Food and Population: Priorities in Decision Making

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Achieving a balance between population and food: the Korean case

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The sheer size and menacing character of population growth in the developing countries today has resulted in widespread demands for action. The rapid growth in population in many nations implies that even more scarce resources will be required for the production of food.

The Republic of Korea is a leader in rapid industrialisation and successful implementation of family planning programmes by the international community. During the decade of the 1960s and the early 1970s, Korea's real GNP increased at an average annual rate of around 10 per cent and the rate of population growth dropped from 2.9 per cent in 1960 to 1.6 per cent in 1974. Despite the fact that the rate of population growth declined significantly, total population increased from 25 million in 1960 to about 33.5 million in 1974 with the growth of large concentrations in the country's urban-metropolitan areas. Population density has reached 'serious' proportions with 339 persons per Km^2. This ranks the Republic of Korea as one of the most densely populated countries in the world. Furthermore, even with a sharp decline in the rate to 1.3 per cent by 1986, the most optimistic projections show that the total population of Korea will increase to 41 million. This means that Korea will have to invest about 5–7.5 per cent of her GNP simply to maintain the same level of living standards as in 1974. As population expands and the economy develops, there is an increasing use of and competition for the nation's scarce resources for different ends. The conversion of land on a large scale from farmland to industrial sites, highways, housing developments and other purposes is occurring rapidly. An average of 20 thousand hectares of agricultural land is lost per annum to competing uses. Such uncontrolled conversion seriously affects potential increases in food production and has touched off heated land speculation. The agricultural labour market is experiencing a structural change as rural to urban migration proceeds rapidly. The seasonal shortage of agricultural labour becomes a serious obstacle to increased food production, even though farm mechanisation is slowly substituting for human labour requirements.

Thus, population growth as a whole has caused an expansion of the economic base and correspondingly greater demands for food, shelter, recreation and government services, especially for rapidly growing urban centres. The quantity and quality of given resources, however, are not sufficient to satisfy the increasing demands of all the sectors of the economy at the same time. The increased competition between sectors for land, water, minerals and the environment brought about by a dynamically growing and shifting population may generate substantial bottlenecks to future economic growth.

In view of these prospects, the economic meaning of population growth and its structural changes should be thoroughly reviewed to provide a sounder basis for long-run economic, social, and population planning. In particular, agricultural development planning needs answers to such questions as: Can we effectively control the future course of population growth? Is the food producing sector of Korea capable of increasing the supply of food enough to keep up with the demand for food arising from the rapid growth in the population and the economy? If not, what are the most significant constraints to increasing food production? To what extent can scientific research contribute to ease those constraints?

Of course it is not easy to discover the full range of consequences that may occur as a result of the interaction between population growth and food consumption and production. However, the illustration of future alternatives and consequences can help to stimulate an increased awareness of the problem. Such awareness is the first step in fostering more intensified biomedical and socio-economic research and in formulating the appropriate development programmes.

Population

Analysis of population growth

Population trends in Korea since 1920 have been documented by means of censuses taken about every five years, as summarised in Table 1. The data indicates that population grew rapidly during the early 1920s but slowed between 1925 and 1944. A very large increase occurred during the period from 1944 to 1949, with a small increase between 1949–1955, and the return of rapid growth between 1955–1960. Rapid growth continued from 1960 to 1966, after which growth had become more modest.

Some of the above fluctuations can be linked to migration and do not reflect the balance of birth and death rates alone. A sizeable emigration of Koreans to Japan, Manchuria and the northern portion of Korea resulted in relatively low rates of population growth from 1925 to 1944. On the other hand, the large jump beteeen 1944–49 can be explained by the repatriation of Koreans from overseas and by refugee movements from North Korea after World War II. Population growth during the 1949–55 period was curbed by a drastic rise in the death rate and a slight reduction in fertility due to the Korean war. These declines were more than offset by the large number of refugees that fled to the south during the war.

From 1953 to 1966, the population has exhibited a relatively high growth rate [2]. The post war baby boom pushed the natural birth rate during the 1955–60 period to 2.9 per cent per year. Since 1962, a series of national population control policies were adopted and incorporated into the nation's first and second five year economic development plans [3]. These, in conjunction with the rapid economic growth, fostered by the family planning and a rapid increase

Tab'e 1
Census population of Korea, 1920–74

Census date	Population in thousands		Intercensal increase in per cent	
	Entire country	Republic of Korea (South)	Entire country	Republic of Korea (South)
1920 (October 1)	17,264	–	–	–
1925 (October 1)	19,020	–	10.2	–
1930 (October 1)	20,438	–	7.5	–
1935 (October 1)	22,208	–	8.7	–
1940 (October 1)	23,547	–	6.0	–
1944 (October 1)	25,120	16,244	6.7	–
1949 (May 1)	29,907	20,167	19.1	24.2
1955 (September 1)	30,532	21,502	2.1	6.6
1960 (December 1)	35,024	24,994	14.1	16.2
1966 (October 1)	–	29,476	–	17.9
1970 (Mid-year)	–	31,469	–	6.7
1974 (Year end)	–	33,459	–	6.3

Source: *Korea Statistical Yearbook*, Planning Board, 1975.

in rural–urban migration have resulted in a drop in the natural birth rate from 2.7 per cent per annum during the 1960–66 period to a more acceptable rate of 1.6 per cent a year during the 1966–74 period.

The decline in the natural birth rate has been attributed to a sharp decline in the nation's crude birth rate. In 1960 this rate stood at 42.9 births per 1,000 total population. By 1973 it had dropped more than 17 points to 25.3 per 1,000 total population. The total fertility rate, i.e., the average number of children born to a woman surviving to the end of the child bearing period, showed a similar decline from 5.9 to 1960 to 3.9 in 1973. The decline, however, was not uniform among all age groups within the child bearing range, the two most found age groups are 25–29 and 30–34, which show a relatively slow decrease during the same period. This overall reduction in fertility level can be attributed to three principal factors: an increased control of fertility within marriage, an increased number of abortions and a later average age at marriage. Fertility decline in rural areas is also noticeable but there still is a big gap in the fertility rate between urban and rural, i.e., 3.2 versus 4.7 in 1973. It seems unlikely that the gap will be overcome.

In every census up to 1974 the sex ratio has consistently favoured males. This has been true despite heavy casualties during the Korean War and the normally higher infant mortality rates associated with male births. Data from the 1974 census, however, seem to indicate a change in this ratio. The 1966 census indicated

		Total fertility rate	*General fertility rate*
1960:	Urban	5.3	180
	Rural	6.7	227
	Average	5.9	200
1970:	Urban	3.5	113
	Rural	5.5	145
	Average	4.5	129
1973:	Urban	3.2	103
	Rural	4.7	114
	Average	3.9	105

a sex ratio of 104.4. By 1974 this had declined drastically to 101.0.

Changes in both the birth and death rates have influenced the age composition of the population over the years as shown below, namely, compared with 1960, a smaller proportion of 'under 20 years' population and a greater percentage of '60 and over' class appeared in 1974 [4].

	1960	*1966*	*1970*	*1974*
Percent of 'under 20 years'	52.45	52.80	52.00	48.23
Percent of '20–59 years'	42.15	42.20	42.65	45.64
Percent of '60 and over'	5.45	5.10	5.35	6.13
Total (%)	100.0	100.0	100.0	100.0

Several evaluations have been carried out in the Republic of Korea since the national family planning programme began operation in 1962. The attitudes of Korean women concerning family size indicate a gradual decline in the ideal number of children that the average woman wishes to have; i.e., from 3.9 persons in 1965 to 3.4 persons in 1973. Despite this decline, the number of children that Korean women want to have still exceeds the goal of the government family planning programme, as expressed in the slogan 'Stop at Two'.

One of the most serious psychological barriers to changes in family size is the Korean strong preference for sons. Most Korean women regard the continuation of the male lineage and the dependence on children in old age as the most important considerations in determining the desired number of children [5]. Previous demographic studies, conducted at different times, have indicated that the long prevailing preference for boys has not significantly changed, although the desired number of children, whether sons or daughters, has slightly decreased. The persistence of a strong boy preference is evidenced in a recent study which found that, among women whose ideal number of children is three, 96 per cent wanted to have two sons and one daughter while only 1 per cent desired to have one son and two daughters [6].

Another study attempted to examine this preference for males using three social variables: education, economic status and residence. The results indicate that the preference for males is lowest among those women who have at least a high school education, are higher in economic status and reside in Seoul. The ideal number of children among this group is smaller than the national average of 3.56, and the actual number of living children is also smaller than the national average of 3.22. Although the number of living children is lower than the number of desired children for all groups, the difference is greater among those groups with low male preference attitudes. Male preference was highest among women who had no education, were residing in rural villages and enjoyed low economic status [7].

Employment and Migration

Changes in the structure of population growth by labour force participation between 1965 and 1974 are presented in Table 2.

Table 2
The population and labour force of the Republic of Korea, 1965, 1970 and 1974

Population classification	*1965*	*1970*	*1974*
	(in 1,000 persons)		
Total population	28,377	31,317	33,459
Economically active population	9,199	10,020	12,080
(%)	32.1	32.0	36.1
Total employed persons (A)	8,522	9,574	11,586
Agricultural and fishing workers (B)	5,000	4,834	5,584
B/A (%)	58.7	50.0	48.2
Mining and manufacturing workers (C)	879	1,369	2,062
C/A (%)	10.3	14.3	17.8
Social overhead capital & service (D)	2,643	3,371	3,940
D/A (%)	31.0	35.2	34.0
Unemployment rate:	7.4	4.5	4.1
Farm sector (%)	3.1	1.6	1.2
Non-farm sector (%)	13.5	7.5	6.8

Source: *Annual Report on the Economically Active Population*, EPB, 1975.

The high fertility rates of the 1950s and early 1960s are now being reflected in a rapid increase in the size of the working population. As the data indicates, the economically active population in 1970 numbered slightly over 10 million and has increased to 12 million by 1974. The ratio of the labour force to the total population has increased from 32.1 per cent in 1965, to 36.1 per cent in 1974. On the other hand, total employed persons increased from 8.5 million in 1965 to 9.6

million in 1970 and again to 11.6 million in 1974. Thus the unemployment rate was reduced from 7.4 per cent in 1965 to 4.1 per cent in 1974. It may be noted that more unemployment exists in the non-farm sector than in the farm sector. In 1974, 48 per cent of the employed persons were engaged in agriculture and fisheries, indicating the transition from a predominantly agricultural to a relatively industrialised economy. Between 1965 and 1974, the agricultural sector experienced both a relative and absolute loss of manpower, while both secondary and tertiary industries grew considerably. The figures indicate that the out-migration rate of the population exceeds the rate of natural growth in the farm sector by 1.5–2.0 per cent. The move away from agricultural dominance is also reflected in the changing occupational structure. The category of 'farmers, fishermen and related workers' has decreased in proportional terms rather sharply in recent years.

The rapid growth of the Korean economy during the 1960s was marked by rapid industrial growth, with a progressively stronger concentration of economic activities in several large cities. The concentration of rapid economic development in the modern industrial sector has stimulated a great number of rural people to flock to the nation's urban centres. In 1949, 17.2 per cent of the nation's population resided in urban areas. By 1966 almost 10 million people or 33.6 per cent of the total population lived in urban centres. During the last decade, urban population increased at a drastic rate so that by 1974 20 million people or 59.8 per cent lived in urban centres.

A striking aspect of this growth has been the rate at which the larger cities have grown relative to the smaller cities. The five largest cities with populations greater than 300,000 in 1974 grew at an annual rate of 4.2 per cent or more between 1960 and 1974. In contrast, small and medium size cities with populations of 100,000 or less grew at an annual rate of about 3 per cent. This trend is especially true for the capital city, Seoul. The population of Seoul was 6.1 per cent of the national total in 1955, 9.8 per cent in 1960, and 19.5 per cent or 6.5 million in 1974.

The situation of 'over-urbanisation' and the growth of large urban areas are viewed by many Korean scholars and policy makers as critical national issues. Whether or not a greater proportion of the population living in urban places than the proportion living in rural areas is justified by the degree of economic development, remains a controversial issue. It seems clear, however, from evidence collected in other developing nations that growth of one or a few gigantic cities may have a number of undesirable socio-economic side effects and eventually hinders policies of rural and regional development.

Kim, studying the causes of rural–urban migration, found no conclusive evidence to substantiate the hypothesis that the difference between urban expected income and rural expected income was solely responsible for 'pulling' rural people into urban centres [8]. He explains that the rapidly growing number of recent migrants is itself one of the most important determinants of further migration. Parents' strong desire to provide their children with a better education and with opportunities for a better life later on leads them to migrate or send their children

to urban schools. Once rural children are well educated and settled down with a permanent job in an urban area, they provide channels for both their parents and their brothers and sisters to migrate to the urban centres.

As a consequence of the increased rate of rural–urban migration, the farm population has begun to decline. Farm mechanisation is viewed by many as the most practical means of replacing the farm labour lost through migration. Adapting Korean agriculture to mechanisation, however, will be a major challenge. Land consolidation and rearrangement, building of access roads, refinements in irrigation systems and improved guidance services are all taking on a greater urgency in the forthcoming period of rapid demographic and economic change. A recent study found that even though the growth of mechanised agricultural production has lagged behind comparable Far Eastern countries, it does constitute a viable and profitable programme over the next twenty years [9].

Another recent study has indicated that the heavy out-migration of farm labour has aggravated a critical labour shortage, particularly during the peak demand periods of June and October. During 1970 it was estimated that this deficit supply constituted 19.7 and 16.3 per cent of the total supply of labour employed in agriculture [10]. Such a supply situation has resulted in the doubling of agricultural wage rates between 1969 and 1974.

Population projections

An extensive study of the Korean agricultural sector by Michigan State University of USA and the National Agricultural Economics Research Institute of the Republic of Korea has been under way since 1972. Population growth and off-farm migration have received major emphasis in the population component of the study. In its original report, issued in 1972 [11], the MSU/NAERI group estimated an increase in population of approximately 30 per cent between 1970 and 1985 under the assumption that existing government policies would continue. During the same period, growth in the rest of the economy was expected to cause high out-migration from rural areas, particularly after 1975. Such out-migration would result in a doubling of the urban population during the 15 year period and a drop of 43 per cent in the rural population.

The impact on Korean agriculture of these changes can best be seen in the projected changes in the supply of farm labour. Following a slight rise to 1975 when farm labour will average slightly more than 2.0 adult male equivalents per farm based on the number of farms in 1971, it will decline to 1.3 by 1985. In other words, for every 100 farm labour units (in adult male equivalents) on farms in 1975, there will be only 65 by 1986.

Clearly, changes of this magnitude will face farm operators with major adjustments – in farm enterprises, in farm operations and in family living. At the same time, these changes will pose major problems for rural and urban educators and for urban and industrial planners if the rural migrants are to be prepared for non-farm occupations, absorbed into the non-farm work force, and accommodated

satisfactorily in their new urban environment.

To arrive at valid estimates for the population projection, a simulation modelling [12] has been attempted using the three sets of different assumptions on fertility and migration rates with the adjusted 1970 census data and survival ratios [11] as the base figures. Single year survival ratios were calculated exogenously from the Coale-Demeny Life Table (West Model), with the following Coale-Demeny Levels used for the indicated years.

Year	*Coale-Demeny level*	*Life expectancy*	
		Males (years)	*Females (years)*
1970	18.6	60.27	64.00
1975	19.5	62.44	66.75
1980	20.3	64.35	68.25
1985	21.0	66.02	70.00

The projected total fertility rates for selected years used in the new model were in two groups. The first one was officially employed by the government in the population estimation during the formulation process of the 4th five year plan. The other was arbitrarily added by the author because the foregoing official estimation seems to be too optimistic. They are:

Year	*Total fertility rate (TFR)*			
	Farm women		*Non-farm women*	
	Group 1	*Group 2*	*Group 1*	*Group 2*
1970	5.964	5.964	3.152	3.152
1975	5.076	5.350	2.699	2.930
1980	4.354	4.730	2.327	2.715
1985	3.763	4.100	2.121	2.500

Net movement between the farm household population and non-farm household population is specified exogenously for the years, 1971, 1976, 1981 and 1986 with the values for specific years interpolated from the following array of point values:

Year	*Rate of net off-farm migration*	
	Group 1	*Group 2*
1970	4.2%	4.0%
1975	3.5%	3.0%
1981	3.1%	2.0%
1986	2.8%	2.0%

By combining these fertility and migration assumptions, we can easily organise the three sets of alternative assumptions on the population aspect of the model, which mainly accounts for food demand pattern. The organisation of the alternative sets can be summarised as follows:

Alternatives	*Fertility*	*Migration*
I	Group 1 (low)	Group 2 (slow)
II	Group 1 (low)	Group 1 (fast)
III	Group 2 (high)	Group 2 (slow)

Alternative I is considered as the base line model by the MSU/NAERI working group and Alternative III deviates from it due to its higher fertility assumption and Alternative II deviates from it due to its faster migration assumption.

The results of the model for selective years are shown in Table 3. Under even the lowest fertility assumption the total population in 1986 is estimated to exceed 41 million. Alternative III shows a relatively faster growth rate with the population increasing from 34.7 million in 1974 to 42.8 million in 1986. This 8.1 million increase constitutes a 23.3 per cent rise over the period or a 1.74 per cent annual growth rate. Alternative I depicts a relatively slow growth rate. Under its assumptions the population grows from 34.6 million in 1974 to 41.4 million in 1986. This increase of 6.8 million constitutes a 19.7 per cent rise or 1.49 per cent per annum increase.

Most demographers believe that under current budget levels the family planning programmes will not be able to achieve the targeted annual growth rate of 1.3 per cent by 1986. At present, research has not been able to determine quantitatively the relationships between the different levels of government budgeting for family planning programmes and their respective consequences. The rather substantial decline in total fertility, from 5.9 children per woman in 1960–61 to 3.9 in 1973–74, has been partially attributed to the family planning programme. Further declines in the years to come will be much more difficult to accomplish. Unless new and innovative programmes are adopted in the near future with regard to farm population policies the 1986 goal of a 1.3 per cent net growth rate will not be realised. Estimates of the ratio of the farm population to total population in 1986 ranges from 24.7 per cent to 28 per cent in the model. The difference between the two extreme alternatives amounts to 1.4 million persons. If we adopt Alternative II as a probable growth path, nearly five million people will move away from agriculture in the next twelve years, requiring a substantial increase in agricultural mechanisation. Under these contingencies farm capital formation is unlikely to be able to provide sufficient capital for the scale of mechanisation required.

On the other hand, if government policies prove effective in decentralising the location of new non-agricultural employment so that more non-agricultural employment is available to persons in farm households, the rate of physical withdrawal from the farm sector is likely to be slowed. Moreover, the need for

Table 3
Results of simulation of population growth, 1974–86

Year	*Alternative I*	*Alternative II*	*Alternative III*
(1) Total population in 1,000 persons			
1974	34,616	34,617	34,737
1976	35,661	35,658	35,908
1981	38,390	38,346	39,136
1986	41,447	41,305	42,838
(2) Farm household population in 1,000 persons (percentage to total)			
1974	13,424 (38.8)	13,333 (38.5)	13,462 (38.8)
1976	12,955 (36.3)	12,742 (35.7)	13,024 (36.3)
1981	12,168 (31.7)	11,381 (29.7)	12,325 (31.5)
1986	11,606 (28.0)	10,201 (24.7)	11,855 (27.7)
(3) Net migrants in persons (net migration rate)			
1974	462,811 (3.37)	505,588 (3.69)	463,547 (3.37)
1976	397,320 (3.00)	458,155 (3.50)	398,821 (3.00)
1981	246,763 (2.00)	361,895 (3.10)	249,500 (2.00)
1986	235,360 (2.00)	292,247 (2.80)	239,934 (2.00)

large scale, capital intensive mechanisation will be reduced since non-agricultural workers living on farms are likely to be available for work in agriculture during the peak seasons – a phenomenon which now occurs in Japan and Taiwan.

Since 1970, the Korean government has encouraged the establishment of more industrial plants in the rural areas; this is called the Saemaul Industry Programme. If the target of the programme, 'one *myun* – one factory' is realised, then the farmers will have sufficient off-farm job opportunities to supplement their low level income and the number of part time farmers will increase.

Impacts of demographic changes on future patterns of food consumption

Three basic demographic trends which have surfaced in recent years are likely to affect food consumption in the future. Firstly, since the proportion of the adult population is expected to increase at the planned rate of natural population growth by 1990 [13], the trend will exert a strong upward pressure on the rate of growth of food demand. In the meantime, the expected trend of continuous rural–urban migration will result in a strong downward pressure on their *per capita* demand for the relatively low income-elastic food sources such as cereal and carbohydrate foodstuffs. As these demographic trends will be accompanied by an acceleration in

the growth of *per capita* income, a rapid increase in the demand for income-elastic foodstuffs such as fruits, vegetable and livestock can be expected. An increase in the demand for this latter commodity will generate an increase in the demand for feedgrains.

The second demographic trend, rapid urbanisation, will influence the pattern of food consumption in two ways. One is that as urban centres expand, urban consumption habits will exert a stronger force on the pattern of rural food consumption. As rural residents become a minority, the probability of their emulating the dietary habits of urban residents will increase. This will result in a decline in the differences between urban and rural consumption patterns. In another way, as urban populations which have a higher propensity to consume more expensive and animal foodstuffs increase, the demands for foodgrains and intensive horticulture will increase. This will result in a shift in the demand for cereals for human consumption to animal consumption and a possible increase in imported food grains.

The above trends, if they occur, may pose some very serious challenges to Korean agriculture. The movement of large quantities of food grain from human to animal consumption may not be a viable long run solution to the country's food-short economy. The inefficient conversion of vegetable foodstuffs to human nutritional elements via animal products and an already high man–land ratio may require the adoption of plant breeding and fortification rather than livestock breeding as a viable solution to the country's protein deficiency problem.

Food supply

Economic development and agricultural production

Endowed with few resources except an abundant supply of human labour, the Republic of Korea adopted an industrialsation/export orientation development strategy during the last decade. This strategy, which was followed closely until the advent of the world food crisis in the early 1970s, expedited the rapid growth of export industries while maintaining low grain prices and wage rates through the importation of foreign farm products which were then abundantly available at concessional terms [14].

Recent food grain imports alone have amounted to 600–800 million US dollars a year. Paradoxically, the necessity of using scarce foreign currency for food imports has severely limited the continuous energetic push for economic development. This sharp increase in grain imports was largely due to increasing food grain consumption. During the 1962–74 period, consumption increased at an average annual rate of 5.6 per cent. This was almost double the average annual production rate of 2.9 per cent during the twelve years period. As a result the self-sufficiency ratio in food grains dropped from 91.6 per cent in 1962 to 69.3 per cent in 1974. Broken down by major commodity, the figures are given below. Production of

food grains, except rice, decreased by an average rate of 7 per cent per year during 1962–74. In contrast, during the same period production of fruits and vegetables, respectively, grew at average annual rates of 16.5 per cent and 9.9 per cent. Imports of non-grain food were irregular and negligible.

	Rice	*Barley*	*Wheat*	*Corn*	*Soybean*	*Other grain*	*Total food grain*
1962:							
Production (1000 metric tons)	3,015	1,378	268	18	156	558	5,423
Imports (1000 metric tons)	–	47	398	36	16	2	499
Self-sufficiency (%)	100.0	96.7	40.2	33.3	90.7	99.7	91.6
1974:							
Production (1000 metric tons)	4,445	1,705	136	58	319	641	7,304
Imports (1000 metric tons)	206	299	1,591	567	66	–	2,731
Self-sufficiency (%)	95.6	85.1	7.9	9.3	82.9	100.0	72.8

On the production side, increasing demands for farm produce along with rapid industrialisation and urbanisation has begun the sector's transformation from a subsistence to a cash crop farming system. Many believe that this transition in part has contributed to relatively slow increases in food grain production. For example, during the seven years of 1967–74, the area planted to food grains including potatoes decreased by 1.9 per cent while that planted to cash crops increased by up to 8 per cent. Similar results appear when examining the ratio of area planted to food crops to the total area utilised in agricultural production. This ratio for grain declined from 90.4 per cent in 1962 to 81.8 per cent in 1974, while the ratio of area planted in cash crops rose from 9.6 per cent to 18.2 per cent. These shifts, in order of their magnitude of value production, are shown in the top table on page 152.

Factors likely to affect future production of foodgrain

A number of strategic factors are required to increase Korea's foodgrain production which formed about 72 per cent of total agricultural production in 1974. These include: seed and technology improvement, increased availability of such inputs as fertiliser and insecticides, farm mechanisation, irrigation and drainage, intensive use and expansion of agricultural land, adequate credit facilities and improved price and marketing systems.

	Rice	*Barley & wheat*	*Other food grain*	*Livestock*	*Vegetables & fruit*	*Agri. by-products*	*Special crop*	*Total*
1962:								
Current value (mil. won)	127,040	32,256	27,623	16,588	14,949	13,560	6,949	238,955
Rank	1	2	3	4	5	6	7	
1974:								
Current value (mil. won)	816,065	159,439	62,375	353,282	246,239	112,133	94,183	1,943,717
Rank	1	4	7	2	3	5	6	

	Total		*Nitrogen*		*Phosphorus*		*Potash*	
	Total (metric tons)	*Per ha. (kg)*	*Total (metric tons)*	*Per ha. (kg)*	*Total (metric tons)*	*Per ha. (kg)*	*Total (metric tons)*	*Per ha. (kg)*
	. . . Elements of fertiliser . . .							
1965	393,098	119.4	217,925	66.2	123,489	37.5	51,684	15.7
1970	562,902	171.0	355,550	108.0	124,354	37.8	82,998	25.2
1974	863,359	254.2	499,383	136.5	231,877	70.5	155,399	47.2

The emergence of new high yield rice varieties, such as Tongil (IR667) and Yushin in recent years has added new hope to achieving the goal of rice self-sufficiency. These varieties have increased yields per hectare by an average of 20–40 per cent over conventional seeds. In 1975 these varieties constituted over 41 per cent of the total paddy planted area in the country, and thereby raised per hectare yield from 2,850 kg in 1965 to 3,830 kg in 1975. However, further incorporation of the new varieties into the present crop production system appears to be highly limited by the availability of irrigation facilities.

In addition, the new high yielding varieties require rather larger amounts of fertiliser and insecticides. It is estimated that the present production of rice, barley and soybean could be increased by 20–40 per cent if farmers would apply the optimum level of fertiliser at the right time. At present, the average farm applies 254.2 kg per hectare. While the increase constitutes a doubling in the fertiliser application rate since 1965, it is still just over a half of what the average Japanese farmer applied in 1972. Nitrogen application rates, however, are comparable with those of Japanese farmers (see bottom table on page 152).

The use of agricultural chemicals provides another method of increasing crop production. Presently, disease and insect damage account for about 10 per cent of the average annual production of rice and barley. This is slightly double that which occurs in Japan. In 1974, the typical Korean farmer used 5.3 kg of agricultural chemicals per hectare. This was less than half of that amount used by Japanese farms during the same period. Broken down into component parts, 65 per cent of the 5.3 kg package of chemicals was composed of insecticides, 21.1 per cent fungicides, 11.8 per cent herbicides and 2.1 per cent miscellaneous chemicals. In 1974, if Korean farmers had applied chemicals at the same rate as their Japanese counterparts, it has been estimated an additional 267 thousand tons of rice and 85 thousand tons of barley could have been safely harvested.

A recent study [15] outlining the effects of farm mechanisation on Korean agriculture revealed that one power tiller with its attachments has the capability of handling the necessary agricultural functions in a timely manner on 3.5 to 5.7 hectares, depending on the crop and region. It was estimated that a mechanisation programme if adopted would generate a 10 per cent increase in the yield of rice; 5 per cent from power spraying, 3 per cent from better timing in planting and harvesting and 2 per cent from better seedbed preparation. Such an increase would have meant an additional 267 thousand tons of rice during the year. As of the end of 1974, there were 60,056 power tillers (mostly 10 HP), 388 farm tractors, 12 power driven rice transplanters, 73 power weeders, 704 power dryers, 116,065 power dusters and sprayers, 108,494 power threshing machines, 53 combines and 149 power sowing machines employed in crop production. In Japan more than 70 per cent of farmers own a power tiller, compared with 2.5 per cent in the Republic of Korea.

The importance of proper irrigation and drainage in rice production has been highlighted in a recent survey of Korean rice producers which compared yields obtained from well irrigated paddy land with those from rain fed paddy land. The

survey indicated that the well irrigated paddy was almost 12 per cent more productive than the rain fed paddy. In 1974 there was 1204 thousand hectares of cultivated paddy land, 70.4 per cent being well irrigated, 22.7 per cent being partially irrigated and 6.9 per cent being rain fed. If drought could have been avoided over the past decade via adequate irrigation, it has been estimated that annual rice production would have been increased by 15 per cent, or 650 thousand metric tons per year [16].

Increased cropping rates, slope land development and tide land reclamation have been proven to be viable approaches to increasing agricultural production. Over the past decade the double cropping ratio on paddy land has declined from 158 per cent in 1965 to 147 per cent in 1974. A reverse of this trend could be accomplished by a little or no additional investment. The lack of price incentives, however, has made it less attractive for farmers to follow the traditional rice/barley double cropping sequence. In 1974, the Office of Rural Development estimated that 5.6 per cent of the total paddy land capable of double cropping in the southern part of the Republic of Korea was not employed in a double cropping system, mainly due to less incentives to do so. If double cropping practices were used, barley production could have been increased by 183 thousand tons (US $55 million) during the year.

Plans for increasing Korea's land base through slope land and tidal land reclamation are presently under way. A recent government survey of land resources indicates that there are 2,450 parcels or 32 thousand hectares of undeveloped slope land under 30 degrees in slope. During the period 1975 to 1980 the government plans to reclaim 112 thousand hectares, half through government programmes and half through private projects made compulsory by law.

Estimates supplied by the Agricultural Development Corporation suggest that an additional 400 thousand hectares of paddy land could be added through tidal land reclamation projects. The cost of reclaiming one hectare was estimated at about 4 million won (US $8,000), compared with the current average market price of 4.5 million won per hectare of paddy land. If the above reclaimed areas were added to the Republic of Korea's present agricultural land base, agricultural land would increase from 22.7 per cent to 30 per cent of all land in the country. By developing the suggested slope and tidal lands, agricultural production might be increased by as much as a third of the present production in the foreseeable future.

During the ealry 1970s short term production loans offered by various institutions (agricultural cooperatives and government) increased as farm operating expenses increased. The proportion of the production loans to farm operating costs rose from 5.4 per cent in 1970 to 7.4 per cent in 1974. A breakdown of yearly loans and production costs appears below. However, the proportion was so small that farmers were forced to borrow from private sources at relatively high interest rates. The annual rate of interest on institutional short term loan during the period ranged from 9 to 15.5 per cent. Private credit sources charged an annual interest rate from 36 to 60 per cent. A 1973 survey conducted by the MAF found that 76.8 per cent of a farmer's year end liabilities came from private creditors with only 23.2 per cent from institutional sources.

Production loan	*1970*	*1971*	*1972*	*1973*	*1974*
Total (billion won)	72	101	150	114	191
A – per farm loan (won)	2,900	4,100	6,100	5,900	7,800
B – per farm operating costs (won)	54,027	64,658	74,613	89,943	104,560
A/B (%)	5.4	6.3	8.2	6.6	7.4

An integral part of any long term increase in crop production is a well planned and administered price and marketing system. The so-called high purchase price programmes for rice and barley since 1968 have positively affected both the farm production and farm income. Recent estimates of the price elasticities of supply for rice and barley were established by the author at 0.34 and 0.38 respectively in 1975, based on the data of 1960–73. The Korean Agricultural Sector Simulation Team estimated them at 0.21 and 0.74 in 1972. Also, the effects of the government controlled grain price on farm household income were found to be substantial. If the rice price were increased in real terms by 10 per cent, overall farm household income would be increased 5.8 to 6.1 per cent based on the 1971–73 data [17]. Net receipts from rice alone comprise 48.3 per cent of total farm household income in 1973. The above results indicate that an increase in the farm purchase price of rice would induce a substantial increase in production and reduce the rural–urban income disparity by increasing farm household income.

Potentials for foodgrain production

A comparison of normal farm yields for rice, barley and soybeans with those obtained by Korean agricultural experiment stations and Japanese farmers indicates that potential yield increases are not only possible but tremendous [18].

Assuming that government programmes are adopted and strengthened to supply adequate amounts of strategic production factors previously mentioned, there is no reason to believe that present yields could not be increased to equal those of Japanese farmers. If this were the case in 1974, Korea would have produced an additional 290 thousand metric tons of polished rice. This would have allowed the country to gain rice self sufficiency and to export 84 thousand metric tons of rice a year. If the nation's farmers were able to attain yields comparable to 70 per cent of those obtained at experiment stations, an additional 800 thousand metric tons of polished rice would have been produced.

Emulating Japanese yields, similar results would have occurred for barley and soybeans. Barley production in 1974 would have been 130 thousand tons and soybean production at 160 thousand metric tons. The implication of this simple exercise is that Korean agriculture, small and poorly equipped as it is, can for a sustained period of time feed more than her population with self supplied grains by fully exploiting her hidden resources.

Annual production increase (1000 metric tons)	*To attain the level of Japanese normal average yields*	*To attain 70% level of Korean exp. stations results*	*Net imports in 1974*
Rice (polished)	290	880	206
Barley (polished)	130	780	299
Soybean	160	295	66

Prospects for food demand and supply in Korea

Using the most current version of Korean agricultural simulation model, a policy experiment was attempted to assess the respective consequences with respect to the demand and supply of food resulting from six different policy-assumption combinations [19].

On the demand side, the three types of population projection profiles developed earlier and the estimates of price and income elasticities were employed as the bases for simulating demand projections for individual commodities. The population models incorporated three basic assumptions for fertility and migration parameters: low fertility and slow migration for Alternative I; low fertility and fast migration for II; and high fertility and slow migration for III. The elasticities of price and income for demand were measured by time series and cross section regression analyses. The estimated elasticities of important food items are as follows:

Commodity	*Direct price elasticity*		*Income elasticity*	
	Rural	*Urban*	*Rural*	*Urban*
Rice	–0.40	–0.45	0.10	0.10
Barley	–0.20	–0.25	–0.19	–0.33
Wheat	–0.40	–0.50	0.20	0.31
Beef	–1.80	–1.40	0.94	1.55
Milk	–2.00	–2.00	5.40	5.80
Pork	–1.00	–1.10	0.59	0.55
Chicken	–1.00	–1.70	0.80	0.95
Eggs	–0.50	–0.80	0.86	1.10
Fish	–0.50	–0.40	0.31	0.72

For the projection of supply of food grain, two price policy alternatives together with the fixed schedules of government's intended investment in land and water development were defined in terms of monetary values. The first assumption for

grain prices in the future is that the government will continue to pursue the artificial high grain price policy as has been since 1968 [20]. The assumed consumer and producer prices of major food grains to be pursued by the first price policy alternative are as follows:

Year	*Rice*		*Barley*		*Wheat*	
	Consumer price	*Producer price*	*Consumer price*	*Producer price*	*Consumer price*	*Producer price*
	. . . won per metric ton . . .					
1974	102,800	113,613	52,093	57,882	42,275	39,233
1975	115,000	115,000	52,500	55,000	47,740	44,000
1980	120,000	115,000	52,500	55,000	47,740	44,000
1985	120,000	115,000	52,500	55,000	47,740	44,000

Because the rapid realisation of self sufficiency in food grain production is of major concern for policy makers and wheat is mostly imported in the Republic of Korea, the second price policy alternative assumes that the consumer price of rice decreased from 120,000 won to 116,000 won per ton during the period of 1980–85 while maintaining the same lower consumer price of barley, and that the consumer price of wheat is increased from 47,740 won to 52,000 won and the producer price of wheat also increased from 44,000 won to 52,000 won in the same period. The objective is to accelerate wheat production and to substitute rice for wheat consumption, thus consuming the expected rice surplus and reducing wheat imports. Prices of other than foodgrain such as beef, pork and milk are assumed to be determined by free market forces and are to be fed back to estimate the elasticities of the subsequent year.

The other variable, considered in projecting future food supply was an investment flow in land and water development. The input figures follow MAF's current plan (161 billion won per year) to 1980 plus additional activities to enlarge production capacity with 60 billion won investment per year after 1980. This calls for the completion of eight large scale investment projects, substantial investment in eight additional projects to be completed by 1985, plus completion of 122 thousand hectares of irrigation improvement, 19 thousand hectares of surface drainage, 107 thousand hectares of subsurface drainage, 180 thousand hectares of land consolidation, and 107 thousand hectares of slope land reclamation. No tidal land improvement is planned other than the acreage included in the large scale projects.

Combining these four variables, the six simulation runs of the policy experiments with respect to food demand and supply are summarised in the table shown on page 158.

The results of the policy experiments are presented in terms of production, consumption, self sufficiency ratio and the nutrition level as shown in Table 4. Out of the six experiments, 'Run 3' turns out to be the most recommendable policy

Policy experiments	*Demand side*		*Supply side*	
	Population projections	*Price and income elasticities*	*Price policy alternatives*	*Land and water development investment*
Run 1	Low fertility/ slow migration	Fixed as the above estimates	High grain prices (I)	MAF's plan to 1980 plus 60 bil. won per year after 1980
Run 2	Low fertility/ slow migration	ditto	Low consumer price of rice vs. high wheat prices (II)	ditto
Run 3	Low fertility/ fast migration	ditto	I	ditto
Run 4	Low fertility/ fast migration	ditto	II	ditto
Run 5	High fertility/ slow migration	ditto	I	ditto
Run 6	High fertility/ slow migration	ditto	II	ditto

combination, in that production of major important foods except wheat and beef meets the self sufficiency level for exceeding the food requirements by 1986. The status of nutrition reaches the highest level of 2,731 calories per person a day with the largest supply of total protein at about 88 grams per person a day. The import requirements of wheat and beef in 1986, however, account respectively for 83.3 per cent and 8 per cent of total consumption in 1986.

Second best policy combinations are either 'Run 1' or 'Run 4', both of which are to achieve self sufficiency in food production except for wheat. 'Run 4' does satisfy an adequate level of beef consumption requirements without imports but all other policy experiments do not. Of these two, 'Run 4' meets the higher level of nutrition in both per person calories and total protein than does 'Run 1', whereas the latter achieves higher self sufficiency ratios in production of major foods except beef.

Various implications flow from this experiment. In order to achieve the self sufficiency in production of major food in the decade to come, vigorous population control programmes should be continuously pursued from the point of view of

Table 4
Summary results of policy simulation experiments for 1986

	Item	*Unit*	*Run 1*	*Run 2*	*Run 3*	*Run 4*	*Run 5*	*Run 6*
Rice	Production	1,000 metric tons	5,696.0	5,696.0	5,697.0	5,697.0	5,696.0	5,696.0
	Planted area	1,000 ha	1,222.0	1,220.0	1,220.0	1,220.0	1,220.0	1,220.0
	Consumption	1,000 metric tons	5,528.3	5,595.8	5,507.3	5,566.8	5,717.4	5,803.6
	Per capita C.	kg/Cap/year	120.9	122.6	120.8	122.3	121.4	123.4
	Balance	1,000 metric tons	167.7	100.2	189.7	130.2	−21.4	−107.6
	Self sufficiency	%	103.0	101.8	103.4	102.3	99.6	98.2
Barley	Production	1,000 metric tons	2,510.0	2,265.0	2,495.0	2,270.0	2,510.0	2,265.0
	Planted area	1,000 ha	928.9	838.2	923.3	840.2	928.9	838.2
	Consumption	1,000 metric tons	2,356.0	2,214.0	2,326.5	2,267.3	2,442.8	2,329.7
	Per capita C.	kg/Cap/year	49.5	48.1	49.0	48.3	49.8	47.9
	Balance	1,000 metric tons	154.0	51.0	168.5	2.7	67.2	−64.7
	Self sufficiency	%	106.5	102.3	107.2	100.1	102.8	97.2
Wheat	Production	1,000 metric tons	376.4	57.6	394.2	57.8	376.4	576.5
	Planted area	1,000 ha	142.0	21.7	149.0	41.6	142.0	217.5
	Consumption	1,000 metric tons	2,292.4	1,755.6	2,358.2	1,763.8	2,331.4	2,311.5
	Per capita C.	kg/Cap/year	53.9	53.0	55.6	53.4	53.1	52.2
	Balance	1,000 metric tons	−1,916.0	−1,698.0	−1,964.0	−1,706.0	−1,955.0	−1,735.0
	Self sufficiency	%	16.4	3.38	16.7	3.38	16.1	24.9
Beef	Production	metric tons	100,500.0	100,900.0	100,900.0	110,400.0	100,500.0	100,900.0
	Consumption	metric tons	112,810.0	122,470.0	109,662.0	97,380.0	121,940.0	116,700.0
	Per capita C.	kg	2.67	2.66	2.82	2.82	2.68	2.67
	Balance	metric tons	−12,310.0	−11,570.0	−8,762.0	13,020.0	−21,440.0	−15,800.0
	Self sufficiency	%	89.1	89.7	92.0	113.4	82.4	86.5
Milk	Production	metric tons	851,200.0	854,600.0	843,900.0	846,900.0	851,400.0	854,800.0
	Consumption	metric tons	851,200.0	854,600.0	843,900.0	844,202.0	784,400.0	854,800.0
	Per capita C.	kg	19.8	19.9	19.7	19.8	19.2	19.2
	Balance	metric tons	0	0	0	2,698.0	67,200.0	0
	Self sufficiency	%	100.0	100.0	100.0	100.3	108.5	100.0
Nutrition	Calories	Cal/Cap/day	2,727.0	2,724.0	2,731.0	2,723.0	2,719.0	2,716.0
	Protein	Gr./Cap/day	87.29	87.08	87.95	87.68	86.90	86.62

moderating rapid increase in food consumption. In this respect, maintaining a low rate of fertility is essential. Assuming that there would be a steady and fast rural–urban migration through the decade, providing them with non-farm employment opportunities poses an immediate problem. Urban problems would increase as the process of migration continues. Also, shortage of farm labour plus rising wage rates would aggravate conditions for increased production unless the process of farm mechanisation makes up the gap caused by a heavy drain of agricultural labour. In this respect, certain measures to slow down the fast migration need to be immediately made, under the circumstances of low funds available to counter-measure the ill effects.

On the supply side, by all means, the current high grain policy should be continued in order to increase grain production on the one hand and to maintain the moderate consumption level on the other. By changing administrative prices, a considerable substitution between barley and wheat production may be expected without jeopardising the level of total production. Wheat imports can be reduced with shifts to higher producer and consumer prices of wheat while lowering consumer prices of substitutable food grain. However, the model test indicates that the reduction rate was unsatisfactory at the current demand conditions. Besides a higher price policy some other non-price measures may be needed to decrease wheat consumption to an acceptable level. If the Republic of Korea is able to reduce wheat imports by one million tons from the estimated amount of 1.7 million tons (Run 3) in 1986, the value will amount to 300 million dollars by applying the price of $300,00 per ton projected by Japanese economists [21].

With the limited number of variables plus rigidity in the use of assumptions the model, however, could not tell us how to economically tackle the problems, given limited amounts of resources and many alternatives to take.

Recommendations and research needs

Attempts to achieve self sufficiency in food production have been made on both production and consumption aspects in the Republic of Korea. The decline in population fertility has been experienced during the past decade, in part due to the vigorous family planning activities of both public and private agencies. It is likely that the 'Stop at Two' campaign now underway will be gradually permeating into the nation if strongly supported by the government. However, some more serious attention needs to be paid to problems arising from the rapid rural–urban migration.

The past investment programmes have placed stress relatively more on the industrial and services sector development until fairly recently, in the wake of the world food crisis. The economic feasibility of increasing agricultural production and rural development is likely to continue under present population pressures and world price trends. To assure continued success in these areas it is recommended that:

1. The government budget for the family planning programme not only be increased, but also the ideal family size of the average Korean be lowered in order to attain the ambitious target of a 1.3 per cent population growth rate by 1986. Particularly, the following policy measures are highly recommended:
   (a) raise the legal age for marriage;
   (b) modify inheritance laws to favour daughters as well as sons;
   (c) relax military draft regulations to exempt a man from military service if he is an only son and has no more than one sister, and thereby encouraging participation in the 'Stop at Two' campaign.

2. Various government ministries cooperate in formulating a basic set of policies concerning urban taxation, pollution abatement, zoning and industrial decentralisation in hopes of slowing down the present trend of rural–urban migration.

3. Research on the effectiveness of family planning communication and education be initiated because communication and education programmes should be mobilised for the purpose not only of transmitting knowledge of contraceptives but also of stimulating and fostering the psychological processes identified to be important.

4. A policy analysis be conducted in order to explore effective measures of decentralising the location of new non-agricultural employment creation, and in realising well balanced distribution of population among different regions of the country.

5. Self sufficiency targets for various commodities be incorporated in the Fourth Five Year Plan, beginning in 1977. This will assure that public investment in increased agricultural production will be dealt with at the national level on a par with other forms of public investment.

6. A comprehensive programme of land use controls and development be adopted. Such a programme should contain a variety of elements, such as the promulgation of a set of uniform laws to minimise the conversion of prime agricultural land to urban uses, and intensified farm land expansion programme including both upland and tideland reclamation and the development of improved irrigation and drainage facilities. Such an intensified programme would likely require a doubling of the government's investment in rural infrastructure development.

7. Large scale pasture development programmes for grazing livestock be expanded to reduce imports of feed grain. A continuance of shift of cereals to feeds as much as is needed for producing animal protein would not be the long-run solution to the problem especially in a land-scarce country. On the consumption side, plant breeding, increases in the production of protein plant and fish catches, fortification of cereals might be alternative solutions to tackle

protein deficiencies.

8. Efforts be intensified to increase the rate of farm mechanisation and to improve the farm produce distribution and marketing system.

   Peak seasons of labour shortages are already beginning to occur because of the rapid increases in rural–urban migration. To overcome these shortages farm machinery should be made available over a wider geographical area. To take full advantage of improved technology in agriculture, marketing infrastructures are also required. Research is urgently needed to minimise storage and processing losses associated with the farm to market distribution system, to design an effective and efficient foodgrain management system at the national level and to enhance the growth and modernisation of the food processing industry.

9. The current production price support system for rice and barley be continued since it has increased both farm production and income. However, to increase efficiency within the system, standard criteria for determining the government purchase price are required. To assure the maintenance of an efficient and viable private wholesale and marketing system the government should discard the present system of setting a fixed seasonal release price and adopt a sliding scale of release price mechanism. This would help to minimise the amount of government funds required to maintain the subsidy programme and provide increased incentives to private wholesalers to maintain larger stocks even during off season periods.

10. The government adopt measures to reduce the growing importation and consumption of wheat. The wheat-made food encouragement programme together with the price support system for accelerated consumption of wheat and wheat flour should be abandoned to foster an increase in demand for locally produced wheat substitutes. Even a higher producer/consumer price system needs to be introduced. Research aimed at developing indigenous varieties of high yielding wheat should be intensified to assure future wheat self sufficiency.

11. The government improve and expand the present farm credit structure to assure adequate long and short term credit facilities for farm modernisation. A streamlining of credit for small farmers with a doubling of the present funds available will be required.

12. A minimum of 1 per cent of the agricultural sector's GNP (approximately 15 billion won) be devoted to the support of agricultural research and experimentation. The payoffs from such research are widely known. For example, the development of indigenous Tongil rice varieties has alone accounted for an increase in rice production of 3,000 metric tons. This is equivalent to a foreign exchange saving of 150 million dollars.

Notes

[1] The major contents of this paper was presented at the FAO/IAAE/UNFPA co-sponsored Seminar on Population and Food and Agricultural Development held in Rome, Italy, December 1–5, 1975. The author wishes to acknowledge Mr Dong Min Kim and Dr Dong Hi Kim of the National Agricultural Economics Research Institute for their contribution to this paper, for which he is solely responsible.

[2] S.K. Ahn, 'The Korean National Family Planning Program' presented at the 'Summer Seminar on Population', Seoul, July 15–19, 1974.

[3] As of 1973, the size of the family planning programme can be elaborated as follows:

Annual total expenditure:	1,827.9 million won (US $4.5 million equivalent)
Proportion of GNP:	0.37%
Number of field workers:	2,353 persons
Coverage per worker:	13,384 persons

[4] Demographic sample surveys and various indirect information estimated that the crude death rate was about 13 deaths per 1,000 total population in 1960, 8.5 in 1970, and 6.6 deaths in 1974. The life expectancy at birth, estimated on the basis of data on children born before 1973, was 62.4 years for men and 66.7 years for women.

[5] H.S. Moon *et al.*, 'Recent Trends in Ideal Family Size', in *Population and Family Planning in the Republic of Korea*, Vol. II, Korean Institute for Family Planning, Seoul, 1974, p. 281.

[6] Sang Joo Lee, 'Psychological Research: Korea', in *Population and Family Planning in the Republic of Korea*, Vol. II, Korean Institute for Family Planning, Seoul, 1974, pp. 281–96.

[7] Chung-Ja Kong, and Jae-Ho Cha, 'Boy Preference in Korea: A Review of Empirical Studies Related to Boy Preference', in *op. cit., supra*, p. 324.

[8] Seyeul Kim, 'The Economic and Social Determinants of Rural–Urban Migration in Korea', *Korean Journal of Agricultural Economics*, Vol. XVII, July 1975, p. 48.

[9] Exotech Systems Inc., 'Farm Mechanization Program for Korea – A Study of the Feasibility of Mechanizing Agriculture in the Republic of Korea', Seoul, 1973.

[10] Population Studies Centre, 'A Study of the Effects of Rural Out-Migration on Rural Development and Their Measures', Seoul, 1971.

[11] George E. Rossmiller, *et al.*, 'Korean Agricultural Sector Analysis and Recommended Development Strategies, 1971–85', Michigan State University, East Lansing, Michigan, USA, 1972.

[12] See John Sloboda and Tom Carroll, 'Approaches to Modelling Off-Farm Migration' (mimeographed), Michigan State University, East Lansing, Michigan, USA, 1974.

[13]

Year	*Proportion of over age 20 to total (%)*	*Annual average growth rate of over age 20*
1981	56.4	2.7
1986	59.7	2.9
1990	61.2	2.2

[14] The agricultural sector being in a relatively low value added position has, however, grown at a modest rate of 4.3 per cent a year during 1962–74. Yet its contribution to GNP declined from 44.1 per cent in 1962 to 22.5 per cent in 1974, attributed to the faster growth of other sectors of the economy.

[15] Exotech Systems, Inc., *op. cit.*

[16] According to IAS Report of 1974, the yield of barley is also affected greatly by the amount of water consumed. That is, there was almost a double difference between the case of water consumption by 325 mm and that by 179 mm. However, this approach assumes overall standard input requirements being satisfied.

[17]

Total farm household income (A)	480,711 won
Income from rice production (B)	232,096 won
B/A (%)	48.3
Direct price-income effect (%)	4.8
Production increase effect (%)	1–1.3
Total income increase (%)	5.8–6.1

[18] For the detailed data on the normal production averages and the experimental results of foodgrains in Korea, Japan and USA, see S.H. Kim and D.M. Kim, 'Population and Food in Korea', Michigan State University, East Lansing, Michigan, USA, 1975, p. 47.

[19] Michael Abkin, *et al.*, 'Briefing Charts on the Korean Agricultural Sector Simulation Project', Michigan State University, East Lansing, Michigan, USA, 1975.

[20] Since 1968 the Korean Government has followed a high grain policy for the dual purposes of: firstly, providing farmers with good incentives for production increase and secondly, leading consumers to follow more economical food consumption patterns. However, the consumer price of barley has been lower than the producer price (government's purchase price) for the benefits of low income households' economy.

[21] Mitsubishi Research Institute, 'A Projection Model of Food Supply and Demand of the World in 1980 and 1985', Tokyo, Japan, May, 1974, pp. 115–116.