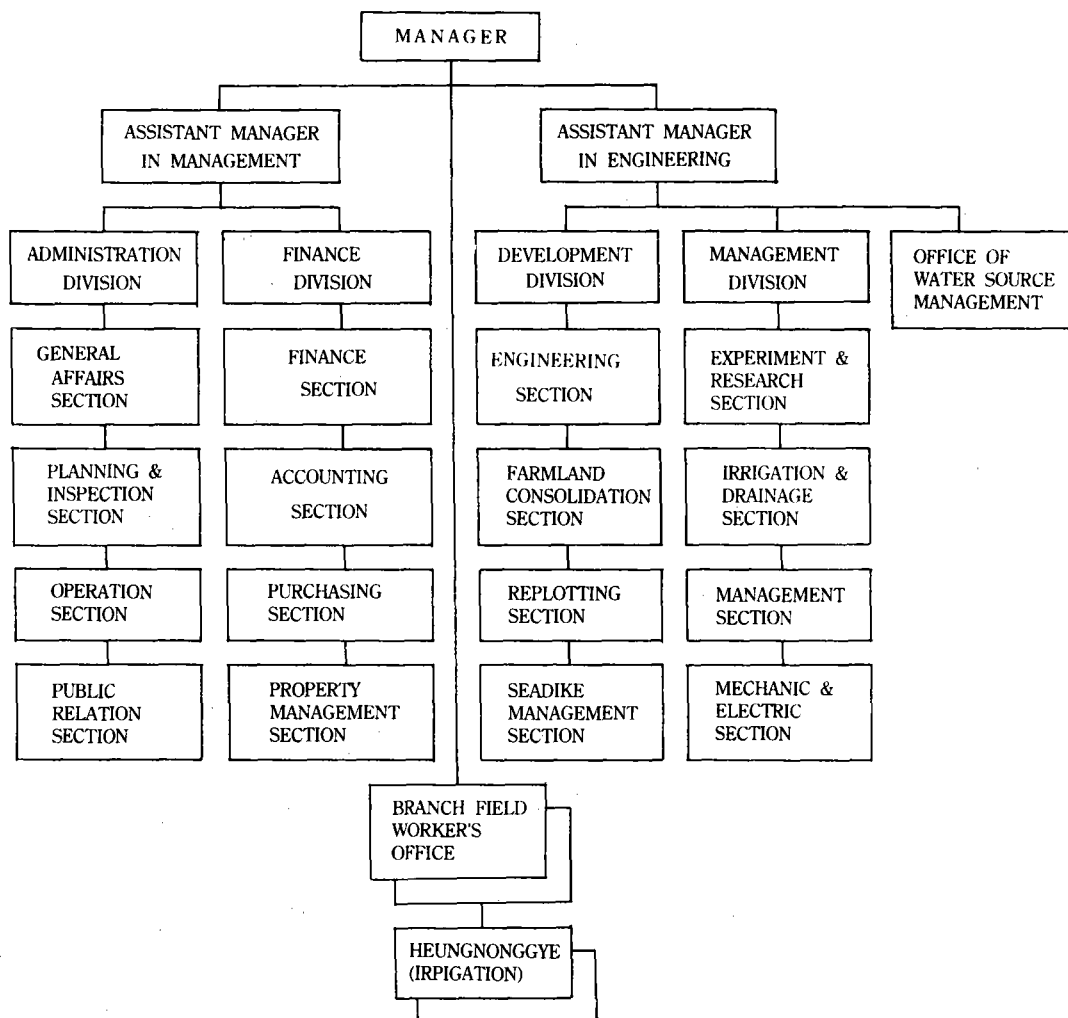


Fig. 3. Typical organization of FIA.

ches, to distribute irrigation water evenly, to establish common seed-beds for members, and to help the field worker's office to collect membership fees. Each Heungnonggye has a chief through election. He receives no salary from FIA. Within a Heungnonggye, one or two common irrigators may be hired for the water distribution and maintenance of farm ditches. Group meetings are held to discuss irrigation plans at least twice a year with the participation of FIA officer and rural extension serviceman.

Prior to the irrigation season every year, an irrigation guideline is issued by the management division at the head office according to the government policy and the existing status of association. This irrigation guideline should be distributed through branch field worker's office for further study and discussions with members of Heungnonggye so as to work out detailed irrigation plans. Then the detailed plans prepared by the branch office should be submitted to the head office for review and approval.

The operators of each branch office are in charge of regulation and controlling water flows along main canal, laterals and sublaterals. The irrigation supervisors are in charge of water control and inspections of farm level water distribution which are undertaken by Heungnonggye members.

In order to ensure adequate service to farmers, the irrigation and drainage systems must be maintained in good operating condition. The farmland improvement association pays more attention to maintenance than construction, and prevention than repair.

Maintenance and repair works may be classified as routine maintenance, annual maintenance, and emergency repairs. The routine maintenance covers minor repair discovered by irrigation supervisors or Heungnonggye members during their daily routine work. This kind of maintenance work may be undertaken by Heungnonggye members on voluntary basis, or with help of material supply by the farmland improvement association. Annual maintenance check up is usually carried out during the non-irrigation season. This work is either done by Heungnonggye through contractors or directly

by branch offices, depending on the scale and the type of works.

The collection of membership fees, the financing of projects, the set-up of the Operational Fund and Cooperative Fund and other revenues are important financing features of the FIA. The annual budget of FIA is drawn up to meet the need of irrigation administrative expenses, engineering construction, maintenance, and damage repairs. The revenue comes from membership fees and government subsidies as the main financial source.

The annual revenue of the FIA mainly comes from membership fees which are collected from the direct beneficiaries to take care of the operation and maintenance cost. The fees are all to be collected in cash. The government has set up a maximum limit of monetary value equivalent to 250~300kg of rough rice per hectare per year.

Project cost fees are collected according to the capital cost and interest of each particular loan project as well as the benefits obtained and the repayment ability of the farmers. However, collection of loan repayment starts from the fifth year after the land is benefited. The average member-

Table-4. The membership fees plus loan repayment in the year of 1987 basis.

Level (kg)	Area benefited (ha)	Average per 10 a		Total amount	
		paddy grains(kg)	money equi- valent(US \$)	paddy grains (1000 kg)	money equi- valent(US \$)
less than					
15 kg	1,681.1	10.5	8.7	177	145,800
15~20	6,443.8	19.8	16.3	1,278	1,050,850
20~25	68,777.7	23.4	19.3	16,091	13,278,540
25~30	132,449.0	26.9	22.2	35,261	29,395,290
30~35	124,016.6	30.6	25.3	37,896	31,339,340
35~40	67,121.0	37.2	30.7	24,968	20,625,400
40~45	22,973.3	40.1	33.1	9,213	7,609,150
45~50	12,397.7	45.7	37.8	5,670	4,682,930
more than					
50	3,980.4	56.0	46.3	2,230	1,842,120
Total or average	439,840.7	30.7	25.4	133,144	109,969,420

ship fee and loan repayment for all the 103 FIAs in 1987 are shown in Table 4. It is observed that the average membership fees including loan repayment per hectare in a year would be 307kg of rough rice which may be equivalent to the monetary value of U. S. \$.250.

V. Major Issues

Adequate and assured irrigation at the farm level is the key to increasing agricultural production which needs special attention in Korea. Since only a limited additional area can be brought under irrigation by new systems considering the total irrigable area available and the limited capital resources, major focus should be given to develop more effective management and utilization of available water at the farm.

Following issues are major problems which may be constraints for improving the water management at the farm level.

1. Low efficiency of water use is one of the major constraint. It was observed that in many gravity irrigation systems, less than 50% of irrigation water can reach to its field due to excessive losses such as canal and management losses. Taking into account the low application efficiency on the farm due to water logging on the paddy field and plot-to-plot irrigation in the absence of field distribution systems, overall project efficiency has been estimated less than 50% in some part of the country.

2. Even though there has been progress, Korea is lacking the experience in drawing up agricultural development programs with adequate provisions for the water management and control at the farm level. Few farmers are able to handle water efficiently. Moreover the fragmentation of farmlands with very small size make it difficult to use water resources efficiently. As far as water management at the farm level is concerned, cooperative farming needs to be tried and tested. In this regard, both the rural extension service and

the organization of farmer's irrigation group as well as FIA should be strengthened.

3. The rapid expansion of cities and urban area throughout the country and the economic growth has resulted in the decreasing farm land without any readjustment of irrigation systems. This means that existing facilities are used to apply irrigation water into the remaining paddies. Because of their reduced areas, management costs per hectare are higher than ever before. Besides, in connection with polluted water into irrigation canals, increase of the management cost due to the increasing labor cost and the rehabilitation cost due to the increase of older systems have resulted in the increasing of O & M cost. This situation would essentially be in the deterioration of the management in various levels of irrigation associations throughout the country unless more subsidies from the government are provided.

4. Many of the existing irrigation systems were designed and built before 1970's. These systems have now become outdated since agricultural technology has advanced rapidly in recent years. Many of the existing systems do not have sufficient flexibility to respond to such changes. It is now estimated that over half of the existing irrigated areas of the country are in need of modernization or rehabilitation.

5. The large scale irrigation systems which have been developed in recent years would require extensive knowledge of the up-to-date technique to operate this facilities efficiently. Trained manpower, therefore, is one of the major constraints. There is a strong tendency that a part of such large scale works should directly be managed by the national government or provincial government.

6. In Korea, a remarkable effort has been made and is still being carried out in the field of water resources development for agricultural use. The engineering undertakings are carried out mainly with major irrigation facilities in connection with water resources development program. With the completion of irrigation projects, improved water

management at the farm level will probably be guaranteed. However, there still remains some inadequate situations at terminal levels and also it has been proved unsatisfactory on some occasions. A coordinated effort is essential to establish a modern high productivity system of irrigated agriculture. This kind of effort has been extremely difficult to achieve under the present governmental organizational structures. Several individual agencies have had the responsibility for supply of inputs essential to irrigated agriculture. For example, ADC is responsible to establish major engineering undertakings while FIA is responsible to the operation and management of the irrigation facilities and systems developed by ADC. The coordination of these two elements and integration of different disciplines in an irrigation system is necessary in assuring irrigation schemes more successful.

VI. Summary

Over the past four decades in Korea, a great emphasis has been placed on irrigation development in its efforts to accelerate agricultural production, particularly rice. Investment in irrigation and land improvement has increased remarkably. It increased about 5 times during the period of 1960's to 1980's and the total investment since 1940's amounted to U. S \$ 6.1 billion. As a result, irrigation potential and irrigated area has greatly expanded and the net irrigation area has increased from 188,200ha in 1945 to 975,750ha in 1988 which is equivalent to 73% of the total paddy area.

Korea has the national bodies entrusted with the task of planning and implementing agricultural water resources development and management. However, there is more than one national-level body involved in water development and management. This has created a problem of coordination among the agencies concerned. Although the problem has been recognized for some time, it remains rather serious.

Farmland Irrigation Associations (FIAs) are organized and operated in accordance with the Rural Modernization Promotion Act. Each FIA has a management division to handle irrigation management policy, planning of water distribution, and management of water resources. In addition, within a FIA several farmer's irrigation groups called Heungnonggye are also organized to take care of water management including water charge collection from the farmers

Several major issues and management, especially at the farm level could be identified as follows:

1. Low efficiency of irrigation system or water use.
2. Unequable distribution of water to all farmers in the command area.
3. Rationalization and collection of water rates/charges.
4. Out-dated existing irrigation systems.
5. Need for trained manpower including farmers, to operate, maintain irrigation facilities efficiently.
6. Weak coordination among agencies concerned.

At present stage of economic growth in Korea, water demand and water pollution has been increasing and the provisions of additional new water sources has become difficult and costly. For further advancement, it is important to emphasize the efficient and economic utilization of the limited land and water resources, as well as the improvement of existing irrigation systems and intensive management.

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