AGRICULTURAL CONSTRAINTS IN PRODUCTION OF DIVERSIFIED CROPS ON IRRIGATED PADDY FIELDS IN KOREA

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AGRICULTURAL SETTING

Country Statistics

Of Korea's total land area of 99,117 square kilometers, only 2,152,357 hectares (ha) were cultivated in 1984. About 61 per cent of the cultivated area consisted of paddy fields and the remainder was classified as uplands. The farm population of Korea in 1984 was 22.2 per cent of the total population of 40,578,000. The average farm household is 4.6 persons. The 1.973 million farm households had an average allocation of 1.09 ha of cultivated land of 1.09; about 31 per cent of these farms were less than 0.5 ha and less than .01 per cent were larger than 3 ha. Thus, it is obvious that Korean farms are small scale operations (Table 1; MAF 1985a).

Table 1. Land use (in million hectares) and average farm size (in hectares) in Korea, 1975 and 1984.

Classification	1975	1984
Total land area	9.881	9.912
Cultivated land	2.240	2.152
Paddy field	1.277	1.320
Upland	0.963	0.832
Forest land	6.635	6.539
Wooded	5.981	6.279
Denuded	0.647	0.242
Unclassified	0.007	0.019
Others	1.006	1.220
Average size of farm	0.94	1.09
Paddy field	0.54	0.67
Upland	0.40	0.42

In 1985, agriculture, forestry, and fisheries accounted for 14.3 per cent of the gross national product of US$81.3 billion at current prices. The growth rate of the agricultural sector increased from 0.2 per cent in 1984 to 5.9 per cent in 1985 due to increased production of garlic, onion, orange, hot pepper, and grape, despite decreasing production of rice, together with the favorable situation of the fisheries and forest sectors.

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Table 2 shows the growth rates, 5.5 per cent in agricultural production, 9.9 per cent in forestry, and 6.7 per cent in fisheries. An especially high rate of 29.7 per cent appears in the livestock sector. Table 3 indicates the overall status of agricultural production in 1985 (MAF 1986).

Table 2. Growth rates (in per cent) of agriculture, forestry, and fisheries.

	1981	1982	1983	1984	1985
Agriculture, forestry, and fisheries	22.4	3.3	6.5	0.2	5.9
Agricultural production	24.3	4.4	6.3	-1.0	5.5
Section of cultivation	27.3	4.8	5.2	-2.4	3.1
Livestock	0.0	0.3	18.1	31.1	29.7
Agricultural services	11.8	0.4	14.4	2.4	1.1
Forestry	5.7	-11.9	31.4	7.8	9.9
Fisheries	16.0	1.6	-4.4	8.3	6.7

Note: Data based on the 1980 constant prices; Bank of Korea 1986.

Table 3. Area (in thousand hectares), production (in thousand metric tons, MT), and yield (in MT/hectare), 1985.

Crops	Area	Production	Yield
Rice	1,237	5,626	4.55
Unhusked barley	64	162	2.54
Naked barley	101	225	2.22
Beer barley	73	184	2.53
Wheat	3	11	3.43
Sweet potato	34	787	23.50
Potato	31	575	18.49
Pulses	196	275	1.40
Corn	26	132	5.04
Other cereals	14	15	3.65
Radish	38	1,586	42.28
Cabbage	41	2,790	67.61
Hot pepper	118	165	1.40
Garlic	39	256	6.57
Onion	11	440	40.92
Other vegetables	90	1,846	20.51
Fruit	109	1,464	13.46
Special crops	366	81	0.22
Total	2,592	16,617	-

Only 48.6 per cent of total food grain consumed in Korea during 1985 was supplied from domestic sources. Even though Korea has recently achieved a self sufficiency in rice production, she still had to import 11.02 million MT

(US$983 million) of food and feed grains in 1985. Along with the rapid income growth of the Korean people, demands for fresh produce and animal protein food increased at a rate faster than economic growth, accelerating land allocation to income elastic crops.

The conversion of land from arable land to industrial sites, highways, housing development, and other non-agricultural purposes is acute. The total area of cultivated land increased gradually between 1949-68, and has decreased at an average of about 10,000 ha/year since. This decrease may be greater in the future, and growing industries and urban settlements in Korea will continue to make significant inroads into cultivated areas.

Climate and Soil

Korea is in the temperate zone with a mean annual temperature above 11°C Mean summer (June to August) temperatures range from 20.7 - 25.5°C, and those of winter months (December to February) -0.6 - 2.6°C, showing the highest and lowest in the month of August and January (Table 4).

The mean annual rainfall is more than 1,000 mm except in the Daegu area where it is 979 mm (TAble 5). Most of it is concentrated in July and August which causes shallow soil depth in sloping land due to severe erosion, while deep soils are developed in the plains near rivers and mountain foot slopes by deposition of alluvium. These show different characteristics depending on the parent material. There is considerable fluctuation in precipitation from year to year and losses in production from droughts have been experienced.

About 12°C is considered the minimum temperature for germinating rice seeds, and 18°C is considered the critical temperature for rice pollen cold damage. Rice growing starts in early April and flowering must be finished by late August. Generally, the annual precipitation is more than enough, but its uneven distribution often causes difficulties such as shortage in the period May to June during rice crop transplanting and excess in the period August to September during rice crop flowering and ripening. This is why irrigation engineers are showing interest in the storage of winter precipitation and quick drainage of flooded paddies.

The soils of Korea are generally deficient in plant nutrients and organic matter. The top soil is relatively thin and poor. Korean farms often require substantial treatment with compost or chemical fertilizers to produce adequate crops. The greatest part of the soil is derived from granite and gneiss and is largely sandy with 12-38 per cent clay[1].

Improvement of Farm Land

In rice farming the paddy land must be flooded for a considerable part of the planting and growing season. Irrigation has been used in Korea for centuries and the irrigated area has been expanding as the demand for rice increases. More than seven decades have passed since the regulations of irrigation associations were issued in 1906 and modern irrigation facilities began to be installed in 1908. The main feature of farmland improvement projects until 1945 was to construct irrigation by establishing irrigation

Table 4. Mean monthly temperature (in degrees Celsius).

Region	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Gangneung	-1.0	0.3	4.7	11.5	16.7	19.7	23.5	24.3	19.7	14.4	8.8	2.4	12.1
Seoul	-4.9	1.9	3.6	10.5	16.3	20.8	24.5	25.3	20.3	13.4	6.3	-1.2	11.1
Chupun-gryong	-3.1	-0.7	4.5	11.0	16.7	20.6	24.5	24.7	19.4	13.0	6.7	0.2	11.5
Daegu	1.6	0.6	5.7	12.1	17.6	21.6	25.3	25.9	20.5	14.2	7.8	1.4	12.6
Jeonju	-1.7	0.2	5.0	11.3	16.8	21.3	25.7	25.9	20.6	13.9	7.8	1.7	12.4
Gwangju	-0.6	1.1	5.7	11.4	16.8	21.4	25.6	26.1	20.9	14.0	8.2	2.4	12.8
Pusan	1.8	3.5	7.3	12.5	16.7	19.8	23.7	25.4	21.6	16.6	11.1	5.0	13.8
Mogpo	1.0	2.1	5.9	11.5	16.5	20.6	24.8	26.1	21.7	16.1	10.3	4.3	13.4
Cheju	4.8	5.2	8.0	12.3	16.2	20.4	25.1	25.8	21.7	16.8	12.1	7.6	14.7
Mean	-0.6	1.2	5.6	11.6	16.7	20.7	24.7	25.5	20.7	14.7	8.8	2.6	12.7

CMO 1968.

Table 5. Mean monthly precipitation (in millimeters).

Region	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Gangneung	36.9	73.4	73.1	70.4	64.1	134.9	212.1	190.7	197.5	87.8	88.0	53.2	1282.1
Seoul	17.1	21.0	55.6	68.1	86.3	169.3	358.0	224.2	142.3	49.2	36.0	32.0	1259.2
Chupun-gryong	25.4	30.1	56.5	71.9	75.4	167.4	267.6	190.8	154.9	40.4	36.5	29.9	1146.7
Daegu	15.8	27.1	45.5	64.4	67.4	132.7	200.2	165.5	161.8	44.0	30.1	24.8	979.3
Jeonju	26.6	32.8	61.0	76.4	84.7	154.6	279.4	239.6	156.4	51.5	41.7	35.5	1240.7
Gwangju	31.5	34.4	69.1	82.2	92.0	168.8	222.6	201.2	189.5	51.9	42.9	36.9	1222.8
Pusan	25.3	44.1	88.5	113.5	5139.3	197.5	247.6	165.0	205.1	73.1	43.9	38.5	1381.6
Mogpo	37.4	40.2	58.4	82.9	101.3	136.0	182.8	187.8	156.0	55.4	44.2	43.3	1125.9
Cheju	59.2	75.6	73.1	82.3	88.8	158.1	209.8	226.6	249.5	87.5	69.2	60.2	1439.9
Mean	30.6	42.1	64.5	79.1	88.8	157.7	242.2	199.9	179.2	69.1	48.1	39.4	1230.9

CMO 1968.

associations. Until the 1960s, most of the projects involved irrigation water development, farmland consolidation, or farmland development at the individual project basis. Since 1969, when the Geumgang and Pyeongtaeg Comprehensive Agricultural Development Projects began with World Bank loans, most of the farmland development projects have been of the comprehensive or multipurpose type.

At the end of 1985, approximately 949,000 ha of paddy land or 72 per cent of the total paddy land in Korea was fully irrigated. (Table 6) There were about 60,000 irrigation facilities: 18,000 reservoirs, 4,600 irrigation pumping stations, 20,000 weirs, 4,700 infiltration galleries, 11,000 tube wells, and 287 irrigation and drainage pumping stations.

Table 6. Present status of paddy land improvement (in thousand hectares).

	1975	1980	1983	1984	1985
Paddy land area	1,227	1,307	1,316	1,320	1,325
Irrigated paddy area	790	893	929	935	949
Ratio (%)	62	68	71	71	72
Land consolidated area	227	369	415	431	447
Ratio (%)	39	52	59	61	63
Drainage improved area	8	20	30	31	33
Ratio (%)	6	16	23	25	26

Target for land consolidated area is 706,000 ha, that for drainage improved area is 127,000 ha; MAF 1986.

Almost all irrigation facilities are installed for rice paddy cultivation. But in the limited dry fields, mainly distributed near urban areas, irrigation facilities provide for cash crops such as vegetables and fruits. The facilities include sprinkler, drip and other establishments from irrigation canals in the paddy field, or tube wells developed by individuals.

PRESENT STATUS OF DOUBLE CROPPING AND DIVERSIFIED CROPS

The total area of paddies has steadily increased from 1976-85 (Table 7; MAF 1985b), while that planted to rice has slowly decreased. Consequently, cropping intensity on paddies also has decreased from 130.2 per cent in 1976 to 114.5 per cent in 1985. This trend was mainly due to the rapidly decreasing planted area of second crops after rice. However, diversified crops alternated with rice increased slightly. Table 8 (ibid.) shows changes in cultivated area of second crops after rice cultivation in paddies from 1975-87. Barley decreased from 364,634 ha in 1975 to 131,700 ha in 1985. But vegetables such as fruit vegetables, garlic, onion, Chinese cabbage, fodder crops, and other crops increased. Table 9 (ibid.) shows the area given to double cropping systems in paddies selected cultivated areas.

Table 7. Changes in rice-cropping intensity (in million hectares), 1975-85.

Year	Total area	Planted area	Rice-rice	Second crop after rice	Diversified crops*
1975	1.277	1.661	1.189	0.389	0.084
1977	1.303	1.610	1.201	0.304	0.105
1979	1.311	1.619	1.221	0.291	0.108
1981	1.308	1.559	1.209	0.230	0.120
1983	1.316	1.561	1.208	0.243	0.109
1985	1.325	1.517	1.218	0.192	0.106

*Alternated with rice.

Table 8. Planted area (in thousand hectares) of second crops after rice cultivation in paddies, 1975-85.

Crops	1975	1977	1979	1981	1983	1985
Barley	364.6	273.2	248.0	193.4	195.5	131.7
Potato (spring)	5.5	4.4	3.1	3.8	4.4	4.1
Fruit vegetables*	5.2	7.4	7.6	9.7	9.4	9.4
Radish (spring)	1.0	1.6	1.3	1.0	1.2	1.1
Chinese cabbage (spring)	1.9	3.1	3.4	3.0	3.0	3.1
Lettuce	0.2	0.3	0.4	0.4	0.5	0.5
Garlic	3.1	4.7	14.5	7.2	10.2	11.1
Onion	1.8	3.8	4.3	3.5	6.3	4.3
Rapeseed	1.1	1.2	0.4	0.1	0.1	0.1
Fodder crops	0.1	0.2	1.6	1.4	3.6	14.5
Other crops**	4.6	4.5	6.1	6.8	8.9	12.3
Total	389.1	304.5	290.8	230.4	243.2	192.0

*Watermelon, melon, strawberry, cucumber, pumpkin, and tomato. **Ginseng, tobacco, flowers, etc.

Table 9. Double cropping area (in thousand hectares) in paddies, 1985.

Cropping pattern	Area	Per Cent	Main cultivated area
Rice-barley	131.7	68.6	Chonnam, Kyongnambuk, Cheju
Rice-garlic, onion	15.4	8.0	Kyongnambuk, Chungnam, Chonnambuk
Rice-potato	4.1	2.1	Kyongnambuk
Rice-leafy vegetables	4.6	2.4	Kyongnambuk, Chonnambuk, Chungnambuk
Rice-fruit vegetables	9.4	4.9	Kyongnambuk, Chonnambuk, Chungnam
Rice-fodder crops	14.5	7.6	All Country
Rice-other crops	12.4	6.4	Kyongnambuk, Chungnambuk, Chonnambuk
Total	192.1	100.0	

Table 10 shows changes in planted area of diversified crops alternated with rice crop in paddies. There were increases of vegetables such as radish, carrot, Chinese cabbage, spinach, cabbage, red pepper, and Welsh onion.

In 1985, 1,218,403 ha or 92.0 per cent of paddies were cultivated with rice, 192,035 ha or 14.5 per cent of paddies with secondary crops after rice cultivation, and 106,935 ha or 8 per cent of paddies with diversified crops alternated with rice.

Table 10. Planted area (in hectares) of diversified crops alternated with rice, 1975-85.

Crops	1975	1977	1979	1981	1983	1985
Upland rice	550	796	614	706	1,072	315
Miscellaneous grains*	438	4,221	457	1,436	1,252	1,025
Pulses**	16,058	16,270	12,148	12,363	11,083	9,059
Sweet potato	279	274	163	188	241	153
Potato (autumn)	-	-	51	99	46	36
Radish (autumn)	384	726	745	1,009	679	749
Carrot	101	145	350	338	301	378
Chinese cabbage (autumn)	1,276	2,366	4,255	5,082	3,334	3,049
Spinach	282	365	930	906	585	942
Cabbage	73	104	432	296	106	353
Red pepper	3,011	713	1,055	3,033	2,577	2,469
Welsh onion	1,093	1,164	1,735	1,821	1,528	1,891
Ginger	68	64	125	3	147	166
Other vegetables+	806	905	1,574	2,329	1,870	2,324
Cotton	69	21	8	8	4	5
Sesame	347	431	318	330	1,213	1,143
Pelilla seed	262	220	438	570	857	871
Peanut	154	91	171	146	127	76
Other special crops	476	518	478	610	578	551
Medicinal crops	653	170	220	107	369	304
Permanent crops	2,185	2,617	569	652	1,493	1,465
Seed-bed	55,225	73,024	78,336	79,558	69,958	63,878
Crops under facilities	-	-	2,511	8,047	9,974	15,181
Total	83,790	105,205	107,683	119,637	109,394	106,383

*Millet, sorghum, corn, buck wheat; ** soybean, red bean, green bean; +eggplant, dropwort, leek, burdock, mallow, taro, lotus root, yam, crown daisy, asparagus, spinach beet, wild rocambole; crops under facilities are various vegetables under vinyl houses; MAF 1985b.

CONSTRAINTS IN DIVERSIFIED CROPPING UNDER IRRIGATED PADDY CONDITIONS

Physical Constraints

Low temperature is the most serious constraint to cultivating winter crops such as barley, potato, garlic, and spring Chinese cabbage. Other constraints include: Land conditions such as poor drainage, inferior irrigation facilities, and infertile soil; damage from insects and disease; and competition with other crops.

Economic Constraints

Unstable and low prices are the most critical constraints to cultivating vegetables and food grains in paddies. Other constraints include: Lack of farm labor; additional labor required; high price of fertilizer and agricultural chemicals; and high price of farm machinery.

Technological Countermeasures for Relaxing Constraints

Drainage improvement practices are needed first of all. Cultivating practices and technological systems of diversified crops such as barleys, pulses, vegetables, and fodder crops are completely different from those of rice crop. In order to cultivate diversified crops in paddies, there are many problems relating to physiology and cultivation of crops. Table 11 shows the fundamental difference between dry field and wet paddies in the cultivating environments. Table 12 also indicates that the two fields differ in the ground water table, soil moisture, soil structure, hydraulic conductivity, oxidized condition of plow layer, and decomposition of organic matter and fertility.

Table 11. Characteristics of paddies and upland.

	Paddies	Upland
Slope	Level	Exist
Ridge	Exist	None
Ground water table	High	Low
Soil moisture	Abundant	Rare
Permeability (water, air)	Low	High
Irrigation canal	Exist	None
Hard plow layer	Exist	None
Oxidation and reduction	Oxidate	Reduce
Decomposition of organic matter	Small	Big
Fertility and nutrient	Accumulate	Leach
pH	High	Low
Availability of phosphate	Big	Small
Form of nitrogen	NH_4NO_3	NO_3
Weed	Few	Many
Damage from insect & disease	Abundant bacteria	Fungi

Japanese Society of Agriculture and Forestry Statistics 1984.

Table 12 shows the target value of subsurface drainage of various crops. Other measures include on-farm irrigation on the ridge and furrow in paddies, and the promotion of soil fertility through applying organic matter.

Table 12. Target value of subsurface drainage.

Drainage item	Unit	Fodder crop	Ordinary vegetables	Gramineae	High-grade vegetables
Design drainage through under-drain	mm/day	50-100	25	40	80
Permissible days of remaining water on the surface	day	1	1	1	1
Falling velocity of ground water table	mm/day	-	60	100	200
Ground water table depth (7 days after precipitation)	cm	60	-	-	-
Hydraulic conductivity	cm/sec	10^{-4}	10^{-4}	10^{-4}	2.5×10^{-4}
Vanishing velocity of precipitation (flooding water)	mm/day	50-100	60	100	200

Japanese Society of Agriculture and Forestry Statistics 1984.

Agro-economic Countermeasures

These include stability of prices of diversified crops such as barleys and vegetables; choice of control cropping systems suitable for local environments; large scale management systems; supply of proper farming funds; reduced prices of fertilizer and agricultural chemicals.

NOTES

1. Chemical properties of paddy soils (Hong 1972).

pH	Organic matter %	Available P_2O_5 ppm	Exchangeable cations K me/100g	Ca me/100g	Mg me/100g	CEC me/100g	Available SiO_2 ppm
5.5	2.6	6.0	0.23	4.5	1.8	11.7	78

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