AN ABSTRACT OF THE THESIS OF

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(Name of Student) (Degree)

in Agricultural Economics presented on April 20, 1973
(Major) (Date)

Title: AN ANALYSIS OF PRODUCTION AND CONSUMPTION OF FOOD IN KOREA

Abstract approved: Richard S. Johnston

The general objective of this study is to analyze the production and the consumption of food in Korea for the years 1955 through 1969 and to project them for the years 1970 through 1980. This study has the following purposes:

(1) To examine the trend in food production and yield.

(2) To investigate the factors affecting food production and food consumption.

(3) To project future food production and consumption.

(4) To examine how much food production can be increased by changing from rice to other grain production in the rain-fed and upland rice area and to examine what effect this would have on domestic food supply.

(5) To project future food production and consumption if other grain production were to replace rice in the rain-fed and

upland rice area.

Total food production increased by 60.6% during the period of 1955 to 1969. While the amount of food supplied domestically (domestic food production plus change in stock) had increased by 42.9% the amount of food consumed was found to have increased 92.5% during the same period. It is shown that during the period of 1955 to 1969, except for 1955, the amount of food supplied domestically lagged behind the consumption of it and the gaps were filled by imports.

The food shortage gradually widened because of (1) rapidly increasing population and (2) changes in income. Food shortages were more crucial in the recent three years from 1967 to 1969. Food shortage as a percentage of total food consumption in 1967, 1968, and 1969 was found to be 14.2, 19.0, and 23.6%, respectively. It was estimated that the quantity of food supplied domestically should be increased by 16.5% for 1967, 23.4% for 1968, and 31.0% for 1969 to achieve the self-sufficient food level at the market prices of those years.

According to the projections of aggregate production and consumption of food, the average year by year food shortage would be 1,414,600 M/T during the period of 1970 to 1980. This is equivalent to 13.05% of the total food consumption and the rate of self-sufficiency would be 85.16%.

If rain-fed and upland rice areas, at least, were replaced by other grain production such as potatoes, millet, and sorghum, which require less water than rice, there is no doubt that more food could be produced. Planted at the right time any of these crops would produce more food volume than does rice under the present uncertain weather conditions and poor irrigation facilities.

A considerable amount of gain can be obtained by replacing the rain-fed and upland rice area by production of other grains, assuming that the same production practices and input factors are used and no change in prices took place. Under this assumption, the average possible gain in production for 1955 to 1969 was found to be about 141, 000 M/T every year. This indicates that food production could have been increased by 2. 35% and the shortage of food could have been reduced by 19. 14% during the same period.

The projected possible shortage of food during the period of 1970 to 1980 would be 1, 190, 800 M/T per year under the assumption that some rice areas are converted to production of other grain. This shortage is equivalent to 11. 0% of the total food consumption and the rate of self-sufficiency would be 87. 79%. Under this assumption, it was estimated that the shortage of food could be reduced by 223, 800 M/T (15. 8%) per year during the projection period.

Korea is not in a position at present and in the near future (projected 11 years) to achieve a level of self-sufficiency in food production. This is, like other developing countries, due to insufficient irrigation facilities; inability of the government to maintain an effective agricultural program; shortage of farm tools and equipment; shortage of trained personnel; and agricultural research organization; and to a shortage of fertilizer supply.

If self-sufficiency is desired, Korean people should change the food consumption pattern from rice to other grain. The most important solution to the food problem would be the pricing policy in the food market and government participation in providing necessary technical assistance and other production incentives needed by farmers.

An Analysis of Production and Consumption of Food in Korea

by

Kwang Hi Im

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

June 1973

APPROVED:

Professor of Agricultural Economics
in charge of major

Head of Department of Agricultural Economics

Dean of Graduate School

Date thesis is presented April 20, 1973

Typed by Velda D. Mullins for Kwang Hi Im

ACKNOWLEDGMENT

I wish to express my most sincere gratitude and appreciation to my major professor, Dr. Richard S. Johnston, Professor of Agricultural Economics. He has been more than a dedicated advisor throughout my graduate days. His patience, understanding, and encouragement have guided me through the worst and provided the incentive to continue.

My sincere appreciation and thanks are expressed to members of my Graduate Committee: Dr. Richard S. Johnston, Dr. Joe B. Stevens of the Department of Agricultural Economics, and Dr. Charles E. Land of the Department of Statistics at Oregon State University.

To Jang-hi, my younger brother, who is a Ph. D. candidate in Civil Engineering at M. I. T., I am indebted for the financial assistance which has enabled me to finish this study.

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AN ANALYSIS OF PRODUCTION AND CONSUMPTION OF FOOD IN KOREA

I. INTRODUCTION

According to Ch'oe (2, p. 4), "The agonies facing Korean agriculture today are found in the heavy proportion of farming families to the nation's population, a scarcity of arable land, and backwardness of farm management, the relatively large numbers in the average farming family and a subsequent labor glut, rudimentary agricultural skills, overemphasis placed on staple grains, and a low yield with its subsequent meagre rural income."

Statistics for 1969 reveal that the Republic of Korea's total population is 31.4 million people, of which 49.6% are members of farm families who are concentrated on 24% of the land. The mountainous and hilly terrain of much of the country is the fundamental limiting factor in the amount of land use. In recent years, the rate of conversion of uncultivated land to agricultural uses has not been as rapid as the rate of growth of population. The population growth rate in 1969 was 2.3% and the average size of a rural household was 6.1 persons, while the average quantity of arable land employed per farming household was 2.2 acres (equivalent to 9.15 tanbo).

Consumption of food in Korea has been growing rapidly and will probably continue to increase significantly in the near future primarily due to population and income increases. Small gains in production are rapidly absorbed by population increases. Although Korea has always been recognized primarily as an agricultural nation, domestic food production has not been able to keep pace with this fast growing consumption. Food deficits have been met by increasing imports. An interesting agricultural policy question concerns the impact of changing some agricultural techniques on the domestic food supply.

Purposes of the Study

The study is conducted to:

1. Examine the trend in food production and yield.
2. Investigate the factors affecting food production and consumption.
3. Project future domestic food production and consumption.
4. Examine how much food production can be increased by changing from rice to other grain production in the rain-fed and upland rice area and to examine what effect this would have on domestic food supply.
5. Project future domestic food production and consumption if other grain production were to replace rice in the rain-fed and upland rice area.

Methodology

In order to meet the above purposes, emphasis was placed on statistical analysis of existing data. Simple linear regression was employed for most of the statistical analyses and projections. Time 't' was employed as an independent variable for most of the simple linear regression equations only for forecasting purposes and for showing the general historical trends. The Cobb-Douglas production function was the principal functional form used for the food production projection. All the projections assume that the general trends occurring between 1955 and 1969 will continue.

A general view of changes which occurred in Korean agriculture is presented here for the period from 1955 to 1969. The availability of continuous statistical time series data on agricultural production and related variables provided the main reason for choosing this time span.

The analysis of food given here is only in terms of physical units and does not reflect the relationship between price and quantity.

Most of the data used were obtained from published sources of various forms by the Ministry of Agriculture and Forestry, the Economic Planning Board, the National Agricultural Cooperative Federation, and other Korean government agencies.

Terminology

The 'food' investigated for this study included grains and potatoes used for human consumption, seed, animal feed, industrial purposes, and, because of measurement problems, included loss and waste. These are grouped into two categories: rice and other grain. Other grain included barleys, wheat, rye, millets, sorghum, corn, beans, and potatoes. All these food grains were expressed in terms of polished weight. Unhulled potatoes are converted into 'polished grain equivalents' with a given weight, i.e., potatoes 0.2 and sweet potatoes 0.31.

The 'cheongbo' and 'tanbo' are Korean units of land; one cheongbo is equivalent to 2.45 acres and one tanbo is equivalent to 0.245 acres. M/T is metric ton and one M/T is equivalent to 1,000 kilogrammes. When regression results are presented, the numbers in parentheses beneath the estimated regression coefficients are the standard errors.

It must be emphasized that the term 'self-sufficiency' is used in this study to describe the situation in which at some level of price domestic production is equal to domestic consumption. No normative implication is intended.

II. CHARACTERISTICS OF KOREAN AGRICULTURE

The agricultural sector is characterized by subsistence farming in the sense that it produces goods primarily for its own consumption. The structure of the Korean agricultural sector can be described as too many people, too little land, and too few natural resources. The topography of the country with its high proportion of mountainous country restricts the farm lands to approximately 24% of the total area, and the pressure of population on the land resources has led to the development of small peasant farms.

Importance of Agriculture

Agriculture is the key to economic development. No country has developed a strong economy and a high standard of living without a highly productive agricultural sector (8, p. 46). Agriculture can contribute to the entire process of economic growth and the interrelationships between the agricultural and non-agricultural sectors help determine the rate of economic development. Yet, making agriculture more productive is one of the most difficult economic tasks that a nation faces.

Korea still retains the characteristics of an agricultural nation. The importance of agriculture in Korea may be seen readily if one considers that about a half (49.6% in 1969) of the total population is engaged in agriculture. Agriculture's 'value added' constituted 28.1% of GNP in 1969.

According to the FAO (7, p. 1), there are five main aspects of agriculture's contribution to economic progress:

1. Agriculture's responsibility for the supply of food and raw materials.
2. Agriculture as an earner of foreign exchange.
3. Agriculture as a base for industrialization.
4. Agriculture as a source of capital.
5. Agriculture as a source of manpower.

The first contribution of agriculture is to provide food and raw materials for the rest of the economy. It is the growing demand for food and raw materials from other sectors which provides the main stimulus to agricultural development. Further, agriculture provides a market for the budding industries of developing economies, while the products of industry furnish the improved implements, fertilizers and other requisites for increased farm production.

The second contribution of agriculture is to provide foreign exchange to import capital goods for the industrial sector. The exports of agricultural products with which to finance the needed imports are a traditional contribution which agriculture makes to economic growth.

The third contribution of agriculture is to provide a base for industrialization. It is common in a developing country to find that agricultural raw materials and unskilled labor are plentiful, while skilled labor, capital and foreign exchange are scarce. The plentiful agricultural raw materials are an incentive to further processing. Developing countries are in a favorable condition to make good use of their abundant resources for their industries and industrial processes. Rising agricultural productivity and income will contribute to the industrial sector.

The fourth contribution of agriculture is to give a source of capital. The process of economic development in a predominantly agricultural economy demands capital for the creation and expansion of manufacturing and mining enterprises, for overhead investments in transportation, power supply and communications, and for the expansion of social services. This transformation of the economic structure is an essential feature of economic progress. In newly developing countries, a key problem of development policy is to find the capital needed to finance this transformation. In the initial stages of economic growth, most of the national product arises in agriculture. At the same time, capital formation is needed within agriculture itself to improve the productive capacity of this sector. Without a net outflow of funds from agriculture at this stage, the growth of the economy as a whole may remain limited. If the burden is allowed to become so heavy that farmers have no incentive for improving methods and increasing production, other serious problems will certainly arise to hold back overall development (7, p. 9).

Finally, agriculture supplies manpower to the industrial sector, but this release of manpower leads to higher agricultural productivity and higher farm incomes. Economic growth is associated with a declining percentage of the labor force engaged in agriculture. Increased agricultural production and productivity can be possible with a declining labor force by the improvement of production methods. This permits the transfer of manpower from agriculture to industry and other non-farm occupation.

Changes in Industrial Structure

Let us partition the Korean economy into three sectors: primary, secondary, and tertiary (see note in Table 1 for definitions of these terms), and examine the contribution of each sector to GNP during the period of 1955 to 1969. In 1955, the primary sector contributed 47.2%, the secondary sector 11.1%, and the tertiary sector 41.7% of GNP. In 1969, that of the primary sector sharply decreased to 28.1%, that of the secondary sector sharply increased to 26.1%, and that of the tertiary sector continuously increased to 45.8% (see Table 1).

If this trend continues and if it can be viewed as a linear trend, the contribution of each sector to GNP projected by linear regression

Table 1. The contribution of each sector to GNP (at 1965 constant market prices).

		Unit: percent		
Year	GNP	Primary sector	Secondary sector	Tertiary sector
1955	100	47.2	11.1	41.7
1956	100	44.2	12.8	43.0
1957	100	44.1	13.2	42.7
1958	100	44.6	13.5	41.9
1959	100	42.3	14.1	43.6
1960	100	41.4	15.1	43.5
1961	100	43.8	14.9	41.3
1962	100	39.7	16.7	43.6
1963	100	39.1	17.8	43.1
1964	100	41.9	17.3	40.8
1965	100	38.7	19.5	41.8
1966	100	37.9	19.8	42.3
1967	100	32.7	22.3	45.0
1968	100	29.0	24.9	46.1
1969	100	28.1	26.1	45.8

Note: Primary sector includes agriculture, forestry, and fishery; secondary sector includes mining, quarry, manufacturing, construction, and electricity and gas services; and tertiary sector includes water service and sanitary, communication, transportation and warehouse, wholesale and retail , banking, insurance and real estate, housing, public administration and national defense, services, and rest of the world.

Source: (33, p. 459)

(see Appendix I, 1) are 24.6, 29.9 and 45.5% in 1975 and 18.8, 34.7 and 46.5% in 1980, respectively. The continued decline in the weight of the agricultural sector and the rise in that of non-agricultural sectors are indicative of the typical pattern of industrialization in

Korea as well as in the rest of the world. Industrialization is an essential factor for agricultural development.

FAO indicates (6, p. 1) that industrialization is one of the chief objectives of every developing country. Indeed, a characteristic difference between developed and developing countries is in the relative position of agriculture and industry in their economies. In developing countries agriculture generally accounts for the major proportion of national income, employment and exports, and manufacturing and other industries as yet play only a small part in the economy. In developed countries the position is reversed, and the non-agricultural sectors predominate. Because of the diminishing relative importance of agriculture as development goes forward, there has sometimes been a tendency to identify economic development with industrialization and to devote insufficient resources to the agricultural sector. However, it has increasingly been realized that agriculture and industry are mutually dependent. Recent experience in a number of countries has demonstrated that a lagging agriculture may jeopardize industrialization and the growth of the economy as a whole.

Type of Farm

Korean farms may be divided into four categories according to the farm size: smallest, small, medium, and large. The 'smallest' farm can be defined as those farm households which own less than 0.5 cheongbo (1.225 acres) of cultivated land, the 'small' farm as those which own 0.5 to 1.0 cheongbo (1.225 to 2.45 acres), the 'medium' farm as those which own 1.0 to 2.0 cheongbo (2.45 to 4.90 acres), and the 'large' farm as those which own more than 2.0 cheongbo.

Tables 2 and 3 show the general trend in cultivated land holdings and in the farm household distribution by size of farm. In 1969, 35.4% of total farm households owned farms of the 'smallest' size and yet these farms accounted for only 11.5% of all cultivated land. On the other hand, the 'small'farm category accounted for 31.7% of the total farm households and represented 26.7% of the total acreage. Likewise, the 'medium' and 'large' farms accounted for 26.2 and 6.7%, respectively, of the total farm households and 40.8 and 21.0%, respectively, of the total arable acreage.

As of 1969, 67.1% of all farm households owned farms in the 'smallest' and 'small' farms and yet the land on these farms totaled only 38.2% of all cultivated land.

If these rates continue, possession of cultivated land in 1975 and 1980 are linearly projected (see Appendix I, 2) to be 8.4 and 5.9% in the 'smallest' farm, 26.1 and 25.3% in the 'small' farm, 42.7 and 44.6% in the 'medium' farm, and 22.8 and 24.2% in the 'large' farm category. Meanwhile, the distribution of farm

Table 2. Percentage of cultivated land owned by various size of farm.

	Unit: percent				
Year	Total	Smallest	Small	Medium	Large
1955	100	18.0	29.2	35.9	16.9
1956	100	17.6	28.5	36.3	17.6
1957	100	17.3	28.3	36.5	17.9
1958	100	16.6	27.9	36.7	18.8
1959	100	16.6	27.9	36.9	19.6
1960	100	16.7	27.9	36.9	18.5
1961	100	15.7	28.7	37.1	18.5
1962	100	15.9	29.7	36.4	18.0
1963	100	16.1	28.9	36.6	18.4
1964	100	15.1	28.3	36.8	19.8
1965	100	12.4	26.7	40.5	20.4
1966	100	12.1	26.9	40.4	20.6
1967	100	11.8	27.0	40.3	20.9
1968	100	11.6	26.7	40.5	21.2
1969	100	11.5	26.7	40.8	21.0

Source: 23, p. 180-181; 33, p. 46-47; 36, p. IV-14-15.

households in 1975 and 1980 are projected (see Appendix I, 3) to be 31.0 and 27.6% in the 'smallest' farm, 33.0 and 33.6% in the 'small' farm, 28.8 and 31.3% in the 'medium' farm, and 7.2 and 7.5% in the 'large' farm, respectively.

According to this projection, in 1975, the 'smallest' and the 'small' farms will be farmed by 64.0% of the total farm households and will represent 34.5% of the total acreage. In 1980, the figures will be 61.2% and 31.2%, respectively.

As shown in Table 3, between 1955 and 1969, the percentage

Table 3. Percentage of total households which own variously sized farms.

	Unit: percent				
Year	Total	Smallest	Small	Medium	Large
1955	100	43.0	31.1	20.1	5.8
1956	100	42.8	30.7	20.4	6.1
1957	100	42.8	30.4	20.6	6.2
1958	100	42.2	30.4	20.9	6.5
1959	100	42.3	30.3	20.9	6.5
1960	100	42.9	30.1	20.7	6.3
1961	100	40.7	31.8	21.1	6.4
1962	100	41.0	32.5	20.5	6.0
1963	100	41.8	31.5	20.6	6.1
1964	100	39.9	31.9	21.5	6.7
1965	100	35.0	32.0	26.0	7.0
1966	100	35.2	32.2	25.8	6.8
1967	100	35.6	32.0	25.7	6.7
1968	100	35.5	31.8	25.9	6.8
1969	100	35.4	31.7	26.2	6.7

Source: 23, p. 180-181; 33, p. 46-47; 36, p. IV-14-15.

of the 'smallest' farm households decreased significantly, while, on the other hand, the percentage of the 'medium' farm households increased remarkably. Meanwhile, the percentage of the 'large' farm households increased steadily.

Management of Farm Land

Table 4 shows that 91.8% of farm households are engaged in the cultivation of food grains in 1969. Korean agriculture still

Table 4. Number of farm households by type of cultivation.

Unit: 1,000 households

Year	Total	%	Cultivation					
			Paddy field	%	Upland	%	Others*	%
1955	2,218	100	1,797	81.0	377	17.0	44	2.0
1956	2,201	100	1,799	81.8	362	16.4	40	1.8
1957	2,211	100	1,812	82.0	360	16.3	39	1.7
1958	2,218	100	1,826	82.3	352	15.9	40	1.8
1959	2,267	100	1,875	82.7	351	15.5	41	1.8
1960	2,349	100	1,948	82.9	362	15.4	39	1.7
1961	2,327	100	1,930	82.9	357	15.3	40	1.8
1962	2,469	100	2,018	81.7	403	16.3	48	2.0
1963	2,416	100	1,966	81.4	405	16.8	45	1.8
1964	2,450	100	1,970	80.4	429	17.5	51	2.1
1965	2,507	100	1,898	75.7	549	21.9	60	2.4
1966	2,540	100	1,868	73.5	593	23.4	79	3.1
1967	2,587	100	1,814	70.1	616	23.8	157	6.2
1968	2,579	100	1,836	71.2	527	20.4	216	8.4
1969	2,546	100	1,825	71.7	512	20.1	209	8.2

Note: *Includes those farm households which cultivate fruits, vegetables, special crops, and cocoon production, etc.

Source: 26, p. II-86-87; 33, p. 36-37; 36, p. IV-18.

remains in the old production mode of self-support for a rural family even though the number of farm households cultivating crops other than food grains is increasing. The percentage of farm households cultivating rice, represented in Table 4 by the numbers in the column headed 'paddy field', shows a decline. The rapid expansion achieved in upland cultivation is due to an increase in the number of families which have reclaimed new land or who have resettled in new areas.

More than 70% of all farm households are engaged in rice cultivation. It is beneficial for farm households to do upland cultivation for other crops requiring less water, such as potatoes, millet, and sorghum (44, p. 82). These other crops planted at the proper time will increase production of food per unit area more than will rice under the present uncertain weather condition.

Population

Total and Farm Population

Total population, agricultural population, and the population of 'man-equivalent' full-time farm workers (defined below) in 1969 were 31.41, 15.59, and 4.84 million, respectively. These figures are approximately 55.5, 17.8, and 15.3% higher, respectively, than that for 1955 (Table 5). Statistics for 1969 reveal that the farm population constitutes 49.6% of the entire population of Korea.

Table 5. Farm population compared with total population.

Unit: 1,000 persons

Year	*Total population (A)	Index 1955=100	Farm population (B)	Index 1955=100	(B/A)%	** Farm workers	Index 1955=100
1955	20,202	100.0	13,230	100.0	65.5	4,196	100.0
1956	22,307	110.4	13,445	101.6	60.3	4,181	99.6
1957	22,949	113.6	13,591	102.7	59.2	4,199	100.1
1958	23,611	116.9	13,750	103.9	58.2	4,214	100.4
1959	24,291	120.2	14,126	106.8	58.2	4,315	102.8
1960	24,989	123.7	14,559	110.0	58.3	4,462	106.3
1961	25,700	127.2	14,509	109.7	56.5	4,425	105.5
1962	26,432	130.8	15,097	114.1	57.1	4,694	111.9
1963	27,184	134.6	15,266	115.4	56.2	4,582	109.2
1964	27,958	138.4	15,553	117.6	55.6	4,654	110.9
1965	28,670	141.9	15,812	119.5	55.2	4,761	113.5
1966	29,375	145.4	15,781	119.3	53.7	4,829	115.1
1967	30,067	148.8	16,078	121.5	53.5	4,911	117.0
1968	30,747	152.2	15,908	120.2	51.7	4,899	116.8
1969	31,410	155.5	15,589	117.8	49.6	4,840	115.3

Note: * The figures shown are the estimates of population projection based on both 1955 and 1960 population census results, as of December 1.
** These figures are estimated by the author.

Source: 13, p. 4; 26, p. II-79; 33, p. 25.

Farm workers consist of all members of the farm household except the school children, the very old and the very young. The productivity of these workers may be different depending on their sex and ages. Therefore, it is reasonable to describe the agricultural labor force in terms of an index of 'man-equivalent' full-time workers between the ages of 15 and 59. Table 6 shows the weights used in constructing one such index. A male worker whose age is between 15 and 59 years is given the weight of 1.0, a female worker of the same age of 0.6, etc.

Table 6. Weights given to workers of different ages and sex to derive 'man-equivalent' labor force index.

Sex	14 and under	15 to 59	60 and above
Male	0.3	1.0	0.6
Female	0.3	0.6	0.4

Source: 3, p. 36.

It has been found that when the workers are given the weights as shown in Table 6 the average farm family of 6.12 members (in case of 1969) has a working force of 1.9 men. The ratio of the total farm population to the 'man-equivalent' working force is (6.12/1.9) = 3.221. Thus, dividing the total agricultural population by 3.221, yields a total labor force measured in terms of full-time male workers between 15 and 59 years of age (see 4, p. 36).

The ratio of the total agricultural population to the 'man-equivalent' working force is different each year due to the fluctuations in the size and composition of the average farm household. The estimated 'man-equivalent' full-time labor force is shown in Column 7 of Table 5.

As shown in Table 7, farm population per farm household increased between 1955 and 1964 and has been decreasing since. On the other hand, the land holding per farm household increased between 1955 and 1958, decreased between 1958 and 1962, and has been increasing since. Meanwhile, there has been a steady decline in the proportion of paddy field holding and an increase in the proportion of upland holding.

It is true that the agricultural population is decreasing in percentage terms; in 1955, 65.5% of the total population were farmers, but by 1969 this figure had dropped to 49.6%. This is primarily due to the efforts of the government for the ultimate goal of modernization. Modernization is considered as urbanization. Korea has experienced a very rapid urbanization rate of late.

For the first time, Korea set the so-called first five-year (1962-66) economic development plan in order to raise its standard of living and to achieve its industrialization. The second (1967-71) and the third (1972-76) five-year plan followed. Each successive plan has called for greater increases in national income and in

Table 7. Trend of increase in the size of farm population per farm household and cultivated land per farm household.

Year	Farm population per farm household (persons)	Cultivated land per farm household (tanbo) Total (A)	Paddy field (B)	(B/A) %	Upland (C)	(C/A) %
1955	5.99	9.07	5.40	59.54	3.67	40.46
1956	6.11	9.13	5.45	59.69	3.68	40.31
1957	6.15	9.12	5.44	59.65	3.68	40.35
1958	6.20	9.15	5.45	59.56	3.70	40.44
1959	6.22	8.96	5.35	59.71	3.61	40.29
1960	6.20	8.69	5.18	59.61	3.51	40.39
1961	6.23	8.81	5.25	59.59	3.56	40.41
1962	6.11	8.42	4.99	59.26	3.43	40.74
1963	6.33	8.68	5.13	59.10	3.55	40.90
1964	6.35	8.93	5.19	58.12	3.74	41.88
1965	6.31	9.07	5.17	57.00	3.90	43.00
1966	6.21	9.10	5.11	56.15	3.99	43.85
1967	6.22	9.01	5.03	55.83	3.98	44.17
1968	6.17	9.07	5.04	55.57	4.03	44.43
1969	6.12	9.15	5.08	55.52	4.07	44.48

Note: Columns 3 to 5 are calculated by the author.

Source: 27, p. III-45; 33, p. 25.

production than its predecessor and reflected some different ideas for priorities. The second five-year plan was twice the size of the first and emphasis was placed on the shift from agriculture to large scale industry. The third five-year plan also called for a larger investment in industry than in agriculture.

According to the 1970 census the total population of 32 major cities in 1960, 1966, and 1970 constituted 29.1, 33.6, and 41.2%, respectively, of the total population. The population of Seoul, the center of government, culture, business, education and entertainment, increased from 2, 445, 402 in 1960 to 5, 536, 377 in 1970, up 126.4% (22, p. 10).

Seoul in 1970 accounted for a staggering 17.6% of the total Korean population. The comparable figure was 9.8% in 1960 and 13.0% in 1966. Thus Seoul has become an even more concentrated population center than Tokyo and London, where around 12% of the respective national populations reside (10, p. 6 and 22, p. 10).

Such a rapid expansion of urban areas is rather common in the developing countries and is regarded as a welcome sign of industrialization except for the accompanying widened povery gap between rural and urban populations. The unsatisfactory movement to urban areas is associated with an increased need for food imports. Meanwhile, this movement may serve to provide cheap labor for urban industries and commercial activities. But this may lead to an increased farm labor shortage during the harvesting seasons. Nevertheless the remarkable economic growth in the second half of 1960's was due to the very sharp expansion of the urban-industrial sectors.

Projection of Total and Farm Population

It is essential to project total and farm population in order to estimate food requirements in the future. Table 8 shows some projected figures.

Total Population Projection

Total population projection figures from 1970 to 1980 shown in Table 8 are based on the published population estimates (17, p. 62-65) of the Economic Planning Board of Korea. These estimates were calculated by the Economic Planning Board from theoretical population models adjusted to accord with observed facts. As is well known, future population growth is affected by many social and economic factors. It is, indeed, difficult to predict accurately what the population will be 15 years or even 10 years hence. These estimates for future population, nevertheless, provide us valuable estimates regarding the trend of Korean population.

Farm Population Projection

As far as farm population projections are concerned, there are no available data on the number of births and deaths or on in-migration, and out-migration of the farm population.

Farm population projections have been made with the simple

Table 8. Projection of total and farm population, and 'man-equivalent' full-time farm labor, 1970-1980.

Year	Total population	Farm population	$\frac{(3)}{(2)}$ x 100	Farm household	(3)/(5) (Farm population per farm household)	(6)/1.9 (Ratio of total farm pop. to the 'man-equiv.' farm labor)	(3)/(7) ('Man-equiv.' farm labor)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	1,000	1,000	%	1,000	person	ratio	1,000
1970	31,727	15,921	50.18	2,607	6.11	3.22	4,951
1971	32,418	16,008	49.38	2,635	6.08	3.20	5,003
1972	33,082	16,071	48.58	2,663	6.04	3.18	5,055
1973	33,745	16,123	47.78	2,690	5.99	3.15	5,114
1974	34,409	16,165	46.98	2,718	5.95	3.13	5,162
1975	35,073	16,197	46.18	2,746	5.90	3.11	5,216
1976	35,737	16,217	45.38	2,774	5,85	3.08	5,267
1977	36,428	16,240	44.58	2,802	5.80	3.05	5,320
1978	37,118	16,250	43.78	2,830	5.74	3.02	5,379
1979	37,809	16,250	42.98	2,857	5.69	2.99	5,426
1980	38,500	16,239	42.18	2,885	5.63	2.96	5,480

Note: Column 2 is projected by the Korean government (17, p. 62-65).

linear regression method using 1955-1969 data. A linear relationship between the ratio of farm population to total population (Table 5) and time has been estimated. This equation was then used to forecast the ratio for the years 1970 to 1980 under the assumption that the same component pattern continues. The estimated forecasting equation is presented in the next section.

'Man-Equivalent' Farm Labor Projection

Projections of the number of farm households have been made using the method as the farm population projection. With these projected results, the 'man-equivalent' farm labor can easily be found by using the weights given in Table 6.

The following simple linear regression was applied for the above projections.

$$\hat{Y} = 62.989 - .800 \underset{(.079)}{X^{*}} \qquad (2\text{-}1)$$

$$r^2 = .89$$

$$S_y = 3.79$$

where X = years from 1955 to 1969.

$\hat{Y}$ = ratio of total population to farm population.

$$\hat{Y} = 2161.80 + 27.825 \underset{(2.85)}{X^{*}} \qquad (2\text{-}2)$$

$$r^2 = .87$$

$$S_y = 141.84$$

* Significant at the 1% level.

where X = years from 1955 to 1969.

$\hat{Y}$ = number of farm households (in units of 1, 000).

III. FOOD PRODUCTION

This chapter will briefly examine the general trend in food production, with emphasis mostly on factor inputs and productivities of factors. Projection for food production from 1970 to 1980 will be made in order to forecast food supply in the future.

Factors of Production

This section will discuss the growth of factor inputs, land, labor, and capital, during the 1955-1969 period. In addition to these factors, rainfall and temperature are also examined.

In Korea, capital inputs are very small with home grown seed likely the most important capital component. Land, because of its scarcity, must be considered as one of the most limiting factors. Labor and the fourth factor of production, the entrepreneur, are the chief sources of labor services (4, p. 22).

Each of the three conventional input factors has its own special characteristic. As an economy develops, the share of the labor force in agriculture declines.

Developed regions are generally characterized by high capital input and relatively low labor inputs per unit of land, whereas less developed regions usually have low capital inputs and high labor inputs (43, p. 83).

Land

Korea, according to the statistics of 1969 from the Ministry of Agriculture and Forestry, has a total area of 9, 929, 484 cheongbo, of which 2, 330, 419 (24%) cheongbo are arable land, and 7, 599, 065 (76%) cheongbo are classified as forest, waste and other lands. These figures are shown in Table 9.

Table 9. Status of national land and cultivated land.

Unit: 1, 000 cheongbo

Year	National total land	Cultivated land Total	(3)/(2) %	Paddy field	(5)/(3) %	Upland	(7)/(3) %
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1955	9, 925	2, 011	20	1, 197	59.5	814	40.5
1956	9, 925	2, 008	20	1, 198	59.7	810	40.3
1957	9, 925	2, 015	20	1, 203	59.7	812	40.3
1958	9, 925	2, 029	20	1, 210	59.6	819	40.4
1959	9, 925	2, 033	20	1, 213	59.7	820	40.3
1960	9, 925	2, 041	21	1, 216	59.6	825	40.4
1961	9.925	2, 049	21	1, 221	59.6	828	40.4
1962	9, 925	2, 080	21	1, 233	59.3	847	40.7
1963	9, 925	2, 097	21	1, 238	59.0	859	41.0
1964	9, 925	2, 189	22	1, 272	58.1	917	41.9
1965	9, 931	2, 275	23	1, 297	57.0	978	43.0
1966	9, 929	2, 312	23	1, 298	56.1	1, 014	43.9
1967	9, 929	2, 331	24	1, 301	55.8	1, 030	44.2
1968	9, 929	2, 338	24	1, 300	55.6	1, 038	44.4
1969	9, 929	2, 331	24	1, 294	55.5	1, 037	44.5

Source: 32, p. 72; 33, p. 20 & 66.

Of the arable land, about 13% are paddy field and about 11% are dry field or upland. A certain amount of the paddy fields, however, is situated on the slopes of hills entirely dependent on rain.

The summer crops are cultivated on dry fields but, in the southern parts of the country, extensive areas of paddy fields are used for cultivating two major crops (barley and wheat) before the rice plants are transplanted to the rice fields in early months (4, p. 36-37).

Table 10 shows the growth of cultivated land. Column 2 shows the total cultivated land and column 4 shows the double crop area. As shown in Columns 6 and 7, total cultivated land and double crop area have increased by 15.9 and 16.8%, respectively, during the period of 1955-1969 when 1955=100.

Applying simple regression analysis to compare the expansion of the total cultivated land and the double crop area during the years under study, a linear relationship between acreage and time can be estimated.

$$\hat{Y} = 1913.97 + \underset{(2.90)}{28.58}\, X^{*} \qquad (3\text{-}1)$$

$$r^2 = .88$$

$$S_y = 136.1$$

where X = years from 1955 to 1969.

$\hat{Y}$ = total cultivated land in units of 1,000 cheongbo.

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* Significant at the 5% level.

Table 10. Growth of cultivated land.

Unit: 1,000 cheongbo

Year	Total cultivated land	Total planted land	Double* crop area	(4)/(2) %	Index of total cultivated land (1955=100)	Index of double crop area (1955=100)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1955	2,011	2,640	315	15.7	100.0	100.0
1956	2,008	2,687	340	16.9	99.9	107.9
1957	2,015	2,758	371	18.4	100.2	117.8
1958	2,029	2,695	333	16.4	100.9	105.7
1959	2,033	2,704	336	16.5	101.1	106.7
1960	2,041	2,726	343	16.8	101.5	108.9
1961	2,049	2,764	357	17.4	101.9	113.3
1962	2,080	2,828	374	18.0	103.4	118.7
1963	2,097	2,916	410	19.6	104.3	130.2
1964	2,189	3,062	437	20.0	108.9	138.7
1965	2,275	3,248	487	21.4	113.1	154.6
1966	2,312	3,116	402	17.4	115.0	127.6
1967	2,331	3,135	402	17.2	115.9	127.6
1968	2,338	3,103	383	16.4	116.3	121.6
1969	2,331	3,065	368	15.8	115.9	116.8

Note: * Double crop area = $\frac{(3) - (2)}{2}$

Columns (4) to (7) were calculated by the author.

Source: 33, p. 76 & 128.

$$\hat{Y} = 327.09 + 6.26\ X^{*} \quad (3\text{-}2)$$
$$(2.20)$$

$$r^2 = .38$$

$$S_y = 45.19$$

where X = years from 1955 to 1969.

$\hat{Y}$ = total double crop area in units of 1,000 cheongbo.

The above two equations show that both cultivated land and double crop areas significantly increased during the period of 1955 to 1969.

Even though the cultivated land and double crop areas are increasing annually, the area of cultivated land per farm household is relatively stable (see Table 7). The cultivated land has increased by 15.9% during the period from 1955 to 1969 (Table 10), while the rate of increase in the number of farm households during the corresponding period was 14.8% (from Table 4), thereby recording a relatively fixed cultivated land allotted to each farm household on an average. Sizeable areas of land are being lost to non-food uses such as highway, parks, residential and industrial expansion.

Multiple cropping is a practice deserving considerable attention as it becomes necessary to obtain a greater output from a limited amount of land. Multiple cropping is not, however, a simple matter of just planting more than one crop per year. It requires substantially greater inputs of capital and labor and more sophisticated management,

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* Significant at the 5% level.

practices. Many physical factors operate to limit multiple cropping. Temperature limitations are perhaps the most common (43, p. 103).

The following Table 11 shows the general trend of planted rice area classified by the nature of the irrigation facilities. As shown in Table 11, the non-irrigated area significantly decreased every year. But we cannot expect this trend to continue because most of these non-irrigated areas are located on the slopes of hills. In 1969 figures, the completely or partially irrigated area is 1, 067, 000 cheongbo, of which the partially irrigated area is 250, 000 cheongbo. Therefore the completely irrigated area is only 817, 000 cheongbo (66.4%).

Rainfall is a limiting factor in Korea since the irrigation systems are not fully developed. Korea has a monsoon climate with relatively warm year round temperatures and is characterized by heavy summer rainy seasons followed by an annual dry season of several months duration. The wet season is ideal for rice cultivation but crops can be successfully grown during the dry season only if irrigation is available.

The following Figure 1 suggests that the total food production in Korea is closely related to the rainfall and temperature. Production of food and annual rainfall moved in the same direction during the period from 1955 to 1969 except for 1956 and 1964. In 1956,

Table 11. Rice planted area by irrigation facilities.

Unit: 1,000 cheongbo

Year	Total rice planted area	Completely or partially irrigated area	Non-irrigated area			(4)/(2) %
			Total	Rain-fed area	Upland rice	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1955	1,098	796	302	298	4(70)*	27.5
1956	1,106	816	290	287	3(55)	26.2
1957	1,114	834	280	276	4(34)	25.1
1958	1,118	849	269	265	4(74)	24.1
1959	1,122	868	254	250	4(44)	22.6
1960	1,130	883	247	243	4(60)	21.5
1961	1,137	901	236	231	5(82)	20.7
1962	1,148	924	224	219	5(72)	19.5
1963	1,165	943	222	215	7(94)	19.0
1964	1,205	984	221	207	14(98)	18.4
1965	1,238	1,010	228	199	29(125)	18.5
1966	1,242	1,029	213	181	32(151)	17.2
1967	1,246	1,037	209	178	31(100)	16.8
1968	1,160	991	169	145	24(122)	14.6
1969	1,230	1,067	163	141	22(154)	13.2

Note: * Figures in parentheses represent yields of upland rice (Kg/tanbo).

Source: 33, p. 130 & 140; 35, p. V-40 & 43.

due to the very low temperature, production of food was very low even with a very high rainfall. But, on the contrary, in 1964, due to the moderate temperature, production of food was very high even with a low rainfall.

Table 12. Rainfall and temperature (average of 12 cities).

Year	Rainfall (mm)	Temperature (°C)
1955	1,077.6	12.8
1956	1,537.4	11.6
1957	1,150.4	11.9
1958	1,434.4	12.7
1959	1,335.3	13.3
1960	1,153.1	13.2
1961	1,536.3	13.4
1962	1,128.2	12.6
1963	1,398.7	11.9
1964	1,296.1	13.1
1965	1,092.9	12.4
1966	1,213.5	12.6
1967	977.0	12.7
1968	959.4	12.6
1969	1,484.6	12.2

Source: 19, p. 148; 21, p. 6 & 12.

Labor

Labor generally seems to be abundant in agriculture regardless of the stage of development. Demand for labor in the non-agricultural sectors of agrarian societies is limited. In advanced economies, demand for labor outside agriculture usually seems to lag behind the surplus of farm labor available for transfer. In underdeveloped societies, the local labor supply is usually more than adequate except possibly during the busy planting and harvesting seasons. The wide-spread seasonal unemployment common to most agrarian societies

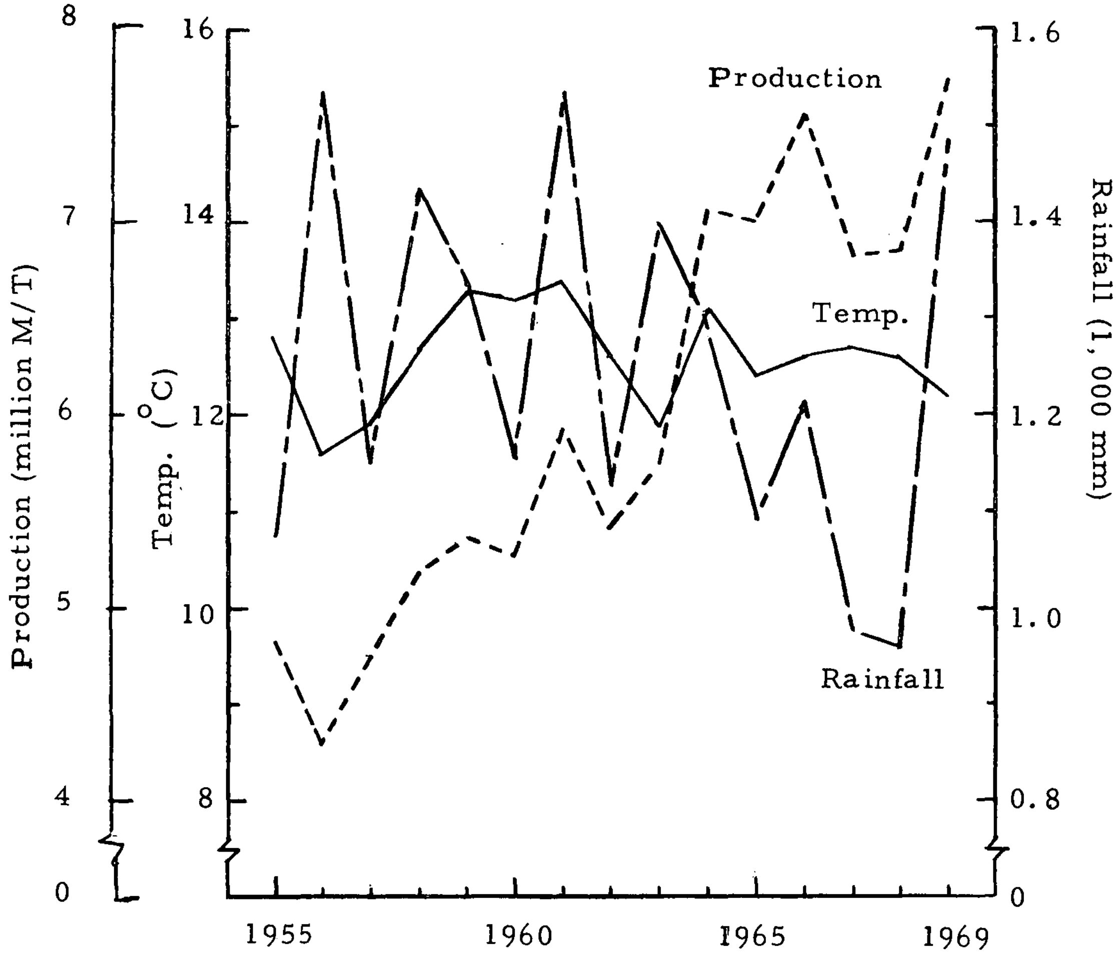

Figure 1. Trend of rainfall, temperature, and production.

Source: From Tables 12 and 16.

contributes much to the low levels of agricultural productivity as usually measured.

Labor input per acre, in many of the more densely populated countries, has reached a level where additional labor inputs would add little to the total production, i.e., the marginal product of labor is close to zero. In many cases higher labor inputs per unit of land could be effectively utilized if more capital inputs such as fertilizer, insecticides, etc., were available. The acres of farm land per number of agricultural labor force varies widely depending on population density and stage of development (43, p. 85).

The size of the total farm population and of the man-equivalent farm labor force were discussed in Chapter I.

Capital

Supply of capital is very limited in the less developed regions.

Using land more intensively means using more labor and capital per unit of land. Additional inputs of labor and capital are not too effective, however, unless used in combination with improved technology. All of the following practices--multiple cropping, fertilization, irrigation, use of pesticides, use of improved seeds, and mechanization--involve the use of more capital. All but the last two, the use of improved seeds and mechanization, also require more labor (43, p. 103).

In this section, two types of capital, current operating expenses and capital service flow, are studied. Current operating expenses include the value of seed, fertilizer, pesticides, and irrigation charges for food production. Capital service flows include the service flows of buildings and large farm implements.

These two types of capital include certain items that undoubtedly are not food grain production. For example, it is difficult to sort out the flow of capital services which go into the production of food grains from those which are used in the production of orchard crops, vegetables, and special crops. They are included because information about these are insufficient to warrant estimates for the years in question. It is believed that the amount would in any case be relatively small.

Some economists have used capital stock as a measure of the capital input for food production function (see 5, p. 116-117; 39, p. 66; 41, p. 134; and 42, p. 11-12). The question of whether stocks or flows are appropriate measures of capital's contribution involves empirical as well as theoretical considerations.

According to Yotopoulos (45, p. 123-124),

> "In the absence of an operational measure of the current flow of capital services, the production function analysis has traditionally relied on a capital stock concept--be it in physical terms or in its monetary value counterpart--to provide the relevant capital input. Mercifully, in certain cases either concept may be used, provided that we are willing to assume proportionality between the capital

stock and the current service flow. In a production function of a multiplicative form, the Cobb-Douglas for instance, it does not make an essential difference if we measure any input up to a factor of proportionality. The constant term will absorb the proportionality and the elasticities of production will remain the same. Incidentally, the marginal productivity of capital will change, since it is the product of the capital elasticity times the inverse of the average capital-output ratio."

If we have capital stock data available showing the market value of the asset at the beginning and ending of the production period, we can find the service flow as (45, p. 144)

$$R_{it} = rV_{it} - (V_{it+1} - V_{it}) \tag{3-3}$$

where V_{it} = current market value (i.e., the market-devaluated net capital stock) of asset i in the t year of its life.

R_{it} = current service flow (for t=1 to T, where T is the retirement age of the asset).

r = discount rate.

It is true that there usually exist non-negative current service flows of inputs in production. But, in certain cases, there may exist a negative current service flow. As Yotopoulos pointed out (45, p. 145), this may happen with assets of relatively short life expectancy and/or with significant changes in value concentrated upon few periods of production. Chickens and certain other animals are a case in point.

Unfortunately, the data on physical capital service inputs or capital stock for large farm implements and buildings available now are notoriously scanty and unreliable in Korea.

The following Table 13 shows the service flow of capital for large farm implements and buildings for food production at different discount rates. Data were not available for the years prior to 1959. As shown in Table 13, there exists a negative service flow of capital up to the 40% of discount rate. We cannot apply these unreliable service flow of capital figures in estimating the parameters of the production function.

Owing to the insufficient information on some form of capital prior to 1959, only one form of capital input, current operating expenses, is used in estimating capital flows from 1956 to the present. The following Table 14 shows the current operating expenses in 1965 constant market prices.

Productivities of Factors

Productivity of each individual factor is determined principally by the amounts of the other factors accompanying it in the production mix. If, for example, small amounts of labor are used in conjunction with very large capital inputs and large quantities of land, then output per unit of labor input will be high.* But if, on the other hand, large inputs of labor are accompanied by little land

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* This assumes, of course, that the high capital inputs are accompanied by an advanced agricultural technology.

Table 13. Service flow of capital for large farm implements and buildings at different discount rates.

Unit: in billion won

Year	Discount rates (%)					
	10	20	30	40	45	50
1955	--	--	--	--	--	--
1956	--	--	--	--	--	--
1957	--	--	--	--	--	--
1958	--	--	--	--	--	--
1959	8.76	13.32	17.88	22.44	24.72	27.00
1960	-11.55	-7.40	-3.26	.88	2.95	5.03
1961	1.13	6.84	12.56	18.27	21.12	23.98
1962	-4.83	1.34	7.51	13.68	16.77	19.85
1963	-22.93	-15.66	-8.39	-1.12	2.52	6.15
1964	20.19	30.48	40.77	51.06	56.21	61.35
1965	-9.70	-.40	8.90	18.20	22.85	27.50
1966	-12.90	-1.70	9.50	20.70	26.30	31.90
1967	-1.49	12.12	25.73	38.84	45.65	52.45
1968	1.97	17.14	32.31	47.48	55.07	62.65
1969	-23.41	-6.92	9.57	26.06	34.31	42.55

-- Data not available.

Source: Calculated from the figures presented in 27, 34, 36 and 28, p. 208.

and only meager inputs of capital, then output per unit of labor input will usually be low. The first example characterizes the developed regions, especially North America and Oceania. The second typifies the less developed regions, especially Asia (43, p. 86).

Productivity is here defined as the relationship between production and input of a specific factor of production (land, labor, capital, etc.).

Table 14. Current operating expenses (at 1965 constant market prices*).

Unit: billion won

Year	Current operating expenses
1955	not available
1956	17.04
1957	16.37
1958	36.40
1959	26.89
1960	26.19
1961	27.61
1962	36.86
1963	41.74
1964	23.43
1965	26.84
1966	27.19
1967	31.45
1968	32.93
1969	33.38

Note: *Converted to the 1965 constant market prices based on the index presented on 16, p. 112, and 33, p. 438.

Source: (1) Period 1956 to 1958 (26, p. II-184)
(2) Period 1959 (27, p. III-154)
(3) Period 1960 (24, p. 136)
(4) Period 1961 (34, P. III-154)
(5) Period 1962 to 1969 (29, p. 74-75)

Land is a key factor in the production function for two reasons. First, it is in finite supply and second, the range of land productivity, i.e., yield, is limited. Labor productivity in agriculture varies widely among geographic regions of the world. Foremost among the many factors influencing the level of labor productivity are the size of the capital complement and area of land per agricultural worker. These influences seem to overshadow physical variation in arable land. As described, productivity of capital inputs in agriculture is difficult to measure because of conceptual problems and scarcity of data. When capital for investment in agriculture is in short supply relative to land and labor, returns per unit of capital used are likely to be high (43, p. 86-87).

For expository purpose it seems useful to partition the growth in output per worker among two components--land area per worker and land productivity as in the following identity (11, p. 1117):

$$\frac{Y}{L} = \frac{A}{L} \times \frac{Y}{A} \qquad (3\text{-}4)$$

where Y = output, L = labor, A = land area,

$\frac{Y}{L}$ = labor productivity,

$\frac{A}{L}$ = land area per worker, and

$\frac{Y}{A}$ = land productivity.

The following Table 15 and Figure 2 show the change in productivity growth. The growth of output per worker (Y/L) in Korea would be highly correlated with changes in land productivity (Y/A). The land-labor ratio (A/L) maintained a stable level from 1955 to 1958, decreased up to 1962, increased up to 1966, decreased to 1967 and then increased. This is due to the fact that the index of farm labor (Table 5) maintained a stable level between

Table 15. Changes in labor productivity, land-labor ratio, and land productivity (1955=100), 1955-1969.

Year	Index of labor productivity (Y/L)	Index of land productivity (Y/A)	Index of land-labor ratio (A/L)
1955	100.0	100.0	100.0
1956	89.8	89.6	100.2
1957	98.4	98.3	100.2
1958	107.3	106.8	100.4
1959	108.2	110.1	98.3
1960	102.9	107.8	95.4
1961	116.8	120.9	96.7
1962	100.6	108.9	92.5
1963	109.2	114.3	95.6
1964	132.3	134.8	98.1
1965	128.2	128.6	99.8
1966	136.5	136.7	100.0
1967	121.3	122.5	99.2
1968	121.9	122.5	99.6
1969	139.3	138.6	100.6

Source: Calculated from Tables 5, 10 and 16.

1955 and 1958, increased significantly up to 1962, decreased to 1963, increased up to 1967 and then decreased. Meanwhile, the index of farm land was relatively stable during the period between 1955 and 1961, increased significantly up to 1968 and then decreased (Table 10).

Capital productivity is not shown in this portion of the study because of lack of appropriate data.

In agriculture the data suggest that it may be appropriate to

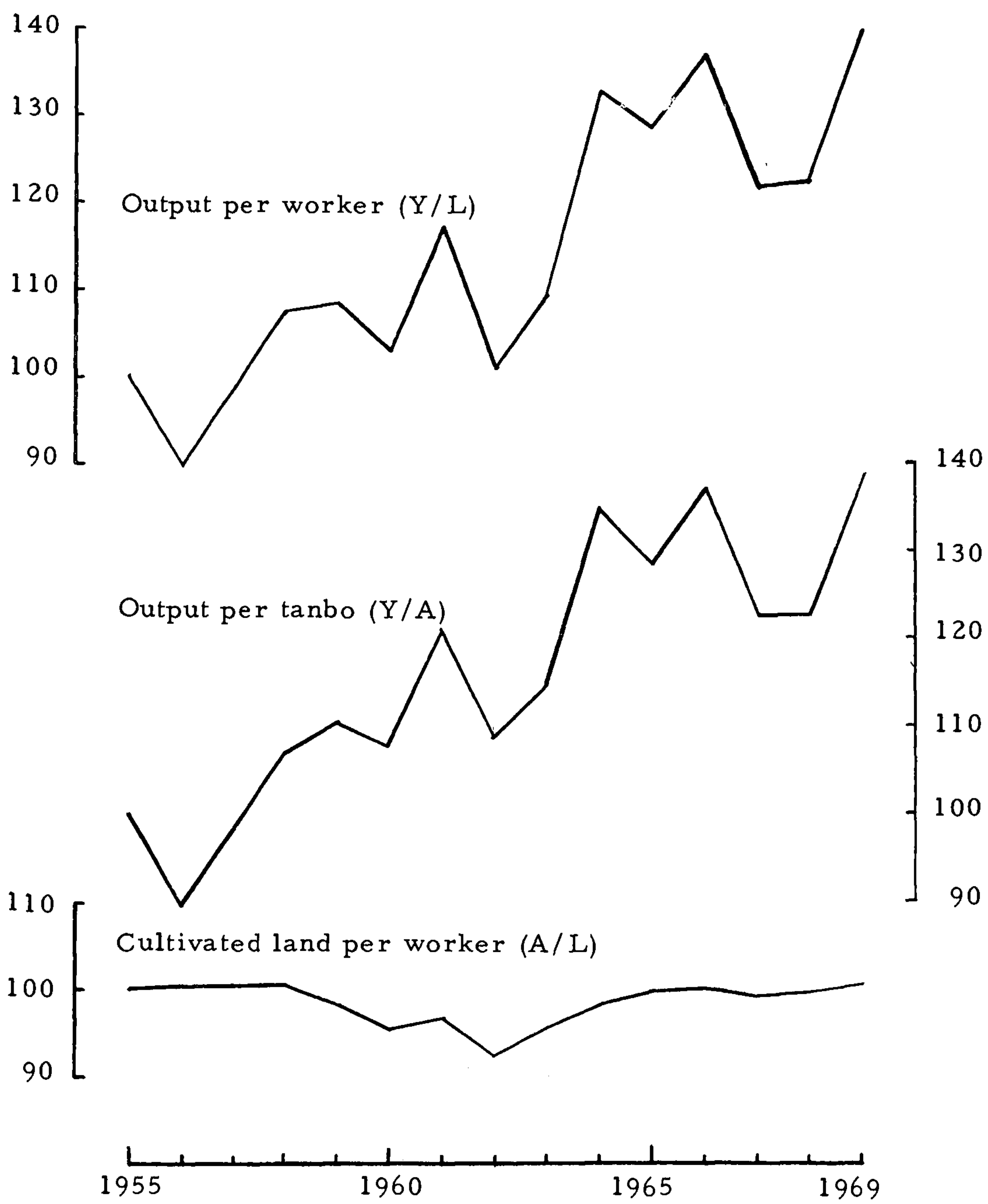

Figure 2. Changes in labor productivity, land-labor ratio, and land productivity (1955=100), 1955-1969.

Source: From Table 15.

consider growth in land area per worker (A/L) and output per land (Y/A) as "somewhat independent, at least over a certain range" (9, p. 242). If this view is accepted, the major source of increase in the land area per worker would be (1) mechanical innovations which facilitate the substitution of other source of power for human labor, (2) changes in planted acreage, and (3) changes in the size of the farm labor force (man-equivalent). Similarly the major source of increase in land productivity would be biological innovations which permit conversion of a higher percentage of the solar energy falling on an area into higher levels of plant and animal production through the increased supply and utilization of plant nutrients (11, p. 1119).

Food Production, Yield and Planted Area

This section will examine the trend in food production, with emphasis mostly on planted area, yield and production.

Table 16 shows the total food production, planted area and yield from 1955 to 1969. Figure 3 shows the general trend in total food production, planted area and yield from 1955 to 1969 when 1955=100.

Total food production depends on the planted area and yield per tanbo. Due to the weather conditions, the year to year production levels have changed, but in general, the production trend

Table 16. Total food production (polished).

Unit:
Planted area ...... 1,000 cheongbo
Yield per tanbo ... Kg
Production ...... 1,000 M/T

Year	Total			Rice			Other grain*		
	Planted area	Yield per tanbo	Production	Planted area	Yield per tanbo	Production	Planted area	Yield per tanbo	Production
1955	2,640	182	4,817	1,098	269	2,959	1,542	120	1,858
1956	2,687	160	4,310	1,106	220	2,438	1,581	118	1,872
1957	2,758	172	4,744	1,114	269	3,002	1,644	106	1,742
1958	2,695	193	5,189	1,118	283	3,161	1,577	129	2,028
1959	2,704	198	5,359	1,122	281	3,150	1,582	140	2,209
1960	2,726	193	5,271	1,130	269	3,046	1,596	139	2,225
1961	2,764	215	5,933	1,138	304	3,462	1,626	152	2,471
1962	2,828	192	5,423	1,148	263	3,015	1,680	143	2,408
1963	2,916	197	5,742	1,165	323	3,758	1,751	113	1,984
1964	3,062	231	7,066	1,205	328	3,955	1,857	168	3,111
1965	3,248	216	7,006	1,238	283	3,501	2,010	174	3,505
1966	3,116	243	7,568	1,242	316	3,919	1,874	195	3,649
1967	3,135	218	6,836	1,245	289	3,603	1,890	171	3,233
1968	3,103	221	6,857	1,160	275	3,195	1,943	188	3,662
1969	3,065	252	7,737	1,230	333	4,090	1,835	199	3,647

Note: * Other grain included barley, miscellaneous grains, pulses and potatoes, where potatoes unhulled are converted by polished grain (potatoes 0.2 and sweet potatoes 0.31).

Source: 33, p. 128-129.

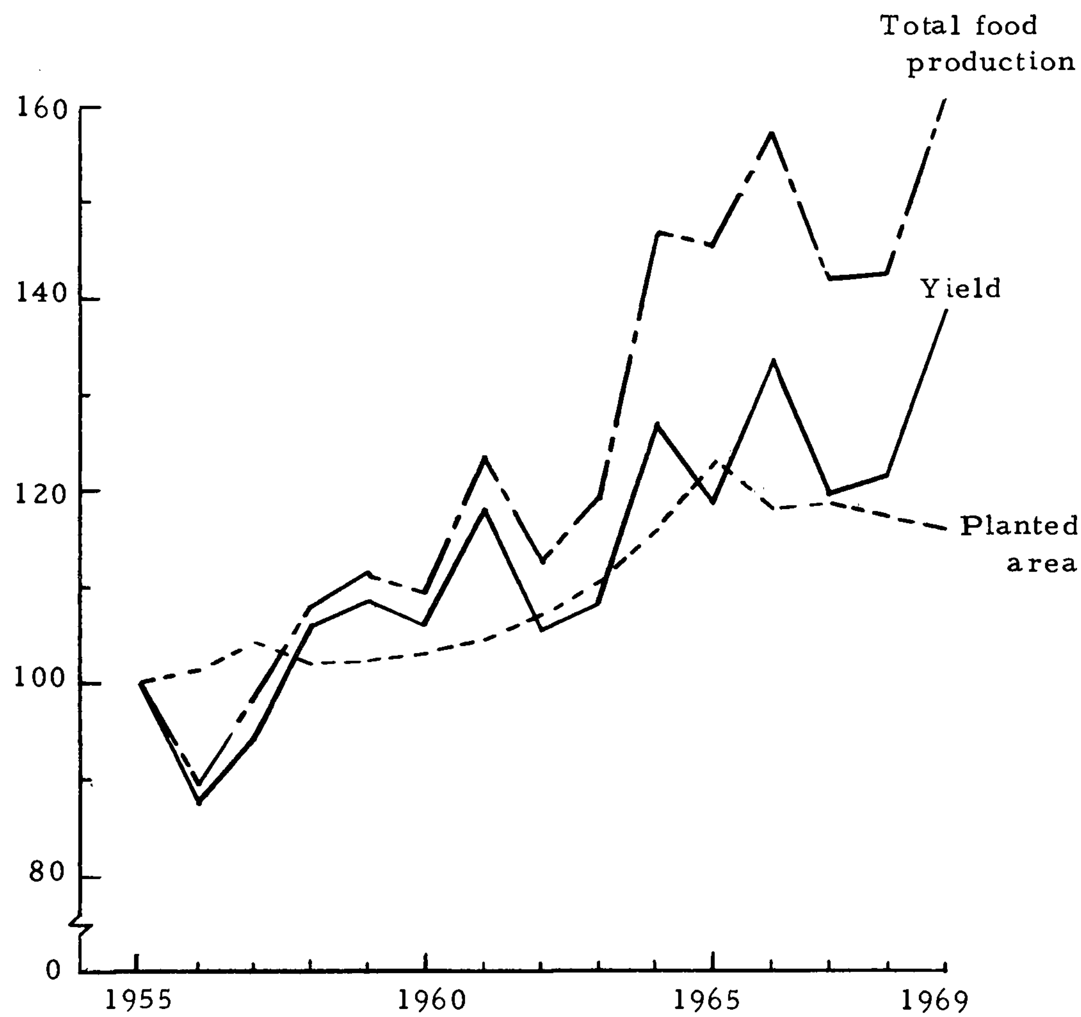

Figure 3. Total food production, yield, and planted area (1955=100).

Source: Calculated from Table 16.

was increasing during the period under study.

Planted Area

As shown in Figure 3, the total planted area increased about 16% in 15 years. Such an increase is due to the utilization of arable land and the increased demand for food. The increase in total planted area during the 1955-1969 period is shown by means of simple regression analysis in the following equation:

$$\hat{Y} = 2568.01 + \underset{(5.58)}{41.06}\, X^{*} \qquad (3\text{-}5)$$

$$r^2 = .81$$

$$S_y = 204.46$$

where X = years from 1955 to 1969.

$\hat{Y}$ = total amount of planted area in units of 1,000 cheongbo.

This equation shows that the planted area significantly increased during 1955-1969 period.

Yield per Tanbo

Because of weather conditions, the yield per tanbo has changed year by year. The smallest yield of total food was in 1956 with 160 Kg/tanbo; the highest yield was in 1969 with 252 Kg/tanbo. The yield per tanbo of total food has increased about 38% in 15 years (Figure 3), whereas the yield of rice and of other grain have

* Significant at the 1% level.

increased 24% and 66%, respectively.

The following simple regression equation shows the change in yield per tanbo of total food during the period of 1955 to 1969.

$$\hat{Y} = 165.59 + \underset{(.778)}{4.99}\, X^{*} \qquad (3\text{-}6)$$

$$r^2 = .76$$

$$S_y = 25.61$$

where X = years from 1955 to 1969.

$\hat{Y}$ = annual average yield per tanbo of total food in units of kilogram.

This equation shows that the yield per tanbo significantly increased during the period of 1955 to 1969.

Total Food Production

As shown in Figure 3, the total food production has increased about 61% in 15 years. The other grain production has increased more significantly than that of rice. The rice and the other grain production have increased 38% and 96%, respectively, during the period of 1955 to 1969.

The following simple regression analysis indicates the increase in the total food production between 1955 to 1969.

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* Significant at the 1% level.

$$\hat{Y} = 4160.84 + 228.70\, X^{*} \qquad (3\text{-}7)$$
$$(24.85)$$

$r^2 = .87$

$S_y = 1098.50$

where X = years from 1955 to 1969.

$\hat{Y}$ = annual total food production in units of 1,000 M/T.

The above equation shows that the production of total food significantly increased during the period of 1955 to 1969.

Projection for Total Food Production

The Cobb-Douglas production function used here is expressed in physical units, except for capital use which is expressed in money terms. The general model for the Cobb-Douglas production function is

$$Y = AX_1^{B_1} X_2^{B_2} X_3^{B_3} X_4^{B_4} X_5^{B_5} . \qquad (3\text{-}8)$$

This production function was estimated by ordinary least squares using time series data. All variables are measured in log form. The variables used are defined:

Y = the dependent variable, the production of total food in units of 1,000 M/T.

X_1 = planted land input, measured in units of 1,000 cheongbo.

X_2 = labor input, measured in units of 1,000 'man-equivalent' full-time workers.

---

* Significant at the 1% level.

X_3 = capital input, measured in billions of won (1965 constant market prices) including seed, fertilizer, pesticide and irrigation charge.

X_4 = rainfall, measured as an average of 12 cities in millimeters.

X_5 = temperature, measured as an average of 12 cities in Celsius degrees.

A = constant term.

B_i = unknown parameters.

The following test statistics were used to examine the estimates of the regression coefficients:

(a) T-statistics, to examine the statistical significance of each variable (at the 90 and 99% levels).

(b) Coefficients of multiple correlation.

(c) Standard errors.

In fitting the production function, no attention was given to making the function homogeneous of the degree one. The Cobb-Douglas production function, i.e., a function which is linear in the logarithms, has been derived by the use of the classical methods of least squares regression. This statistical procedure assumes that there are no errors of observation.

The food production equation applied in this thesis for projection is said to be valid for the following reasons: (1) there is no autocorrelation between residuals. Two different tests, the 'runs' test and the Durbin-Watson test, have been made to show this (see

Appendix II, 1), and (2) it is assumed that, independent variables are truly exogenous to this system; i.e., that there is no correlation between each independent variable and the 'true' error terms. To the author's knowledge, no rigorous test of this assumption is available.

As shown in Table 17, the regression coefficients are elasticities of the product with respect to the factors of production. They show the average percentage change in the product if a factor of production increases by 1%. For example, the regression coefficient of the logarithm of planted land on the logarithm of the production is 2.029. Hence, an increase of the amount of planted land by 1%, holding other factors constant, will lead to an increase of the production by 2.029%, on the average. The coefficient of multiple correlation indicates that 95.5% of the variation in production is explained by the factors included in the equation. This coefficient ordinarily explains the percentage of variation in the dependent variable which, on the average, is associated with the independent variables.

The elasticities of X_1, planted land, X_2, labor, X_5, temperature are greater than unity and, therefore, indicate increasing marginal returns to these production factors: holding each of the other factors constant, the marginal return of each factor will increase the more the factor is used. The elasticity of X_3 is not

Table 17. Food production function estimated by least squares with annual data from 1956 to 1969; showing elasticities of production, standard errors (in parentheses) and related statistics.

	Constant (log of)	Land X_1	Labor X_2	Capital X_3	Rainfall X_4	Temperature X_5
Regression coefficient (elasticities)	-9.493	2.029	1.052	.001	.356	1.167
Standard errors		.524	.699	.068	.107	.334
t-values		3.872*	1.503**	.023***	3.335*	3.489*
Marginal productivities		4.228	1.399	.210	1.711	563.240

R^2 = .955. Sum of elasticities = 4.6

Note: * Significant at the 1% level.
** Significant at the 10% level.
*** Not significant at the 10% level.

statistically significant in this model. The sum of the elasticities is 4.6 which indicates increasing return to scale. This means: An increase of all factors of production by a given percentage will increase the product by more than this percentage.

The estimated marginal productivities taken at the geometric mean of the input factors are shown in Table 17. These marginal products are estimated in the manner of the following equation where $\overline{Y}$ refers to the mean production and $\overline{X}$ s refer to the mean factor inputs.

$$\frac{\partial \overline{Y}}{\partial \overline{X}_1} = \frac{B_1 A\ \overline{X}_1^{B_1}\ \overline{X}_2^{B_2}\ \overline{X}_3^{B_3}\ \overline{X}_4^{B_4}\ \overline{X}_5^{B_5}}{\overline{X}_1} = \frac{B_1 \overline{Y}}{\overline{X}_1} \qquad (3\text{-}9)$$

The marginal productivities indicate the returns which, on the average, are expected from the addition of one more unit of the various productive factors. Therefore, on the average, an additional unit used of planted land input, X_1, would return 4.228 units of additional production, other inputs held constant. An additional unit of labor input, X_2, on the average, would return 1.399 units of additional production.

The coefficient of capital, X_3, is not statistically significant but indicates .210 units of marginal returns to an additional input.

The marginal productivity of labor is zero if the supply of labor is unlimited. This implies that the additional increments of labor would not increase production. Korean agricultural techniques are labor intensive, consisting mostly of manual operations. Furthermore, for many farm households, there is a shortage rather than a surplus of farm labor during the harvesting season. That is why the marginal productivity of labor in Korea is rather high, although during the rest of the year the marginal productivity of labor is much lower. The data used here are annual rather than seasonal, so this difference is not revealed.

The inputs of rainfall, X_4, and temperature, X_5, are beyond the control of human decision. But, good weather conditions would 'return' units of additional production. For example, an additional unit of rainfall (X_4) and temperature (X_5) 'input' would return 1.711 and 563.240 units of additional production, respectively, other inputs held constant, according to the estimated results.

There may be a multicollinearity problem here but this is not explored in this study. The simple correlation coefficients among inputs are presented in Table AII-4.

Projections of the total food production from 1970 to 1980, as shown in Table 18, are forecasted by the Cobb-Douglas production function and presented in Table 17.

Table 18. Projections of total food production, 1970-1980.

Unit: 1,000 M/T

Year	Total food production
1970	7,989
1971	8,272
1972	8,562
1973	8,857
1974	9,157
1975	9,464
1976	9,778
1977	10,190
1978	10,526
1979	10,850
1980	11,190

IV. AGGREGATE PRODUCTION AND CONSUMPTION OF FOOD

The estimates given here involve only physical quantities and do not reflect the relationship between price and quantity.

Theoretically, the demand for a product depends on the price of the product, prices of substitute and complementary products, and the per capita change in level of income. That is, changes in income and in the price level affect not only the total quantity of each food commodity demanded but also relative quantity demanded (1, p. 30). It is very difficult to take account of these types of changes over time with the scarcity of statistical data available in Korea.

Factors Affecting Consumption of Food

Because food consumption data for Korea are not available, only three factors, population growth, income elasticity coefficient for food, and national income per capita, are considered here in discussing consumption of food in Korea. Of the three factors, population growth has the greatest influence on food consumption. According to Engel, people spend more money for food consumption as income increases. The income elasticity coefficient is measured by the relative change in income and food consumption. If this coefficient is greater than one, food consumption will increase faster than income. Other factors, of course, beyond these three would affect food consumption.

According to Stevens (40, p. 55-56), a simple equation can be used to estimate food requirements: The rate of increase in national food consumption, c, is equal to the rate of population growth, a, plus the rate of increase in income per capita, b, times the income elasticity coefficient for food, x.

Thus:

$$c = a + bx \tag{4-1}$$

This is a very simplified equation but is sometimes used for estimating the annual rate of increase in the demand for food (see Burk and Ezekiel, 1967, p. 343). The above equation requires data for the three variables, a, b, and x.

Stevens also indicated that, in general, the income elasticity coefficient for food tends to be high (0.7 or 0.8) in countries of low per capita income and low (0.3 to 0.5) in industrialized countries.

In the present study it is assumed that the income elasticity coefficient for food in Korea is 0.5. The quantity of food consumed in the year t, Q_t, can be described through the following equation:

$$Q_t = Q_{t-1} + cQ_{t-1} = Q_{t-1}(1 + c) \tag{4-2}$$

where Q_{t-1} = quantity of food consumed in the previous year.

c = rate of increase in consumption of food.

The numerical variation of each factor affecting the consumption of food and the quantity of food consumed are presented in Table 19. It is noted that Korea, at this moment, does not have the actual consumption figures.

Estimate of Aggregate Production and Consumption of Food

The year 1954 was the first year since 1950 that the level of food production reached the 1949 level (38, p. 264).

Column 6 in Table 19 shows the quantity of food consumed for each of the years 1954 to 1969. These figures were estimated under the assumption that, in 1949, the production of food was roughly equal to that of consumption and the additional assumption that per capita income in 1954 is roughly equal to that of 1949, so that the consumption of food in 1954 was about 4.9% higher than that of 1949, since the increase in population during the 5-year period was 4.9%. The estimated total food production in 1949 was 4,625,000 M/T (25, p. 50-51). Therefore, the quantity of food consumed in 1954 was estimated as 4,852,000 M/T.

Table 20 shows the quantity of food supplied. These figures can be obtained by adding domestic production, net imports, and changes in stocks.

Table 19. Estimation of aggregate consumption of food in Korea.

Year (1)	Rate of increase in population (2)	Rate of increase in per capita income (3)	(3) x .5 (.5 = income elasticity coefficient for food) (4)	(2) + (4) Rate of increase in food consumption (5)	Aggregate consumption of food (1,000 M/T) (6)
1954					4,852
1955	2.9	4.3	2.15	5.05	5,097
1956	2.9	-1.1	-.55	2.35	5,216
1957	2.9	4.8	2.40	5.30	5,493
1958	2.9	0.5	0.25	3.15	5,666
1959	2.9	-.5	-.25	2.65	5,816
1960	2.9	-.6	-.30	2.60	5,967
1961	2.9	3.2	1.60	4.50	6,236
1962	2.8	-1.8	-.90	1.90	6,354
1963	2.8	7.9	3.95	6.75	6,783
1964	2.8	7.1	3.55	6.35	7,214
1965	2.7	2.9	1.45	4.15	7,513
1966	2.5	9.3	4.65	7.15	8,050
1967	2.4	5.1	2.55	4.95	8,458
1968	2.3	8.6	4.30	6.60	9,017
1969	2.2	13.2	6.60	8.80	9,810

Note: Columns (4) to (6) were computed by the author.

Source: 14, p. 23; 15, p. 172-173; 18, p. 8; 20, p. 34.

Table 20. Quantity of aggregate supply of food.

Unit: 1,000 M/T

Year	Domestic production	Net* imports	Changes** in stocks	Aggregate supply
1955	4,817	85 (0)	424	5,326
1956	4,310	502 (0)	68	4,880
1957	4,744	965 (0)	4	5,713
1958	5,189	968 (0)	-70	6,087
1959	5,359	262 (5)	233	5,854
1960	5,271	443 (25)	291	6,005
1961	5,933	595 (8)	83	6,611
1962	5,423	435 (64)	-44	5,814
1963	5,742	1,312 (6)	83	7,137
1964	7,066	902 (14)	-83	7,885
1965	7,006	643 (26)	150	7,799
1966	7,568	475 (50)	-23	8,020
1967	6,836	1,096 (4)	423	8,355
1968	6,857	1,494 (3)	451	8,802
1969	7,737	2,330 (6)	-247	9,820

Note: Numbers in parentheses are the amount of exports.
* Imports minus exports.
** Carryover in supply (carryover at the beginning of the year) minus carryover in demand (year-end carryover).

Source: 30, p. 12-13; 31, p. 14-15 & 92-93; 33, p. 128-129.

Table 21 shows the shortage of food over time. This is equivalent to the needed quantity of food imports. The figures on food shortages and food imports are different. In part, this is because imports of foods are not distributed immediately in Korea. Furthermore, the Korean government has sometimes overestimated the aggregate consumption of food in order to get more foreign assistance. In fact, U.S. surplus food was imported in excess of domestic food

Table 21. Shortage of food over time.

Unit: 1,000 M/T

Year	Domestic supply* of food (Index: 1955=100)	Consumption of food (Index: 1955=100)	Shortage of food (as a percentage of total consumption)
1955	5,241 (100.0)	5,097 (100.0)	-184 (-3.6)
1956	4,378 (83.5)	5,216 (102.3)	838 (16.1)
1957	4,748 (90.6)	5,493 (107.8)	745 (13.6)
1958	5,119 (97.7)	5,666 (111.2)	547 (9.7)
1959	5,592 (106.7)	5,816 (114.1)	224 (3.9)
1960	5,562 (106.1)	5,967 (117.1)	405 (6.8)
1961	6,016 (114.8)	6,236 (122.3)	220 (3.5)
1962	5,379 (102.6)	6,354 (124.7)	975 (15.3)
1963	5,825 (111.1)	6,783 (133.1)	958 (14.1)
1964	6,983 (133.2)	7,214 (141.5)	231 (3.2)
1965	7,156 (136.5)	7,513 (147.4)	357 (4.8)
1966	7,545 (144.0)	8,050 (157.9)	505 (6.3)
1967	7,259 (138.5)	8,458 (165.9)	1,199 (14.2)
1968	7,308 (139.4)	9,017 (176.9)	1,709 (19.0)
1969	7,490 (142.9)	9,810 (192.5)	2,320 (23.6)

Note: *Domestic food production plus changes in stocks.

Source: From Tables 19 and 20.

shortages, and this made it possible to support the government's low price policy of food grains.

The domestic food supply (domestic food production plus changes in stocks) increased by 42.9% during the period of 1955 to 1969 and the consumption of food increased by 92.5% during the same period. The rate at which the domestic food supply is increasing is less than half of that of consumption. The shortage of food was more heavy during the recent three years, 1967-1969. In 1969, domestic food supply covered only 76.4% of consumption.

It is well known that the increase in the total food production can be obtained by increasing arable land and by raising yield. Since arable land is almost a fixed factor, consideration of increasing total food production must be given to raising yield. The raised yield can be achieved by fertilization, improved seeds, better methods of cultivation, improved irrigation systems, and disease control.

Beyond the application of improved methods, it is possible for Korea to raise yield and thereby increase the total food production by planting the rain-fed and upland areas to the other grain production.

The yields of rain-fed and upland rice (see Column 6 in Table 11) are far below that of other grain (see Column 9 in Table 16). These areas, in 1969, were about 13.2% (see Column 7 in Table 11) as large as the total rice planted areas. They are entirely dependent on rain-fall and have the same characteristics as the dry field areas.

By replacing this 13.2% of the total rice planted area (in case of 1969) to the production of other grains, a considerable amount of yield and production can be obtained, under the assumption that the same production practices and input factors are used, and have the same yield as that of the other grain planted elsewhere.

Table 22 shows these results and Table 23 shows the possible gain in production if other grain production were to replace rice in

Table 22. Possible production and yield if other grain production were to replace rice in the rain-fed and upland rice area.

Unit: Area .... 1,000 cheongbo
Yield .... Kg per tanbo
Production .... 1,000 M/T

Year	Total			Rice			Other grain		
	Planted area	Yield per tanbo	Production	Planted area	Yield per tanbo	Production	Planted area	Yield per tanbo	Production
1955	2,640	188	4,961	796	345	2,748	1,844	120	2,213
1956	2,687	167	4,486	816	279	2,278	1,871	118	2,208
1957	2,757	179	4,945	834	349	2,907	1,923	106	2,038
1958	2,695	198	5,343	849	349	2,962	1,846	129	2,381
1959	2,704	207	5,608	868	350	3,038	1,836	140	2,570
1960	2,726	200	5,461	883	328	2,899	1,843	139	2,562
1961	2,763	221	6,099	901	363	3,269	1,862	152	2,830
1962	2,828	197	5,577	924	309	2,854	1,904	143	2,723
1963	2,916	198	5,778	943	376	3,549	1,973	113	2,229
1964	3,062	234	7,179	984	375	3,688	2,078	168	3,491
1965	3,248	219	7,110	1,010	318	3,216	2,238	174	3,894
1966	3,116	246	7,667	1,029	350	3,597	2,087	195	4,070
1967	3,136	223	6,983	1,037	327	3,394	2,099	171	3,589
1968	3,103	224	6,960	991	302	2,989	2,112	188	3,971
1969	3,066	255	7,817	1,067	360	3,839	1,999	199	3,978

Note: Rice planted areas included completely or partially irrigated areas (same figures as Column 3 in Table 11) and non-irrigated rice planting areas (rain-fed and upland rice areas) included to the figures of other grain planted areas (Column 4 in Table 11 plus Column 8 in Table 16). Meanwhile, total planted areas were not changed (same figures as Column 2 in Table 16).

The figures of rice production included production of rice planted in completely or partially irrigated areas (Column 7 in Table 16 minus Column 4 in Table 11 times Column 6 (figures in parentheses) in Table 11) and other grain production included original other grain production plus rain-fed and upland rice areas times yields of other grains (Column 10 in Table 16 plus Column 4 in Table 11 times Column 9 in Table 16).
Yields per tanbo of total, rice, and other grain can easily be found by dividing each corresponding figure of planted areas to production.

Source: Estimated from Tables 11 and 16.

Table 23. Domestic food production change if other grain production were to replace rice in the rain-fed and upland rice area.

Unit: In 1,000 M/T

Year (1)	Production (2)	Possible production (3)	Possible gain (3) - (2) (4)
1955	4,817	4,961	144
1956	4,310	4,486	176
1957	4,744	4,945	210
1958	5,189	5,343	154
1959	5,359	5,608	249
1960	5,271	5,461	190
1961	5,933	6,099	166
1962	5,423	5,577	154
1963	5,742	5,778	36
1964	7,066	7,179	113
1965	7,006	7,110	104
1966	7,568	7,667	99
1967	6,836	6,983	147
1968	6,857	6,960	103
1969	7,737	7,817	80

Source: From Tables 16 and 22.

Table 24. Projections of aggregate production and consumption of food in Korea, 1970-1980.

Unit: In 1,000 M/T

Year	Consumption	Production	Shortage	Shortage (as a percentage of consumption)
1970	9,369	7,989	1,380	14.7
1971	9,684	8,272	1,412	14.6
1972	9,999	8,562	1,437	14.4
1973	10,314	8,857	1,457	14.1
1974	10,630	9,157	1,473	13.9
1975	10,945	9,464	1,481	13.5
1976	11,260	9,778	1,482	13.2
1977	11,576	10,190	1,386	12.0
1978	11,891	10,526	1,365	11.5
1979	12,206	10,850	1,356	11.1
1980	12,522	11,190	1,332	10.6

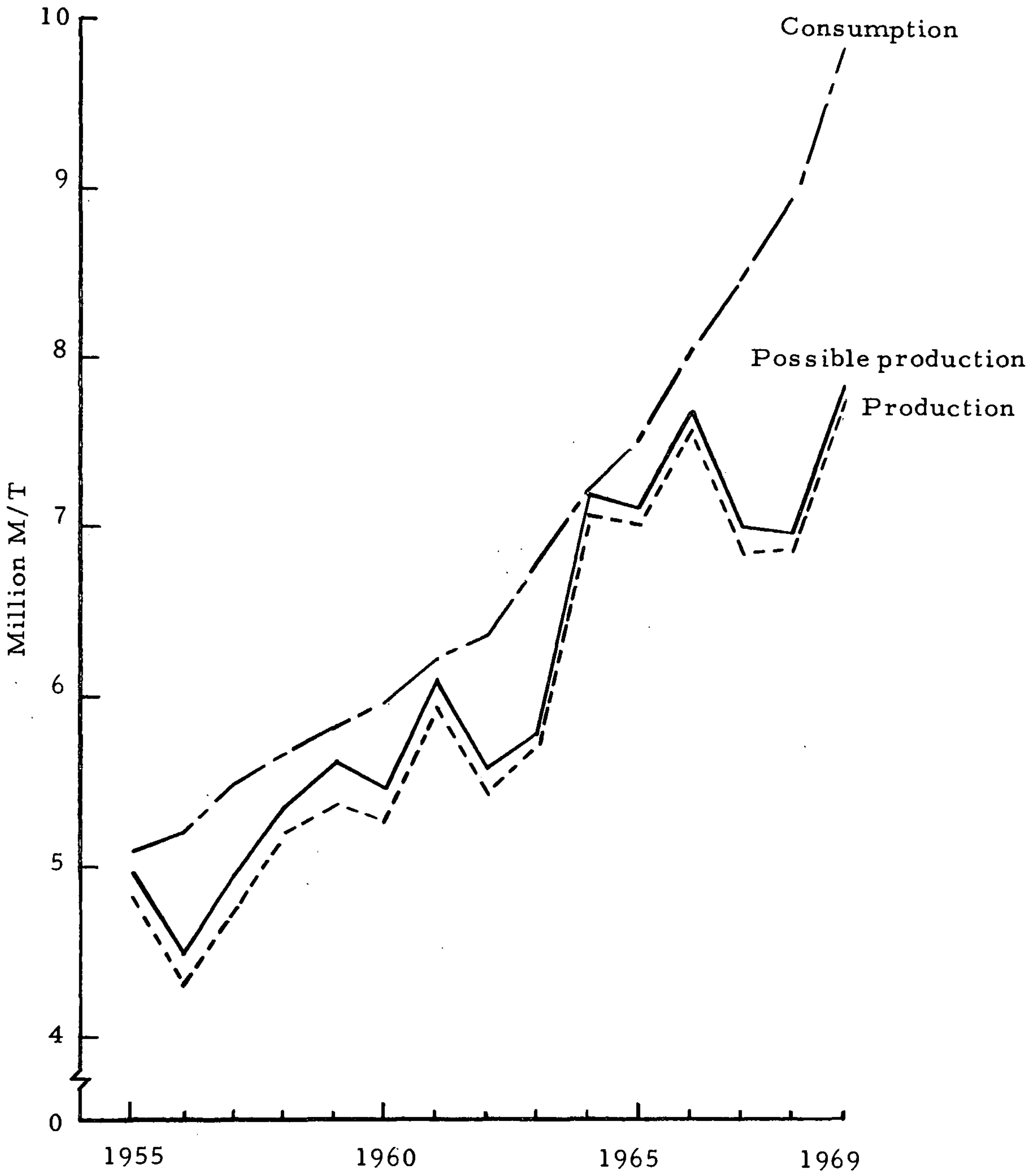

Figure 4. Comparison between production and consumption of food in Korea.

Source: From Tables 21 and 23.

the rain-fed and upland rice area. The average possible gain in production during the period of 1955 to 1969 was estimated at about 141,000 M/T every year. This figure is equivalent to 2.35% of the average total food production and 19.14% of the domestic food shortage during the same period. In other words, domestic food production can be increased by 2.35% and the shortage of food can be reduced by 19.14%, on the average, if other grain production were to replace rice in the rain-fed and upland rice area. The reader should be reminded that these data do not consider possible impacts in price.

Figure 4 shows the comparison between the general trend of consumption of food and possible gains in production.

Projections of Aggregate Production and Consumption of Food

Table 24 shows the projections of production and consumption of food for the period 1970-1980. Projections of food production have been made in Chapter III (Table 18). Projections of food consumption have been made using the following equation:

$$\hat{Y} = 4323.428 + \underset{(21.469)}{315.321}\, X^{*} \qquad (4\text{-}3)$$

$$r^2 = .94$$

$$S_y = 1452.03$$

---

* Significant at the 1% level.

where X = years from 1955 to 1969.

$\hat{Y}$ = total consumption of food in units of 1,000 M/T (it is noted that the total consumption figures from 1955 to 1969 obtained by the equation of (4-1), c = a + bx, were used for projections).

From Table 24, the average year by year shortage of food during the period of 1970 to 1980 would be 1,414,600 M/T. This is equivalent to 13.05% of the total projected consumptions and means that domestic food production would support the Korean people to the extent of only about 85.16% of their consumption.

Assume that the domestic food production can be increased by 2.35% if other grain production were to replace rice in the rain-fed and upland rice area. Table 25 shows the possible shortage of food under this assumption and says that the average year by year possible shortage of food during the period of 1970 to 1980 would be 1,190,800 M/T. This is equivalent to 11.0% of the total projected consumption and, therefore, domestic food production would be 87.79% of total food requirements. It is estimated that the shortage of food can be reduced by 223,800 M/T (15.8%), on the average, under the above assumption.

Table 25. Projections of total possible production and consumption of food in Korea, 1970-1980 (under the assumption that domestic food production can be increased by 2.35% if other grain production were to replace rice in the rain-fed and upland rice area).

Unit: 1,000 M/T

Year	Consumption	Possible production	Possible shortage	Possible shortage (as a percentage of consumption)
1970	9,369	8,177	1,192	12.7
1971	9,684	8,466	1,218	12.6
1972	9,999	8,763	1,236	12.4
1973	10,314	9,065	1,249	12.1
1974	10,630	9,372	1,258	11.8
1975	10,945	9,686	1,259	11.5
1976	11,260	10,008	1,252	11.1
1977	11,576	10,429	1,147	9.9
1978	11,891	10,773	1,118	9.4
1979	12,206	11,105	1,101	9.0
1980	12,522	11,453	1,069	8.5

V. SUMMARY AND CONCLUSIONS

This study analyzes the production and consumption of food in Korea for 1955 to 1969 and projects the production and consumption figures for 1970 to 1980. The past growth of the national income per capita in Korea was estimated. Population statistics and trend were considered and the future population was projected (by the Korean government) and the 'man-equivalent' full-time labor force was projected. Historical trends of food production, consumption and trade data were analyzed and all other factor inputs, land, capital, rainfall, and temperature, were analyzed.

Based on the above considerations, the production and consumption of food for 1955 to 1969 were analyzed and the possible food shortages for 1970 to 1980 were computed from the projections.

Beyond the above considerations, many other historical trends and projections were analyzed and evaluated.

The percentage of value contributed to GNP by the various economic sectors in 1955 constant market prices for the 1955 to 1969 period were estimated to be: for the primary sector, 47.2% in 1955 and 28.1% in 1969, an average annual decrease in contribution of 1.15%; for the secondary sector, 11.1% in 1955 and 26.1% in 1969, an average annual increase in contribution of .97%; and for the tertiary sector, 41.7% in 1955 and 45.8% in 1969, an average annual increase in contribution of .18%. If these trends continue, the percentages of value contributed to GNP by the various economic sectors were projected to 24.6, 29.9 and 45.5% in 1975 and 18.8, 34.7 and 46.5% in 1980, respectively.

The primary sector's contribution decreased significantly during the period under study and the reverse is true in the secondary sector. This is due to the fact that the Korean government put a lower priority on the primary sector than on the other sectors, even though about a half of the total population were farmers.

Korean's GNP grew by a yearly average of 8.3% during the period of the first five-year (1962-66) plan. The average growth during the first three years of the second (1967-71) plan was by 12.6%. Especially, in 1969, the growth rate reached 15.5%. Korean's GNP doubled during the eight-year period, 1962-69, with her per capita GNP increasing from $96.10 to approximately $200.00.

Expanded industrial activities, stimulated partly by the phenomenal export increase and partly by a heavy inflow of foreign capital resources, have been the foremost factor making the rapid GNP growth possible (37, p. 9).

Korean government has, since 1962, called for urbanization and industrialization. This has brought many problems to Korea--heavy concentration of industry and population in urban areas with a shortage of housing and water, transportation difficulties and pollution, a widened poverty gap between rural and urban population, etc. There are also problems on the agricultural side. The cost of all farm materials has been very high in relation to the selling price of the farm products. The Korean farmers have been faced with low prices for their products, especially food products. The Korean government had long conducted a low food price policy to protect consumers. This policy had kept farm prices down. As a result, farmers had no incentive to invest in fertilizer, improved seed, irrigation, pesticides and other inputs for expanding food production. Thus many rural people moved to urban areas in order to find better opportunities. This activity caused a farm labor shortage during the harvesting season and thereby food shortage.

Total population, agricultural population, and man-equivalent farm workers in 1969 were estimated to increase 55.5, 17.8, and 15.3%, respectively, above the corresponding figures for 1955.

Agricultural population as a percentage of the total population was estimated at the annual rate of decrease of .8% for the 1955-69 period and projected to decrease to 46.18% in 1975 and to 42.18% in 1980 (65.5% in 1955).

As Korea industrializes rapidly and an increasing proportion of the labor force is occupied in non-agricultural activities, the agricultural sector must continue to expand and to contribute to the overall economy.

Total planted land, cultivated land, and double crop area in 1969 were estimated to increase 16.1, 15.9, and 16.8%, respectively, above the corresponding figures for 1955. Since agricultural land is almost a fixed factor, the rate of increase is very meagre, about 1% per year. About 16% of the total cultivated land was used for double cropping in 1969.

Areas producing rice and areas producing other grains during the 1955-69 period were estimated to increase by 12 and 19%, increasing from 1,098,000 and 1,542,000 cheongbo in 1955 to 1,230,000 and 1,835,000 cheongbo in 1969, respectively.

During the fifteen-year period, 1955-69, the average size of farm land holdings per farm household was relatively stable but the number of farm persons per farm household increased from 5.99 to 6.12 persons. The smallest and the small farms, which own less than one cheongbo (2.45 acres) of cultivated land, were found to characterize 67.1% of all farm households in 1969 and yet this land totals only 38.2% of the whole cultivated land. With increasing pressure on the present arable land and a highly increasing population in Korea, may call for an increase in the amount of land being cultivated for agricultural production.

As far as the rice planted area is concerned, that which is completely or partially irrigated was estimated to increase by 34%

during the 1955-69 period, increasing from 796,000 cheongbo in 1955 to 1,067,000 in 1969. However the non-irrigated area, which is completely dependent on rainfall and mostly located on the slopes of hills, was estimated to decrease by 46% during the same period, decreasing from 302,000 cheongbo in 1955 to 163,000 in 1969. The non-irrigated area as a percentage of the total rice planted area was decreased from 27.5% in 1955 to 13.2% in 1969. We cannot expect this decreasing trend to continue because most of them were located on the slopes of hills and would, thus, not be suitable for irrigation.

Regarding irrigation, it should be pointed out that, even in the completely irrigated areas, the supply of water is dependent on the rainfall. In many cases, irrigation reservoirs are not large enough to save sufficient water for rice production. When rains are too scanty to maintain enough water in the reservoirs during the season, the yield and production are affected.

Weather conditions are the most important factor affecting agricultural production in Korea. Droughts are very common in Korea. Rice production is affected by droughts which delay transplanting or affect the growth of the rice. On the other hand, heavy rains cause floods which damage crops and irrigation facilities. Even the summer grains--barley, wheat, oats, and rye--planted in the fall are damaged by excessive cold during the winter season.

This study suggests that the food production could be changed. Under the uncertain weather conditions and poor irrigation facilities, the rice planted area is overextended and should be reduced if food production is to increase. Reduction of rice planted area means a larger area for other grain (44, p. 82).

In order to increase food production, rain-fed and upland rice area, at least, should be replaced to the production of other grain because other grain such as potatoes, millet, and sorghum require less water than rice. Planted in the right time any of these crops would produce more food than rice under the present uncertain weather conditions. In other words, limiting the rice planted area would reduce losses. The present practice of farms is to wait for rain to plant rice and if the rains do not come in sufficient amount or if they come too late, then millet, sorghum, corn, beans, potatoes, or buckwheat are planted instead of rice. The unnecessary delay in planting these crops results in poor yields. Some Korean rice farmers do not recognize the potential from growing other grains. If some pioneering farmers do make the switch, others may follow. The present study has discussed the possible likely outcome on the relationship between domestic production and consumption.

Potatoes produce a larger quantity of food from a given land area than do most other food crops. A larger part of the starch requirements of the Korean diet may eventually be obtained from potatoes.

Concerning crop improvements, a great deal of attention has been paid to rice improvement in Korea; several varieties have been introduced and developed. Because of this, the yield of rice has much improved. But, unfortunately, very little attention has been given to the improvement of other grains. More attention should be given to the other grain improvement and double cropping if the total volume of grains produced domestically is to be increased.

The average yield of total food per tanbo was estimated to increase by 38.5% during the 1955-69 period, increasing from 182 Kg/tanbo in 1955 to 252 in 1969. Meanwhile, the yield of rice and other grain increased 23.8 and 65.8% during the same period, respectively, increasing from 269 and 120 Kg/tanbo in 1955 to 333 and 199 Kg/tanbo in 1969, respectively.

The total food production increased 60.6% during the period of 1955-69, increasing from 4,817,000 M/T in 1955 to 7,737,000 M/T in 1969. In the meantime, the production of rice and other grain increased 38.2 and 96.2%, respectively, during the same period, increasing from 2,959,000 and 1,858,000 M/T in 1955 to 4,090,000 and 3,646,000 M/T in 1969. Remarkable expansion was made in the production of other grains compared with that of rice. This is true whether one looks at planted land or yield per tanbo or production.

A considerable amount of gain can be obtained by replacing the rain-fed and upland rice area by other grain production. This estimation was made in Table 22 and the possible gain was shown in Table 23 under the assumption that the same production practices and input factors are used and have the same yield as that of the other grain grown elsewhere. The average possible gain in production for 1955 to 1969 was found to be about 141,000 M/T every year. This indicates that food production can be increased by 2.35% and the shortage of food can be reduced by 19.14% if other grain production were to replace rice in the rain-fed and upland rice area.

Domestic supply of food (domestic food production plus changes in stocks) was increased by 42.9% (Table 20), from 5,241,000 M/T in 1955 to 7,490,000 M/T in 1969. Consumption of food was found to increase by 92.5%, and from 5,097,000 M/T in 1955 to 9,810,000 M/T in 1969. It is shown that during the period of 1955-1969, except for 1955, the domestic supply of food lagged behind the consumption of it and the gaps were filled by imports from abroad. Food shortages were more severe during the recent three years, 1967-69. Food shortages as a percentage of the total food consumption in 1967 to 1969 were found to be 14.2, 19.0, and 23.6%, respectively, amounting to about 1.2, 1.7, and 2.3 million M/T. The food shortage gradually widened because of rapidly increasing population and income per capita.

It was estimated that in order to achieve self-sufficiency in food production, Korea would have to increase the quantity of food supplied domestically by 16.5% for 1967, 23.4% for 1968, and 31.0% for 1969.

According to the projections of aggregate production and consumption of food, the average year by year food shortages would be 1,414,600 M/T during the period of 1970 to 1980. This is equivalent to 13.0% of the total consumption and the rate of self-sufficiency would be 85.16%.

The possible shortage of food during the same period would be 1,190,800 M/T per year under the assumption that the domestic food production can be increased by 2.35% if other grain production were to replace rice in the rain-fed and upland rice area. This shortage is equivalent to 11.0% of the total consumption and the rate of self-sufficiency would be 87.79%. Under this assumption, it was estimated that the shortage of food can be reduced by 223,800 M/T (15.8%) per year during the projection period. If weather conditions are favorable and sufficient fertilizers are supplied at the right time, yields and food production may go even higher than those shown in the projections and food shortages may be highly reduced.

Korea is not in a position at present or in the next 11 years to achieve a level of self-sufficiency in food production. This is, like other developing countries, due to insufficient irrigation facilities; inability of the government to maintain an effective agricultural program; shortage of farm tools and equipment; shortage of trained personnel and agricultural research organizations; and to a shortage of fertilizer supply.

Food production must be increased greatly if the food shortage situation of Korea is to be reversed. Korean people should change the food consumption pattern from rice to other grain. The most important solution to the food problem may be the pricing policy in the food market and government participation in providing necessary technical assistance and other production incentives needed by farmers. This may be an appropriate topic for future research.

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APPENDICES

APPENDIX I

1. The contribution of each economic sector to GNP.

(1) Primary sector

$$\hat{Y} = 48.881 - \underset{(.149)}{1.154}\, X^{*}$$

$$r^2 = .82$$

$$S_y = 5.693$$

(2) Secondary sector

$$\hat{Y} = 9.508 + \underset{(.072)}{.971}\, X^{*}$$

$$r^2 = .93$$

$$S_y = 4.493$$

(3) Tertiary sector

$$\hat{Y} = 41.611 + \underset{(.084)}{.183}\, X^{**}$$

$$r^2 = .27$$

$$S_y = 1.581$$

where X = years from 1955 to 1969.

$\hat{Y}$ = contribution of each economic sector to GNP.

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* Significant at the 1% level.

** Significant at the 5% level.

2. Percentage of cultivated land owned by various size of farm.

(1) The 'smallest' farm

$$\hat{Y} = 19.068 - .508 X^{*}$$
$$(.048)$$

$$r^2 = .89$$

$$S_y = 2.402$$

(2) The 'small' farm

$$\hat{Y} = 29.136 - .148 X^{*}$$
$$(.044)$$

$$r^2 = .46$$

$$S_y = .976$$

(3) The 'medium' farm

$$\hat{Y} = 34.952 + .369 X^{*}$$
$$(.061)$$

$$r^2 = .74$$

$$S_y = 1.921$$

(4) The 'large' farm

$$\hat{Y} = 16.995 + .276 X^{*}$$
$$(.038)$$

$$r^2 = .80$$

$$S_y = 1.384$$

where X = years from 1955 to 1969

$\hat{Y}$ = percentages of cultivated land owned by various size of farm.

---

* Significant at the 1% level.

3. Percentage of total households which own variously sized farms.

(1) The 'smallest' farm

$$\hat{Y} = 45.106 - \underset{(.090)}{.671}\, X^{*}$$

$$r^2 = .81$$

$$S_y = 3.335$$

(2) The 'small' farm

$$\hat{Y} = 30.377 + \underset{(.035)}{.123}\, X^{*}$$

$$r^2 = .49$$

$$S_y = .788$$

(3) The 'medium' farm

$$\hat{Y} = 18.540 + \underset{(.081)}{.490}\, X^{*}$$

$$r^2 = .74$$

$$S_y = 2.554$$

(4) The 'large' farm

$$\hat{Y} = 5.977 + \underset{(.014)}{.058}\, X^{*}$$

$$r^2 = .55$$

$$S_y = .348$$

where X = years from 1955 to 1969.

$\hat{Y}$ = percentage of total households which own variously sized farms.

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* Significant at the 1% level.

APPENDIX II

1. Autocorrelation tests between residuals

(1) The 'runs' test

In Table AII-3, the residuals show the following sequence of signs:

- + + + + - - - - - + - + +.

Here, N (number of observation) = 14.

n_+ (number of plus sign) = 7.

n_- (number of minus sign) = 7.

n_r (number of uninterrupted sequences of one symbol) = 6.

From the Table of Critical Values of n_r in the 'Runs' Test (61, p. 422-423), we see that at 5% significance the critical value of n_r under these circumstances is 3. Hence, using a simple runs test we cannot reject the hypothesis that the residuals are independent.

(2) The Durbin-Watson test

This test employs the statistic d, a weighted ratio of the sum of squared differences in successive residuals:

$$d = \frac{\sum_{t=2}^{N} (e_t - e_{t-1})^2}{\sum_{t=1}^{N} e_t^2}$$

Table AII-1. Worksheet for Durbin-Watson calculation.

Year	e^t	$(e_t)^2$	e_{t-1}	$e_t - e_{t-1}$	$(e_t - e_{t-1})^2$
1956	-.2362279190	.0005580362971			
1957	.0250916600	.0006295914015	-.0236227919	.0487144519	.002373097824
1958	.0150564939	.0002266919859	.0250916600	-.0100351661	.000100704558
1959	.0031951902	.0000102092404	.0150564939	-.0118613037	.000140690525
1960	.0001211560	.0000000146787	.0031951902	-.0030740342	.000009449686
1961	-.0089976417	.0000809575561	.0001211560	-.0091187977	.000083152471
1962	-.0163511921	.0002673614831	-.0089976417	-.0073535504	.000054074703
1963	-.0119068920	.0001417740771	-.0163511921	.0044443001	.000019751803
1964	-.0084856416	.0000720061133	-.0119068920	.0034212504	.000011704954
1965	-.0204044157	.0004163401800	-.0084856416	-.0119187741	.000142057176
1966	.0188672948	.0003559748130	-.0204044157	.0392717105	.001542267245
1967	-.0088966425	.0000791502477	.0188672948	-.0277639373	.000770836214
1968	.0093883802	.0000881416827	-.0088966425	.0182850227	.000334177510
1969	.0269450445	.0007260354231	.0093883802	.0175566643	.000308236461
		.0036522851797			.005890201130

The statistic d can easily be found in Table AII-1.

$$d = \frac{.0058902011300}{.0036522851797} = 1.61274$$

In a Table of 5% Significance Points of d_l and d_u in two-tailed tests (61, p. 424), cases of N=15 are not tabulated. The best that can be done is to extrapolate:

In case of two exogenous variables

$$d_l\ (14) = d_l\ (15) - .03 = .83 - .03 = .80$$

$$d_u\ (14) = d_u\ (15) - .00 = 1.40 - .00 = 1.40$$

Table AII-2. Regions of acceptance and rejection of the null hypothesis in the Durbin-Watson test.

Value of d	0 — d_l	d_l — d_u	d_u — 2 — $(4-d_u)$	$(4-d_u)$ — $(4-d_l)$	$(4-d_l)$ — 4
	Reject the null hypothesis; accept the hypothesis of positive autocorrelation	Neither accept nor reject the null hypothesis	Accept the null hypothesis	Neither accept nor reject the null hypothesis	Reject the null hypothesis; accept the hypothesis of negative autocorrelation

Source: 12, p. 367.

Since the calculated d lies between d_u and $4-d_u$, one may hold with 95% confidence that the residuals are not autocorrelated.

Table AII-3. Residuals from applying the production function, $\log Y = -9.49360359 + 2.02977854 \log X_1 + 1.05212866 \log X_2 + .00160857 \log X_3 + .35664912 \log X_4 + 1.16721509 \log X_5 + \log e$, to Korean data, 1956-1969.

Year	$\log e_t$ (in 1,000 M/T)
1956	-.0236227919
1957	.0250916600
1958	.0150564939
1959	.0031951902
1960	.0001211560
1961	-.0089976417
1962	-.0163511921
1963	-.0119068920
1964	-.0084856416
1965	-.0204044157
1966	.0188672948
1967	-.0088966425
1968	.0093883802
1969	.0269450445

Table AII-4. Simple correlation coefficients among inputs.

	Land	Labor	Capital	Rain	Temperature
Land	1.00	.88	.25	-.50	-.05
Labor		1.00	.50	-.54	.11
Capital			1.00	-.08	.21
Rain				1.00	-.10
Temperature					1.00