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DEVELOPMENT PROCESS OF AGRICULTURE AND TECHNOLOGY - A CASE STUDY OF KOREA

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ABSTRACT

Development process of agricultural technology has been studied with a case study of Korean agriculture. Technology is considered as a transformer of inputs into outputs and hence technological appropriateness, an important aspect of agricultural development strategies, is considered as a dynamic concept.

Considering the concept of agricultural system as a delivery system for providing essential materials and services to producers and consumers, it has been divided into two major groups of dimensions viz. external challenge dimensions and internal response dimensions. Market, investment and agro-ecosystem constitute the external challenge dimensions; whereas trade, technology as well as production and resources allocation constitute internal response dimensions. The system manager is responsible for maintaining equilibrium in the mentioned six sub-systems. Two kinds of alternative paths of technological development viz. land saving technology and labour saving technology have been studied. Technology is considered as a combination of four basic components viz. facilities, abilities, facts and frameworks. Adoption of innovations in agriculture depends on profitability, awareness, risk aversion, financial capacity, institutional infrastructure, availability of physical inputs and adaptability to the local conditions.

For a case study of Korea, changes in the agricultural system through external challenge dimensions are investigated. The impacts of industrialization on agro-ecosystem reported are shift of labour from the agricultural sector to non-agricultural sectors and continuously increasing demand of farm land for non-agricultural sectors accompanied by increase in land prices. The impacts on the commodity market discussed are shift in demand from rice, barley and other cereals to meat, dairy products and vegetables; and increase in supply capacity of agricultural inputs. The process of agricultural development from 1962 to 1991 (i.e. from start of the first to the end of the sixth five year plan) are also discussed in details with several policy measures taken. The trend of agricultural income and productivity are also analyzed. The main cause of increase in the agricultural income is considered as increase in labour productivity. The study revealed that during the span of 1965-88, holding size has not changed significantly, but both the land and labour productivity increased and so did the agricultural income. R & D activities in Korea have changed over time in three stages viz. import of improved technology, localization by adaptive research and technological mastery. For the new technology to

be made affordable to farmers, policy measures like fertilizer and food grain exchange system, dual price system in rice and barley and loan for machinery were strengthened.

Key Word: Korea, Agriculture, Development, Technology

INTRODUCTION

Agricultural development over time involves a dynamic process of technological development for adjustment of production resource endowments. Technology acts as a transformer of inputs into outputs (APCTT, 1989), therefore, technological appropriateness is not an intrinsic quality of technology but is a dynamic concept and depends largely on the technology put into use. Thus, the choice and adoption of technology suitable for local socio-economic condition become an important aspect of agricultural development strategies.

This paper deals with the formulation of the agricultural development model based on system's theory. From a case study of Korea, the process of agricultural development in relation to the development of national economy is explained; the process and role of agricultural technology in the context of changes in agricultural resources endowment are analyzed; and technological development policies focused on the mechanical technology are investigated.

AGRICULTURE AS A SYSTEM

Agriculture is an activity of man, carried out primarily to produce food, feed and fibre by the deliberate and controlled use of plants and animals (Spedding, 1979). One concept of an agricultural system includes, within its boundary, the delivery systems for providing essential materials and services to producers and getting products to consumers. Considering this concept following six sub-systems are identified; market, investment, agro-ecosystem, trade, technology, and production and resources allocation (Fig. 1). The first three of these may be called 'external challenge dimensions' and remaining three may be called 'internal response dimensions' (Campell, 1985).

External Challenge Dimensions

In marketing subsystem, there are competitive relationships between the consumers and the suppliers, including foreign traders, for quantity, quality and price of traded commodity. Investment subsystem also has a competitive relationship between investment in agricultural and non-agricultural sectors. The agro-eco subsystem has competitive relationship between the use of resources, especially labour and farm land, in the agricultural and non-agricultural sectors. The center of gravity of each of above three sub-systems is in the environment of the agricultural system and the environment exerts a centrifugal force on the agricultural system which tends to pull it apart.

Internal Response Dimensions

Trade, technological development and production subsystems are related with farmers' activity within the conditions provided by the three external challenge dimensions. They exert a centripetal force on the agricultural system which tends to hold it together. Trade takes place within the context of market conditions to increase farmers' profits. The profit is determined by market price and technology employed in the production process. The technological development takes place in relation to the investment made. It serves to substitute relatively abundant resources for scarce and expensive resources. The production takes place within the boundary of the current agro-ecosystem. This subsystem includes the choice of crops depending on market conditions and decisions on the amount of production which is determined by allocated resources and production technology used. The system manager (e.g., a farmer or the government) is responsible for maintaining equilibrium in the mentioned six subsystems.

AGRICULTURAL PRODUCTION SYSTEM

Agro-ecosystem structure includes all the elements of the ecosystem and the manner by which they are functionally interconnected to each other. Production technology is a blue print for agro-ecosystem. It is total a package which a farmer uses to mold a given area into an agro-ecosystem (Marten, 1988). In this paper, a combination of the agricultural technology and agro-ecosystem is defined as the agricultural production structure. In a wide sense, agricultural production structure includes agricultural production infrastructure which provide supportive services to individual farmers for production. The agricultural infrastructures act as a transporting media for timely flow of materials, money, information and services.

Flow of materials and energy in and out of the production structure (transformation process) is called the production system function. Production efficiency is determined not only by the agricultural technology but also by agro-ecosystem structure and agricultural infrastructures. The functional relationship between technology and agro-ecosystem may be defined as adaptability.

Agricultural Technology

The agricultural production process is spread over time and space. The spatial nature of agriculture requires relatively more land than other economic activities and the seasonality in its activities leads to a seasonal variations in demand for labour. Due to its biological nature, agricultural production depends on agro-climatic conditions and thus there is always an element of uncertainty associated with it.

Agricultural technology grew to eliminate the bottlenecks caused by resources constraints. There are two alternative paths towards technological development: (i) biological and chemical technology primarily needed for the increase of land productivity (land saving technology), and (ii) mechanical technology primarily needed for the increase of labor productivity (labor saving technology) (Hayami and Ruttan, 1971).

According to induced development model by Hayami and Ruttan (1971), relative factor price guides the behavior of farmers, public policy and research programs, and

institutional innovations in the direction of an optimal choice. An additional factor inducing changes in agricultural technology is the reduction of uncertainty of agro-climatic conditions in the agricultural production system.

Technology is a combination of the four basic components, viz. facilities, abilities, facts and frameworks (APCTT, 1989), as described below:

(i) Production tools and facilities - the object-embodied form of technology (or technoware). It includes all physical facilities necessary for transformation operation, such as instruments, machinery, infrastructures and factories.

(ii) Production skills and experiences - the person-embodied form of technology (or humanware). It includes all acquired abilities necessary for the transformation operation, such as expertise, dexterity and creativity.

(iii) Production facts and information - the document-embodied form of technology (or inforware). It includes all facts and figures required for transformation operation, such as designs, specifications, relations, equations, charts and theories.

(iv) Production arrangements and linkages - the institution-embodied form of technology (or orgaware). It includes the frameworks required for transformation operation, such as groupings, allocations, systematization, organization, networks, management and marketing.

Adoption of Innovation in Agriculture

Adoption of innovations in agriculture depends on profitability, awareness, risk aversion, financial capacity, institutional infrastructure, availability of physical inputs (e.g., fertilizer and farm machinery) and adaptability to the local conditions (Yudelman et al., 1971). Farmers in Korea have limited R & D ability for development of technology and also shown 'Safety First' tendency which impedes adoption of new technology. Besides these, for adopting new technology, some times changes are required in the agro-ecosystem structure and agricultural infrastructures within the system to which the technology belongs. As the farmer has very limited ability to change the agro-ecosystem and agricultural infrastructures, the government has to play a key role in introducing technological changes in the agriculture.

A CASE STUDY OF KOREA

In this section, changes in agricultural system through external challenge dimensions due to industrialization are investigated. Based on this, development process in agricultural policies and technologies to cope with the external challenges and changes in agricultural income and productivity of agricultural resources are examined. At the last, technological development strategies focusing on mechanical technology are analyzed.

Impacts of Industrialization on Agriculture

The impacts of industrialization on the agro-ecosystem are classified into two categories. The first one is shift of labor from the agricultural sector to non-agricultural

sectors. Rapid industrialization has caused decrease in the farm households and farm population since 1967, and of employment in agriculture since 1976. The other impact is the continuously increasing demand of farmland by the non-agricultural sectors accompanied with increase in land prices. The trends of agricultural labor and farmland are shown in Fig. 2.

The impacts on the commodity market are classified into two groups. The first impact leads to a shift in demand from rice, barley and other cereals to meat, dairy products and vegetables. The other impact tends to increase the supply capacity of agricultural inputs such as fertilizer and farm machinery.

Process of Agricultural Development

Since 1962, six five-year economic development plans have been implemented in Korea. The urgency of achieving food grain self-sufficiency strengthened policies to increase the food grain production. At that time, in spite of abundant farm laborers, farmland was scarce and thus, the main policies were the extension of farmland and promotion of research to increase the land productivity.

During the first five-year economic development period (1962-1966), some important institutions like Rural Development Administration (RDA) for research and extension (1962) and National Agricultural Cooperatives Federation (NACF) to promote farmers' cooperative activities and to route agricultural finance (1961) were established. By installation of fertilizer factories, fertilizer production capacity was rapidly increased from 85,000 tons per year in 1961 to 132,000 tons per year in 1967. To improve farmer's purchasing ability of fertilizer, direct exchange of food grain with fertilizer was facilitated.

During the second five-year plan period (1967-1971), the dual price policy for rice and barley was introduced in 1969. Farm land reclamation, rearrangement of farm land and improvements in irrigation systems were also carried out to increase land productivity and stabilize production. To achieve these objectives, the Agricultural Promotion Corporation was established in 1970.

In the beginning of the third five-year plan period (1972-1976), the most significant progress was the development and spreading of high yielding crop varieties. During this period, the dual price system for rice and barley was fully implemented. A large quantity of fertilizer and vinyl resin were needed to grow the high yielding crop varieties. The dual price system encouraged adoption of new technology by improving farmer's financial investment capacity. To cope with decrease in availability of agricultural labor, agricultural mechanization projects were accelerated.

Although in late 1970s, self-sufficiency in rice and barley was achieved, an imbalance in demand and supply of meat, dairy products and vegetables caused fluctuations in productions and prices. Profitability became an important issue. Due to the government policy of supporting selected industries having greater comparative advantages, imports of agricultural products increased whereas government support for agriculture was reduced.

In the beginning of the 1980s, first priority was given to reduce the inflation in order to stabilize the national economy. During this period, increase in agricultural income was strictly restricted. To complement farm household income, increase in off-farm income

opportunity by rural industrialization was considered as a policy measure. In the late 1980s, improvement in balance of payment situation strengthened market liberalization, leading to competitive imports. Under such condition, Korean agriculture is searching for a new policy for sustainable agricultural development which would also lead to a more efficient production system.

Trend of Agricultural Income and Productivity

The main cause of agricultural income growth has been the increase in land productivity. The effect of increased farm size is not significant (Fig. 3). Due to rapid increase in labor and farmland prices, capital was substituted for the resources. Until the first half of 1970s, productivity of each resource increased rapidly but after that period the increase rate slowed down (Fig. 4). Especially the capital productivity dropped continuously since 1972 with a few exceptions. Such trend indicates that the current land saving technology poses the limitation in increasing the farm income. Therefore, to increase the farm household income the farm size should be enlarged to improve labor productivity through mechanization. To adopt the labor saving technology, current farm land structure such as small scale farming system and scattered plots are unfavorable.

Process of Agricultural Mechanization in Korea

Agricultural mechanization is a sub-system of the agricultural system. The process of agricultural mechanization should, therefore, be investigated in relation to resource endowment for agricultural production such as labor and land. The strategy for agricultural mechanization should be coordinated with the overall changes in the agricultural technology (Ahn, 1992). An overview of mechanization stages and development of technology diffusion framework have been investigated in this section.

Stages of agricultural mechanization in Korea

Based on changes in mechanization policy the stages of agricultural mechanization are divided into following five phases (Kang et al., 1988):

(a) Agricultural mechanization before 1961: Most of the agricultural machinery during this phase were operated by human or animal power. The major machines employed were manual sprayers and pedal threshers.
(b) Preparation for agricultural mechanization (1961-1971): The major farm machinery used were comprised of disaster prevention equipment such as power sprayers and water pumps.
(c) First stage of agricultural mechanization (1972-1976): Soil preparation operations were gradually mechanized owing to rapid dissemination of power tillers.
(d) Second stage of agricultural mechanization (1977-1986): Farm mechanization was focussed mainly on paddy transplanting and harvesting. Farm mechanization was introduced for all the farm operations, and the spread of high capacity machines such as tractor and combine started in 1978. The government enacted the Agricultural Mechanization Promotion Law for implementing mechanization policy systematically.
(e) Third stage of agricultural mechanization (1987 onwards): Agricultural mechanization in this stage has expanded to up-land crops, vegetables, orchards and livestock.

Extension, training, and repair and maintenance facilities have been further strengthened.

The stages of mechanization are influenced by availability of labour. Until 1960s, land was scarce but labor was abundant. Thus, agricultural technology focused on increasing land productivity and production stability. Under such situation, mechanical technology was required as a supporting, complementary input to biological and chemical technology such as water pumps and pesticide applicators. From the first half of 1970s, labor became a scarce resource. Power tillers were used to meet the initial labor shortage and to maintain agricultural production. After 1977, labor in agriculture decreased rapidly and agricultural mechanization played a key role in increasing labor productivity with the use of transplanters, harvesters and tractors.

Development of technology diffusion arrangements

Technology diffusion arrangements can be examined in terms of following categories:

(i) Agency for R & D: Before 1962, the agency for farm machinery R & D was situated in the farm management section of the Central Agricultural Technology Institute. In 1979, it developed into the Agricultural Mechanization Institute. The R & D activities in farm mechanization have progressed in the following three stages:
   (a) Stage of importation (up to middle of 1960s): R & D activities were focused on testing and improving machines such as farm engines, water pumps, power sprayers, and small tools.
   (b) Stage of localization (from mid of 1960s to end of 1970s): Research activities were concentrated on the adaption and testing of foreign machines, and then on their local production.
   (c) Stages of advancement (from the beginning of 1980s): Research activities were concentrated on the development of farm machinery suited to Korean farming conditions, the improvement of the existing machinery, and the promotion of machinery utilization (Agricultural Mechanization Institute, 1988).

(ii) Development of farm machinery: At present there are five large scale manufacturers called generalized manufacturers which produce sophisticated farm machinery like power-tillers, tractors, transplanters, binders and combines. Eleven small and medium scale specialized manufacturers produce power sprayers, threshers, water pumps, grain dryers and straw cutters. Other small and medium scale manufacturers produce various attachments and tools.

(iii) Development of skills: There are two kinds of training systems for farm machinery operators. One is the governmental system and the other is the private system. In the initial stages of agricultural mechanization, government training facilities played a very important role, because the manufacturers of machinery had poor national network and limited capacity for imparting training. At present, however, private companies have taken up the task of imparting training.

(iv) Information exchange and dissemination: The R & D activities for farm mechanization are jointly carried out by national institutions, manufacturers and universities. During the initial stage, Rural Development Administration (RDA) and National Agricultural Cooperation Federation (NACF) played the primary role in providing information to farmers through extension activities. At present, many commercial companies supply information to farmers as a part of their sales activities.

(v) Development of organizational arrangements: During the period between 1977 to 1981, the government established integrated mechanization groups with 300 ha operational area in each province. In 1981, 510 farm mechanization centers of 50 ha each were also established through out the country to collect information for formulating mechanization policies and to provide information about machinery utilization to farmers. By 1989, approximately 20,000 mechanized farming groups consisting 5 to 10 farmers were established.

(vi) Supply and after sales service of farm machinery: Till the beginning of 1980s, farm machinery had been supplied mainly through the NACF. With the growth of machinery industries since 1984, farm machines have been supplied mainly through the agents and dealers as well as through local agricultural cooperatives.

(vii) Financial support: Two kinds of loans have been provided by NACF channels. For individual purchase, the government lends 70-90% of the purchasing price at 5% interest rate; and for cooperative utilization, 50% of purchasing price is subsidized and the rest is loaned at 5% interest rate.

(viii) Inspection of farm machinery : Since 1962, model inspection was assigned to the Institute of Agricultural Engineering and Utilization (IAEU) under the RDA and NACF. At present, National Agricultural Materials Inspection Office (NAMIO) inspects farm machinery in accordance with the Agricultural Mechanization Promotion Law.

(ix) Standardization of farm machinery: Since 1970s, Korean Standard and Korea Farm Machinery and Tool Industry Cooperative have been developing standards for farm machines and their parts to unify specifications such as size and quality. Standardization plays an important role for development of industries, because it provides not only interchangeability of parts, components and generic units, but also provides economy of scale by mass production.

CONCLUSIONS

(i) Korean agriculture has progressed by appropriate choice and technological development to meet socio-economic conditions. Until 1970s land saving labour intensive technologies were developed to achieve self-sufficiency in rice and barley under scarce farmland and abundant labour. As farm labour decreased, small sized power driven machines like power tiller were introduced to meet initial labour shortage. Thereafter, as farm labour decreased rapidly, high labour saving machines such as tractors, transplanters and harvesters were introduced. For the new technology to be affordable to farmers, policy measures like

fertilizer and food grain exchange system, dual price system in rice and barley, loan for machinery, etc. were strengthened.

(ii) Changes in R & D activities took place in three stages: import of improved technology, localization by adaptive research and technological mastery. Through interventions such as standardization, quality control and certification and specialization of machinery production, the government accelerated R & D activities and provided opportunity for taking advantage of the scale of economy.

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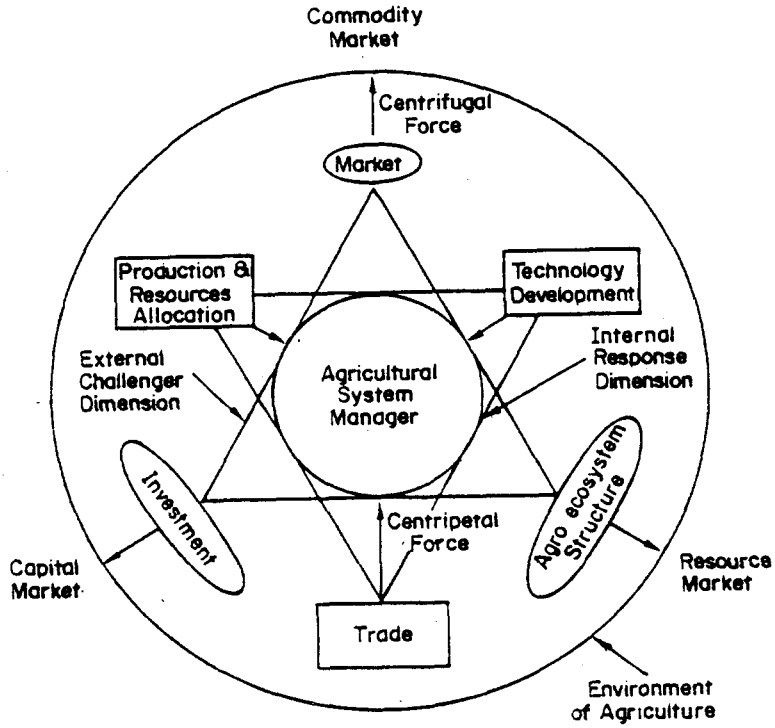

Fig. 1: Agricultural system structure (adapted from Campell, 1985)

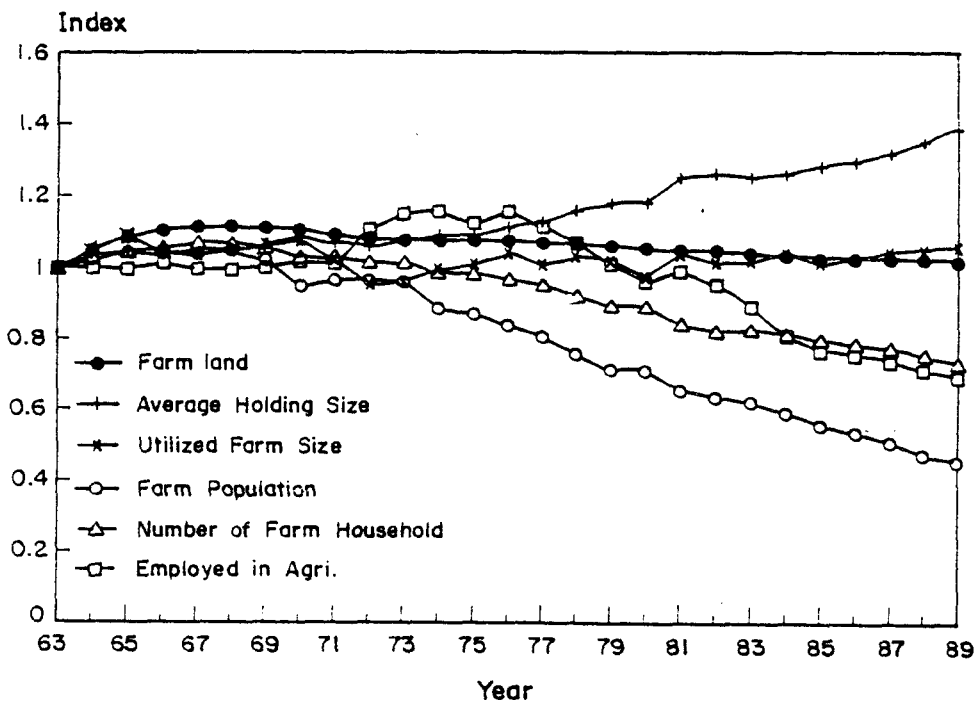

Fig. 2: Trend of agricultural labour and farm land (Source: Statistical yearbook of agriculture, forestry an fisheries, Korea, 1962-1989)

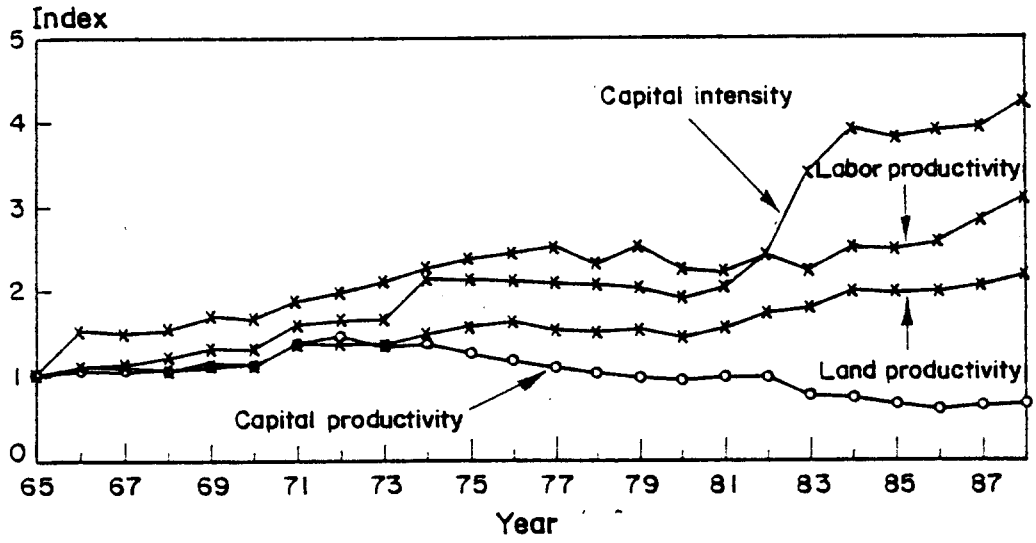

Fig. 3: Trend of agricultural income and land productivity (Source: Statistical yearbook of agriculture, forestry an fisheries, Korea, 1964-1990)

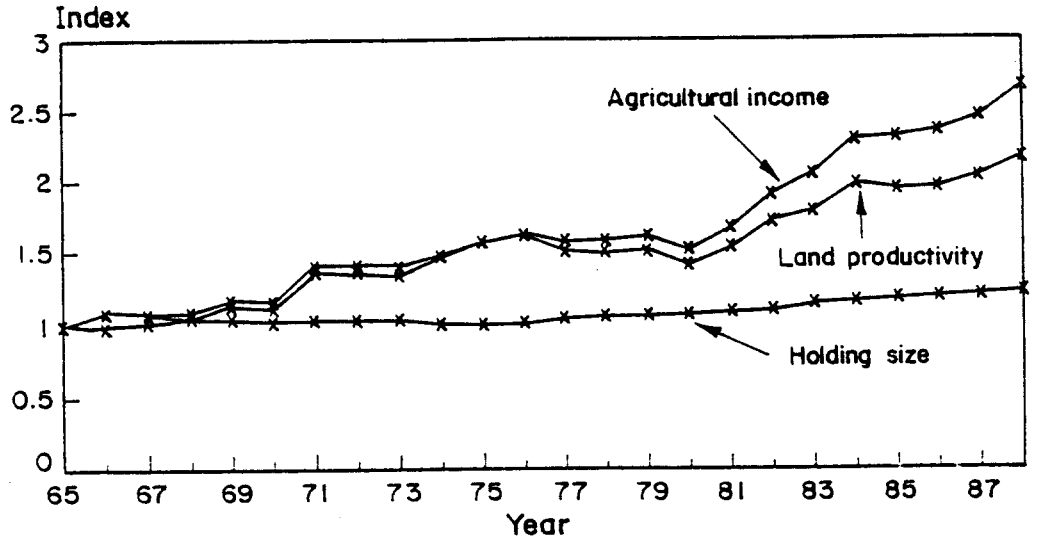

Fig. 4: Trend of productivity (Source: Statistical yearbook of agriculture, forestry an fisheries, Korea, 1964-1990)