Economic Implications of the "Green Revolution" and the Strategy of Agricultural Development in West Pakistan

by

HIROMITSU KANEDA*

INTRODUCTION

The short-stemmed varieties of wheat and rice imported from abroad and the increased use of fertilizers have dramatically enlarged the potential for rapid increases in the agricultural output of West Pakistan. This recent breakthrough in foodgrains production is sometimes referred to as the "green revolution". Because of the generally favourable conditions in West Pakistan in regard to irrigation water and solar energy, and due to the unusually favourable weather in 1967/68 in particular, the "green revolution" is spreading most rapidly. It is high time to focus our attention on some of the economic implications of the new developments in agriculture.

Recent agricultural growth in West Pakistan has been the result of improvements in the production relationship in the agricultural sector. However, the relationship between land and man in agriculture and that between agricultural production and other economic activities tend to be neglected in the current discussions of the ways in which the country may sustain the recent growth performance. Having identified the sources of growth in the agricultural sector during the 1960's[1], some expound the virtue of further improving the produc-

*The author is a Research Adviser at the Pakistan Institute of Development Economics. The author wishes to thank Bruce F. Johnston and Frank C. Child for many valuable suggestions during the course of this study. He is also grateful to Robert D. Havener and Jerry B. Eckert of the Ford Foundation and to a referee of this journal, who contributed hopeful comments on the earlier draft. Of course, the author assumes sole responsibility for the analysis, opinions, and conclusions contained in this paper.

[1]Private groundwater development contributed substantially to the growth of West Pakistan's agriculture during the second-plan period (1960-65). Although the adverse weather conditions in the early years of the third-plan period (1965-70) retarded growth in the agricultural sector, blessed by the good weather, a spectacular performance was achieved in the 1967/68 season. The prime source of output growth in this most recent spurt is the much more favourable production relationship attributable to the development of new varieties of major crops, especially wheat and rice, and to the improved environment of the farmers resulting from more liberal policies of input provision and output price-support programmes.

tion relationship by introducing an extensive mechanization programme in the agriculture of West Pakistan. The engineering criteria used in such arguments are seemingly flawless. And, it is attractive to state that after water and biological-chemical technology has been introduced, mechanical-engineering technology should follow to promote further improvements in the basic production relationship in agriculture[2]. However, the choice of techniques, the ways in which the factors of production are to be combined, and the phasing-in of new technologies cannot be determined solely on the basis of mechanical-engineering criteria. There are other questions which call for economic analysis focused not only on the production relationship in agriculture *per se*, but also on the marketing and distribution systems and on the relation between agriculture and nonagricultural sectors of the economy.

The opportunities created by the "green revolution" present some challenging economic issues besides the mechanization question. A rapid increase in agricultural output and the consequent increase in the marketable surplus of agricultural products are expected to overwhelm the processing, warehousing, distribution, and marketing systems that exist today. The rapid achievement of self-sufficiency in foodgrains will bring a very sharp reduction in the PL 480 programme in Pakistan and in the generation of counterpart funds that the government has relied upon to finance a substantial fraction of its development programme. A rapid increase in cash income for the agricultural sector will call for a re-examination of the system of agricultural taxation as well as the entire strategy of economic development. The problem of a stagnant agriculture has been primarily on the supply side; now that agriculture has experienced a rapid increase in productivity it must face an increasingly difficult problem of expanding effective demand to match the growth of supply. The euphoria of the present situation cannot, itself, sustain the view that there is unlimited demand for increased agricultural output. The prospects for international as well as domestic marketing have to be seriously explored.

In this paper I shall deal with a few of these problems. My immediate concern is the question of tractor mechanization in West Pakistan. I shall deal with other problems in the context of this main theme but only to the extent that they are relevant to the theme. First, the economic implications of West Pakistan's demographic characteristics will be analyzed in order to give perspective to the agricultural development of the province. Attention will be focused on the relationship between the land-man ratio and the output trend in

[2]The phrase "biological-chemical technology" refers to agricultural technology bound up with the biological growth process of farm products and yield-increasing chemicals such as fertilizers, pesticides, and herbicides. The phrase is used in contrast to "mechanical-engineering technology". As will become clear in the text of the paper below, "biological-chemical technology" is more divisible, quicker in payoff, and primarily yield-increasing in contrast to "mechanical-engineering technology" that is in general "lumpy", slow in payoff, and primarily labour-displacing.

the agriculture of West Pakistan. Secondly, I shall review the sources of productivity growth in the agriculture of Japan and the United States. The experiences of these countries provide us with a comparative framework for analyzing the interrelationship between factor endowment and strategy of agricultural development. Thirdly, the question of tractor mechanization in West Pakistan will be examined from the standpoint of economic efficiency and the choice of strategy for agricultural development. Finally, I shall present some basic considerations for an alternative strategy of the agricultural development of West Pakistan in view of the further progress of the green revolution.

II. DEMOGRAPHIC CHARACTERISTICS OF WEST PAKISTAN

As in other countries, industrialization in West Pakistan has been accompanied by a decline in the relative share of the agricultural labour force in the total labour force. The 1961 Census shows that the share of agriculture was 59.3 per cent of the total labour force, declining from 65.1 per cent in 1951[3]. During the ten years between the two decennial censuses, however, the agricultural labour force grew at the compound annual rate of 2.0 per cent and the nonagricultural labour force at 4.6 per cent, while the total labour force grew at the rate of 3.0 per cent per annum. Consequently, the absolute number of the agricultural labour force in West Pakistan increased from approximately 6.2 million in 1951 to 7.6 million in 1961[4].

On the basis of the assumption of constant fertility and declining mortality, experts at the PIDE estimate that the population of West Pakistan will rise at the annual rate of 3 to 4 per cent in the coming decades. If fertility is assumed to remain constant until 1970 and then decline linearly by 30 per cent to the period 1980-85, the effect of this minor change in fertility is minimal with respect to growth rates. The growth rate of population in West Pakistan will then fluctuate between 2.9 per cent to 3.1 per cent per annum [2].

Given the high rate of population growth (which implies a high growth rate of the total labour force), and the very large share of the agricultural labour force in the total, it will be a long time before the absolute size of the agricultural labour force starts declining. According to the calculations carried out by Jerry B. Eckert, if the share of agricultural labour in the initial year is 59.3 per cent (as observed in 1961), with the total labour force increasing at 3 per cent and nonfarm employment growing at 4.6 per cent per annum, it would take about 15 years for the share of agriculture to decline to the level of 50 per cent and more than 30 years for the absolute size of the agricultural labour force to

[3]In contrast to West Pakistan, in the East Wing the growth of the agricultural labour force exceeded that of the total labour force and the province was consequently becoming more agrarian instead of being less so.

[4]*See* the censuses [11] and [12]. The figures include those aged 10-and-over.

begin to decline[5]. Table I presents a hypothetical pattern of growth of labour force on the basis of the parameters observed during the decade of 1951 to 1961.

TABLE I

PROJECTED LABOUR FORCE BY SECTOR: WEST PAKISTAN SELECTED YEARS

(*in thousands*)

Year	Labour force			Share of agricultural labour force (%)
	Total	Nonagricultural	Agricultural	
1951 (Census)	9,507	3,319	6,188	65.1
1961 (Census)	12,763	5,193	7,570	59.3
1965	14,359	6,211	8,148	56.7
1968	15,685	7,104	8,581	54.7
1969	16,154	7,429	8,707	53.9
1970	16,637	7,769	8,868	53.3
1974	18,717	9,293	9,424	50.4
	50% nonagricultural			
1975	19,276	9,718	9,558	49.6
1980	22,334	12,156	10,179	45.6
1985	25,878	15,205	10,673	41.2
1990	29,984	19,019	10,964	36.6
1992	31,803	20,800	11,002	34.6
	Agricultural labour force begins to decline			
1993	32,753	21,753	11,001	33.6

The assumed constants are as follows:

Share of agricultural labour force (1961): 59.3

Compound growth rates (1951-1961):

Total labour force	2.99%
Nonagricultural labour force	4.58
Agricultural labour force	2.02

Source: Computed by Jerry B. Eckert.

[5]The projected changes in total farm and nonfarm labour force were obtained by Eckert on the basis of a method suggested by Bruce F. Johnston.

The influence of the existing occupational structure of an economy on the rate of change of the farm labour force is given by an identity:

$$\dot{P}_a = \frac{P_t}{P_a}\dot{P}_t - \frac{P_n}{P_a}\dot{P}_n$$

where P_t, P_a, and P_n refer to the total, agricultural and nonagricultural labour force respectively, and the dots refer to the annual rates of change of the respective variables. This procedure assumes that the size of the agricultural labour force is determined as a residual on the basis of exogenously determined rates of change in the total and nonagricultural labour force. As Johnston points out, this assumption is fairly reasonable during the early phase of growth when an economy is still predominantly agrarian [8, p. 272].

The table shows that the projected labour force in agriculture is expected to increase by 2.4 million over its 1968 level before it begins to decline absolutely. It is of vital importance, therefore, to realize that the agricultural labour force in West Pakistan will continue to increase in absolute size and to account for the bulk of the labour force for some time (several planning periods) to come. Absorption of the rapidly increasing labour force into productive employment is, rightly, one of the most urgent policy issues facing the economy[6]. Since relatively capital-intensive investment is inevitable in building up the infrastructure and in expanding large-scale manufacturing industries[7], agriculture has a special role to play as the most important "self-employment sector"; it must not only retain the current level of the agricultural labour force but also absorb residual increases in the total labour force in excess of those finding employment in the nonagricultural sectors of the economy.

In view of the pronounced objective of emphasizing the regional equity, and the implied relative slow-down in the rates of investment growth in West Pakistan, together with the dimmed prospects of *net* foreign assistance in the coming plan periods, the employment implications of alternative strategies for agricultural development should receive increasing attention in the policy-making circles.

Man-Land Ratio and Output in the Agriculture of West Pakistan

During the period between 1951 and 1961 the agricultural labour force in West Pakistan grew at the annual rate of 2 per cent. The cropped area in West Pakistan, on the other hand, increased at about 0.7 per cent per annum [14]. Consequently, the land area available per worker in agriculture declined substantially during the decade.

Table II presents agricultural labour force, planted acreage, and gross crop production in West Pakistan during the period between 1951 and 1964. It is easy to derive relative changes in planted acreage per worker and in gross

[6]The 1961 Census gives the agricultural labour force of all Pakistan at 21.9 million. According to the third-plan document, however, agricultural employment in 1960/61 was estimated to be 17.85 million man-years. The implied agricultural unemployment ratio is 18.5 per cent for all Pakistan. The problem acquires an additional dimension, moreover, when it is realized that 42 per cent of the 1961 population of West Pakistan were children under 15 years of age.

[7]The marginal capital-labour ratio rose from an estimated 3,650 rupees in the early fifties to about 5,250 rupees in the second-plan period. The ratio is estimated to rise further to 7,250 rupees during the third-plan period [17].

crop production per acre from the information presented in the table. The results of such derivations are shown in the following tabulation:

PERCENTAGE CHANGES IN ACREAGE PER WORKER AND OUTPUT PER ACRE, WEST PAKISTAN, SELECTED YEARS, 1951-64[8]

Changes in	*1951-55*	*1955-61*	*1961-64*
Acreage per worker	none	—10.3%	—2.1%
Output per acre	none	4.2	9.2

The stagnation of agricultural production during the 1950's is attributable to the worsening land-man ratio which was not fully compensated for by the slow increase in output per acre. In contrast, the celebrated performance of agriculture during the second-plan period is the result of the expansion in planted acreage almost paralleling the growth of the agricultural labour force and a rapid expansion of yields per acre (real output per acre per year).

TABLE II

AGRICULTURAL LABOUR FORCE, PLANTED ACREAGE AND GROSS CROP PRODUCTION, WEST PAKISTAN, 1951-1964

Year	Agricultural labour force (*million*)	Acreage planted under crops[a] (*million acres*)	Gross crop production[a] (million rupees in FY 1960 prices)
1950-52	6.188[b]	24.69	4,105
1954-56	6.620	26.58	4,385
1960-62	7.570[b]	28.39	4,870
1964/65	8.148	29.12	5,587

[a]Crops included are as follows: rice, wheat, bajra, jowar, maize, barley, gram, sugarcane, rapeseed, mustard, sesamum, linseed, cotton and tobacco.

[b]Census figures for the mid-year, 1950/51 and 1960/61, respectively.

Sources: Agricultural labour force: Table I
Acreage planted: [14]
Gross crop production: [23]

[8]Computed from the figures in Table II.

Since the number of years included in each selected time interval is different, varying from three years for 1961-64 to six years for 1955-61, direct comparison of the percentages is not advisable. Nonetheless, a general picture emerges quite clearly.

If we are to measure the performance of agriculture in West Pakistan in terms of output per worker, the years between 1951 and 1955 should be characterized as those of virtual stagnation, the first-plan period as the period of retrogression, and only the second-plan period may be termed a successful period. The encouraging performance during the second-plan period took place largely as a result of water-resource development, in which private tubewells were particularly important. Additional supplies of water from tubewells increased both the cropping intensity and crop yields[9].

III. SOURCES OF PRODUCTIVITY GROWTH IN AGRICULTURE

In analyzing the basic production relationships and in assessing the productivity performance of agriculture, it is convenient to consider the following identity:

$$O = L \times \frac{A}{L} \times \frac{O}{A}$$

where O denotes output in agriculture, A planted acreage, and L stands for workers gainfully employed in agriculture. The output per worker is then given by the product of the two ratios on the right-hand side of the identity, namely, planted acreage worked by a unit of labour and output per acre. The identity states that, in incremental terms, an increase in output of agriculture results from an increase in any one of the three terms on the right-hand side so long as such an increase is not offset by adverse effects on the other terms.

It is clear that there are many ways in which factors of production can be combined to achieve a certain level of output. For any given set of factor prices different techniques of production (*i.e.*, different combinations of factors) can be arranged in order of increasing unit cost of production. For any given price of the product this is also the order of decreasing profitability. It follows, therefore, that given factor and product prices it is profitable to adopt and use the method of production which minimizes per unit cost of production. Economists would call this method of production the most efficient[10]. Thus, from economists' point of view, that a certain operation is performed more

[9]According to Ghulam Mohammad, additional water made available by the tubewells enabled the farmers to: *i*) increase the depth of irrigation of existing crops; *ii*) increase the intensity of cropping by eliminating fallowing and by double cropping; *iii*) grow more valuable crops like cotton, rice, fruits and vegetables; *iv*) increase the use of fertilizer; *v*) increase the efficiency of bullock use; and *vi*) increase the output per manual worker [10] . Additional supplies of water from tubewells, thus, played the role of catalyst in introducing the yield-increasing (per acre per year) innovations as well as in affecting the expansion of planted acreage.

[10]There are two assumptions underlying this statement. One is that the factor and product prices are given and the other is that there are no economies of scale. The statement remains valid if either one of these assumptions is dropped, provided that the other is retained.

"efficiently" in the engineering sense, be it in fuel-energy conversion, body weight-energy conversion, or in the power-draft-speed relationship, does not necessarily mean it is a more efficient operation than other alternatives. Economic discussions of the choice of technique are couched crucially in terms of the relative prices (opportunity costs) of the substitutable factors of production.

Where a particular factor is relatively abundant, the price of that factor is low, and vice versa. Because of market imperfections and systems of discriminating subsidies and taxes, prevailing costs of the factors of production do not reflect their opportunity costs with any accuracy in developing economies. Nonetheless, it is undebatable that the economically most efficient technique is that which employs relatively larger amount of abundant resources and economizes on the use of scarce resources. In other words, the criterion of economic efficiency dictates that output per unit of scarce resources be maximized by combining abundant resources as much as economical with a unit of scarce resource[11].

If land is in ample supply and labour is scarce, the primary emphasis of the agricultural development may be on an increase of acreage per worker, thus raising the output of each worker in the sector. On the other hand, if labour is abundant and land is scarce, the basic theme in the growth of agricultural productivity will be an increase in yields per acre to enhance the output per unit of available land. Although it is often impossible to distinguish clearly the effect of an innovation in agriculture, it is convenient to associate loosely mechanical-engineering technology with an increase in acreage per worker and biological-chemical technology with a rise in yields per acre. Then, we may state that the emphasis of the agricultural development in a land-rich, labour-poor economy will be primarily on mechanical-engineering innovations, and that the basic theme in a land-poor, labour-abundant economy will be on biological-chemical innovations. In case both land and labour become the constraints for the growth in agricultural production, both acreage per worker and yields per acre are proper targets for improvement. Expansion of output per acre and acreage per worker will increase agricultural output even under the

[11]The standard objection to the use of the "factor proportions argument" as given here is that factor costs may change markedly over time as a result of economic development, so that an advantage based on, say, cheap labour may prove to be quite limited in duration. Relevant consideration for the case of West Pakistan's agriculture in this regard is that the agricultural labour force is to continue to grow in absolute number for some decades to come. Thus, the opportunity cost of labour is expected to remain low until the structural transformation of the economy takes place several decades hence.

Another standard argument against the line of reasoning given here emphasizes the possibilities of reinvesting surpluses of large (mechanized) farms. I shall refer to this point in a later section entitled, "Economic Implications of 'Bi-Modal' Pattern of Agricultural Development".

condition of the declining agricultural labour force and reduced acreage available for farming[12].

Experiences of the United States and Japan[13]

According to an illuminating study by William Parker and Judith Klein, output per man-hour in the production of principal grains in the United States quadrupled during the period between 1840-1860 and 1900-1910 [19]. The authors attribute this gain to two broad sources: *i*) westward movement of crop production[14], and *ii*) mechanization and other improvements which reduced labour inputs per acre. They observe that mechanization and the regional shift of production are responsible for nearly the whole effect of the productivity increase in wheat and corn (maize). The changes in yields apparently play a very minor role. Indeed, grain yields per acre in the United States rose only slightly, if at all, during the period prior to the 1920's.

In the United States, the source of agricultural growth in the late nineteenth century and the early decades of this century is found in the advances in mechanical-engineering technology characterized as "horse mechanization" of its agriculture. Given ample land resources to the west of the country, the mechanical technology of these years increased the acreage worked by individual farmers, or what amounts to the same thing, decreased the amount of labour input per acre. During the period between the 1920's and the 1940's the so-called "tractor mechanization", mechanization of motive power — the replacement of horses by tractors — swept the country. This new mechanical-engineering technology had the effect of drastically increasing the acreage worked by the farm worker (reduced labour input per acre) and kept increasing agricultural output in the face of an absolute decline in the farm labour force resulting from absorption of the rural population in the urban industries.

Since the 1940's, new biological-chemical technology has started exerting its major effects on the agriculture of the United States. The innovations relating to improved seeds, fertilizers, herbicides, and pesticides took effect on the bulk of the United States farms and led the way to an unprecedented increase

[12]It is common knowledge that machines and implements save labour required for any specific operation. Proponents of tractor-mechanization, however, would emphasize the yield effect rather than the labour-displacement effect when faced with a situation characterized by an abundant supply of labour. One of the most important of the favourable effects of mechanical power and implements on better yields is the so-called "timely preparation of seedbed". Of course, timeliness in seedbed preparation is less critical on irrigated lands than on rain-fed areas, which have to rely on the moisture retained in the soil for the growth of crops. However, it is often argued that the time element in seedbed preparation becomes of crucial importance on irrigated lands if there is a pressure to achieve multiple cropping. In West Pakistan, the most binding constraint on increasing the intensity of cropping is the availability of additional supplies of water, rather than mechanical power *per se*.

[13]This section draws from my earlier article [9].

[14]The growth of the West relative to the low-yield border states of the upper South raised the national average yields.

in crop yields per acre that continues today. As is well known, this new technology, in combination with the ever-increasing engineering efficiency of farm machinery, is responsible for an embarrassing accumulation of surplus farm products in spite of decreases in acreage as well as in the farm labour force.

An abundance of arable land on the frontier and the most favourable land-man ratio contributed significantly to the pattern of the agricultural development in the nineteenth-century United States. Since labour, not land, was the scarce resource, it was output per worker which was constantly enhanced. Under these circumstances the output per worker in the United States was first raised by increasing acreage per worker by means of mechanical-engineering innovations and, more recently, by reducing the number of workers on the farm and by increasing crop yields per acre by means of biological-chemical innovations.

In contrast to the environment of the United States, agriculture in the nineteenth-century Japan was characterized by the most unfavourable land-man ratio and the virtual disappearance of unutilized arable land (except in the northernmost parts of Japan) before the modernization process began in 1868. Despite these circumstances, a remarkably rapid growth in agricultural output was attained with notably small demands on the scarce resources, land and capital, in the framework of small-scale agriculture. In order to eke out a living with the holdings of about 1 hectare (2.47 acres) per farm household (and with its holdings typically fragmented into some 10 to 15 scattered parcels of irregular shapes), farmers practised an intensive and skilful agriculture: according to one estimate, before World War II Japanese agriculture had already attained the highest production per acre in the world, yielding an estimated net product per acre several times as large as that of the United States[15]. Since, however, the amount of land worked by a farmer was severaly limited, output per farmer was extremely low. Farmers did not hesitate to expend an immense amount of labour in order to coax out the maximum possible yields from their fields.

Since the scope for expanding the cultivated area was limited by the topographic conditions as well as economic reasons, and since the number of farms stayed virtually constant over a long period until after the mid-1950's, the agriculture of Japan attempted to increase the productive capacity of a unit of available land. The ways in which this central theme has been successfully carried out in Japan form the most interesting as well as instructive elements of the agricultural development of Japan.

Generally speaking, the gains in land productivity in the early years derived largely from the institutional reforms which made possible the diffusion

[15]Kazushi Ohkawa estimated net product in agriculture per hectare of agricultural land in Japan at $146 just before the War (at pre-War prices). This figure was seven times as great as that of the United States [20, p. 331].

of techniques and knowledge over the entire country. Veteran farmers travelled throughout the country (often under government auspices) teaching improved methods of cultivation that were based initially on their own experiences rather than scientific experimentation. These techniques emphasized the achievement of higher yields through the application of improved husbandry, organic sources of plant nutrition and pre-Mendelian methods of plant improvement, primarily through selection rather than through breeding.

The production and use of chemical fertilizers began to increase rapidly during World War I, and by the late 1920's had surpassed the organic fertilizers[16]. It is to be noted that two major factors contributed to this increase in fertilizer use over the years. One factor was the development of new variety of seeds (especially for rice) which would give a strong response to heavier applications of fertilizers. The other was the development and innovations in the fertilizer industry, which made commercial fertilizers available to farmers at increasingly favourable terms[17]. During the period between 1890 and 1935 grain yields per acre in Japan increased by 55 per cent. Of this increase, about a half is attributable to the contribution derived from developments in the fertilizer industry and the associated improvements in seeds.

Until about the middle of the 1950's mechanization in the agriculture of Japan was limited largely to ancillary operations (*e.g.*, threshing and husking of rice after harvest) and irrigation systems. The *field* operations were carried out almost exclusively by hand, although animal power was often used in ploughing. To be sure, in pre-War Japan, after the turn of century, animal-drawn implements as well as hand tools for agricultural operations were progressively improved with the advent of urban industries[18]. However, it should be noted that mechanization of field operations in Japan is strictly a post-World War II phenomenon.

---

[16]For many years, Japan has used large amounts of both farm and commercial fertilizers to maximize crop production. During the inter-War years the rates of fertilizer application per acre were already among the highest in the world. Manure, green manure, night soil, compost, and other organic fertilizers have been used in Japan for hundreds of years. The use of these so-called farm fertilizers has increased only slowly, however, because of the limited number of farm animals and the scarcity of land for raising green manure crops. For this reason, as cultivation practice became more intensive and multiple cropping spread in warmer areas of the country, the use of various types of commercial fertilizers increased rapidly. Such manufactured organic fertilizers as soyabean cake, rapeseed cake, and fish meal were the first to become commercially important.

[17]That is to say, the price of fertilizer in terms of the price of rice declined.

[18]Among these improvements, important are the development of modern short-bottom ploughs, which permitted either deep or shallow ploughing and provided added stability in handling over the older ones, the development of rotary threshers, which originally were powered by manpower through a foot-pedal mechanism and replaced the comb-toothed threshers, and the replacement of long-nailed, rake-shaped weeders by the rotary intertillage weeders. The sources of motive power other than human and animal power were poor and the available mechanical power was limited to stationary machines used in irrigation, drainage, and post-harvest operations.

Intensive application of factors of production to the limited land is still the prominent feature of the agriculture of Japan. However, the composition of the factors of production applied to the land has changed since the 1950's when the land-reform programmes were completed and the spectacular growth of Japanese economy got underway. The owner-farmers, newly created by the land-reform programme, supported by the rise in their real incomes and proded by the increasing real wage levels both on the farm and elsewhere, took the initiative in mechanizing field operations. Moreover, the use of agricultural chemicals which reduced the requirements for labour, particularly herbicides and insecticides, spread to all agricultural enterprises and especially to rice cultivation. The processes of mechanizing field operations and of increasing application of agricultural chemicals are the *prima facia* evidence of a gradual shift of emphasis from the land-productivity growth to the labour-productivity growth in the post-War Japanese agriculture. Nonetheless, it is to be emphasized that the recent emphasis is a consequence of a remarkable structural transformation of the Japanese economy, epitomized by the beginning of an unprecedented (absolute) decline in the agricultural labour force (at 3 or 4 per cent per annum). Total agricultural labour force in Japan numbered less than 10 million in 1967, or less than 20 per cent of the total labour force of the country.

In terms of sheer numbers, power threshers and huskers totalled more than 3.1 million in 1965, and their traditional importance on the farms in Japan (5.6 million households in 1965) has not diminished yet. However, power tillers have shown the most conspicuous increase since the 1950's. They numbered less than 90,000 in 1955, jumped to over one million in 1961, and increased further to the level of almost 2.5 million in 1965. In value terms, the production of power tillers (mainly destined to domestic use) constituted 56 per cent of the total farm machinery produced during the period between 1961 and 1965. Almost one in every two farm households now owns a power tiller[19].

It is important to note that all through the pre-War period of agricultural development and also since the completion of the land-reform programme in the early 1950's the basic organization of the agriculture of Japan has remained small and family-oriented. The theme underlying the agriculture of Japan has been that of progressively modifying farming systems rather than attempting a wholesale substitution of "modern" for "traditional" agriculture. Moreover, in the development of Japanese agriculture, the change in yields per acre has always been the most important single factor. Only after the mid-1950's,

[19]The farm equipment used in field work is light and adapted to small fields that Japanese farms operate. About 98 per cent of power tillers have less than 10 horse powers and are not unlike large garden equipment used in Western countries. They are designed mainly for carrying out the limited processes of cultivation, such as tillage, breaking of clods, levelling, and puddling. Although an increasing number of exceptions can be found recently, power machines are scarcely used in seeding, transplanting, and harvesting.

when the labour supply in agriculture became increasingly short, was mechanization for the purpose of saving labour introduced. Since land is the limiting factor, attempts at increasing land yields have always been emphasized. However, the rate of expansion in yields per acre has slowed down considerably in recent years. This fact, in conjunction with the growing labour shortage, prompted the rapid rate of mechanization in order to increase output per unit of labour. The essence of mechanization in the agriculture of Japan is that the acreage worked by a farmer was expanded by the adoption of labour saving equipment only after the growth in output per acre had become slow and extremely costly.

IV. TRACTOR MECHANIZATION IN WEST PAKISTAN

Development of Official Views on Mechanization of Agriculture in Pakistan

It is interesting to trace the transition in official views on the question of mechanization of agriculture in Pakistan. The Pakistan Agricultural Inquiry Committee looked into the question right after the independence and reported as follows [15, p.11]:

> We depend on imports of most of the fuel oils and lubricants required, as also the tractors and implements. These are two serious handicaps. Labour, owing to natural increase of population and influx of refugees is abundant. It has got to be provided with employment. For these reasons it would be unwise to follow exactly the same pattern of rapid transition from animal to tractor power as adopted by the countries [*e.g.*, U.K., U.S.A., U.S.S.R., *etc.*] as referred to above. It is estimated that complete farm mechanization would displace at least 2 out of 3 labourers. Such a change in agricultural economy might create a serious problem of unemployment. Caution against too rapid mechanization is, therefore, needed in settled areas as industrial development will take considerable time to absorb the surplus labour. We must, therefore, develop mechanization to suit our own conditions.

The Committee, thus, cautiously disavowed tractor-mechanization in Pakistan's settled areas and recommended only limited programmes of mechanization on "new canal and anti-erosion project areas", which were expected to provide additional employment and result in substantial increase in the production of food and cash crops.

Ten years later a set of new considerations was recognized. The Food and Agriculture Commission of 1960, charged with the responsibility to evaluate methods of increasing agricultural production after a decade of the rather slow progress in production (particularly of food crops), pointed out some dynamic considerations relevant to the question of mechanization at the time. The Commission had this to say in its report of 1960 [16, p. 106]:

> The standard objection in Pakistan to the mechanization of agriculture is the fear of widespread unemployment and it is a very valid one. Moreover, it is important to use to the fullest extent the one resource the country has in abundance, namely, human labour. Nevertheless, there are strong reasons for examining the case for mechanization. In judging its value there is need to assess whether its use may not earn or save far more foreign exchange than its importation costs and, by increasing production, create far more jobs in the long run than it displaces. It is true that in Pakistan industrialization has not reached a stage where population displaced from the land can easily find employment. When individuals are displaced, real human problems are created but these individual cases of hardship have to be compared with the prospect of poverty and unemployment faced by the whole country, if agricultural production is not increased.

Re-examination of the case for mechanization by the Commission is based fundamentally on its pessimism regarding the possibility of agricultural development in Pakistan so long as her agriculture depended solely on draft power of bullocks. Since bullocks are small and underfed, the use of improved implements is precluded and the poor conditions necessitate ploughing the land several times before it is satisfactorily prepared: as a consequence, planting is delayed or prevented and the intensity of land use and the cropping ratio are kept low. Low productivity of agriculture, in turn, necessitates the maintenance of small, underfed draft animals. Thus, according to the Commission report, the vicious circle of stagnant agriculture is complete. In the Commission's view, the first benefit to be derived from mechanization, therefore, was the breaking of this vicious circle in cultivation-ploughing operations. By increasing the intensity of land use and the cropping ratio, output would be increased and its benefits might outweigh the short-run foreign-exchange costs of mechanization programmes. Given this possibility, the displacement of labour by mechanization of settled areas should be viewed from a new perspective. The standard case against mechanization of Pakistani agriculture, therefore, should be closely re-scrutinized.

It is indeed interesting to compare the basic tenets of the two reports on the question of mechanization; each point of view reflects, by necessity, the circumstances of Pakistan's economy and agriculture as given in its respective time. During the early 1950's, the influx of refugees and the natural increase in population and the state of industrial development made the employment problem quite visible. The Committee's report, therefore, emphasised the labour-displacing effect of mechanization and disavowed the wisdom of extensive mechanization in the already settled areas. During the next ten years, however, the foodgrain position of the country deteriorated. A poor crop in 1952/53 turned Pakistan into a large net importer of foodgrains. The next

poor crop in 1955/56 accentuated the food deficits and fixed the country's position as a chronic net importer of foodgrains. In view of the need for urban and industrial development, the dissipation of the scarce foreign-exchange resources on foodgrains imports came to be viewed as an urgent problem. Moreover, the combination of a low per capita output (income), a high propensity to consume farm products on farm, and a small quantity of marketable farm products came to be regarded as limiting the possibility of rapid urban-industrial development. It is, therefore, quite understandable that the Commission's report emphasised the output-increasing effect, rather than the labour-displacing effect of mechanization. It reflected the reality of the early 1960's when agriculture was stagnant and there was an urgent need for import substitution in foodgrains.

If mechanization of agriculture in Pakistan increases output, which will earn foreign exchange by increasing exports of farm products and manufactures or save foreign exchange by decreasing imports of foodgrains, the foreign exchange required for imports of machines, implements, and fuel are not wasted resources. The Commission report, therefore, proposes to weigh the costs and the benefits of mechanization in terms of foreign-exchange resources. Furthermore, the Commission asks whether the short-run displacement of workers from land, though undoubtedly a hardship on the individuals concerned, would necessarily outweigh the chronic, overall unemployment associated with low agricultural productivity and limited industrial development. In the Commission's view, if unemployment in the short-run is inevitable, policy should consider the long-run problem of overall poverty and unemployment resulting from the chronic stagnation of agricultural production.

These are all difficult questions. Aside from the methodological problems involved in the cost comparisons urged by the Commission, fundamentally more difficult to resolve are the practical implications of such views when translated into policy measures. Given the fact that imported foodgrains feed the urban population rather than the rural in Pakistan, the import-substitution policy being contemplated must aim at an increase in the "marketable surplus" of foodgrains as well as an increase in output *per se*. Since a lower per capita output (income) and a high propensity to consume farm products on farm combine to limit the quantity of the marketable surplus expected from small land-owners and tenants, as a practical matter, import substitution must aim at increasing the output of larger land-owners. By necessity, therefore, mechanization programmes must be focused on the larger land-owners[20]. The bulk of the nation's farmers would be excluded from the benefits and the hardship of unemployment and displacement would fall exclusively on the landless workers.

[20]This point is in addition to the more technical reason that a large management unit is prerequisite to the maximum use of machines and implements. More on this later.

A series of development in the agriculture of Pakistan in recent years, however, seems to make most of the Commission's query irrelevant. With the benefit of hindsight we may say that the output-increasing effects of the tube-wells in the second-plan period and the "green revolution" of the more recent years have shown, without doubt, distinctive alternatives to mechanization for a rapid agricultural development. Pakistan now has broken out of the so-called vicious circle by means which are inexpensive in terms of the scarce resources of foreign exchange and capital. Tubewells and low-lift pumps, to say nothing of the new biological-chemical inputs, are prime examples. Moreover, the country has found in the "green revolution" the way to increase output without displacing (or even with increasing) the employed labour force in agriculture. Finally, and not least important, substantial increases in yields obtainable by the further progress of the "green revolution" would make it possible for the mass of the nation's farmers to share satisfactory increases in ouput while solving the problem of chronic foodgrains deficits in Pakistan.

The Private and Social Profitability of Tractor-Mechanization

Generally speaking, tractor-mechanization has progressed in countries where the land-man ratio is extremely favourable and where economic development has reached the phase in which a large quantity of accumulated capital per man would make the productivity of labour high and capital cost cheaper relatively to the cost of labour. As we have seen, the land-man ratio in Pakistan is expected to worsen rather than improve and, given the dimmed prospects for massive foreign assistance and the increasing population, capital accumulation per man will be slow in the foreseeable future. Nonetheless, it is clear that the tractor population in private hands has increased substantially, particularly in West Pakistan. There are indications that in the Punjab a number of large land-owners are setting up management units of 150 acres or more as they obtain tractors. On such farms the number of hired workers has been drastically curtailed as compared with the situation before the introduction of tractors and implements[21]. There are reports, moreover, that self-propelled combine harvesters are being purchased by some of these land-owners.

A number of important factors explain this phenomenon. The Government of Pakistan made it clear that the move towards self-sufficiency in food requirements is one of the specific objectives for agriculture in the Third Plan. The government has promoted new farming techniques by its policies concerning the prices of inputs and outputs which enhance farm profits. On the input side the most prominent have been the subsidies on fertilizers, pesticides, and water rates. Important also have been the government measures to grant tax and

[21]Reports indicate, furthermore, that even the tenants are being moved off the land. Although rights of tenants are protected by law, if the landlord introduces mechanization programme on his farm and cultivates the land himself, tenants can be removed by legal process. This is another instance of divergence between private profitability (for landlords) of tractor-mechanization and its social profitability (for the economy as a whole).

tariff exemptions to the imports of agricultural investment goods and to license imports at the artificially low official rate of exchange. On the output side, a key feature of the government policy has been price-support schemes on some commodities in order to provide an incentive to farmers by giving them the prospects of a more predictable income. Floor prices, which the government guarantees by purchasing in the regular commercial markets when necessary, are established for wheat, rice, maize, and groundnuts. These policy measures have been quite successful in accomplishing the immediate task for which they were intended. The use of fertilizers has continued to expand and output of foodgrains has increased. However, they have also introduced a peculiar price structure which has tended to distort real economic calculations for the agriculture of Pakistan.

According to a study by Oddvar Aresvik, assuming the world import price of wheat at 12.70 rupees per maund (the average for 1960/61 to 1964/65), the *f.o.b.* Karachi price of wheat for export from West Pakistan would have to be about 11.00 rupees per maund. Counting the handling and transport charges necessary for wheat exports, therefore, the price on the farm level would have to be much lower (8.00 rupees per maund) [1][22]. Given the official exchange rate, there is no doubt that the domestic price of wheat is substantially higher than the world price. The support price is double the price "justified" by the world market. In other words, the "justifiable" price of wheat, in this sense, is one-half of the current support price.

On the other hand, the substantial exemption of agricultural capital goods from tariffs and taxes means that tractors and machinery can be obtained at the official exchange rate for the price prevailing in the world market. It is evident that in terms of the quantity of output to pay for a given input, Pakistani farmers pay only about one-half the amount of wheat which the world farmers have to pay for a tractor of equal design and power. Tractor-mechanization in Pakistan becomes a profitable if not economical proposition. In Pakistan's capital-poor economy, capital equipment is obtainable at a cheaper price in terms of output than in capital-rich economies, whereas the economic measure of relative scarcity should indicate the contrary for the economy as a whole. This paradox reflects a situation in which a relatively cheap input (labour) is being replaced by a relatively dearer input (capital). The prices artifically maintained by the government measures thus make the private marginal productivity of investment in tractor-mechanization considerably higher than its counterpart abroad (in capital-rich countries) and its social marginal productivity at home[23].

[22]Latest reports indicate that the world import price of wheat is on the decline. In early 1968 the comparable world price was about 11.00 to 12.00 rupees per maund for wheat graded No. 1. *See* [22, p.39].

[23]The fact that the private costs of obtaining tractors are lower than the social costs contributes significantly to their uneconomical uses for cartage (of people as well as goods) and other marginal uses observable in the Punjab.

Microeconomics of Tractor-Mechanization and its Implications

Despite all that has been said in government's policy pronouncements and the assertions made about the yield-increasing effects of mechanization, one is struck by the paucity of data in West Pakistan on this subject. The available data on costs and incomes comparing the mechanized farm operations and bullock-power operations, such as those appearing in the report of the First Machinery Conference and Exhibition held in Lahore during early March 1967, appear to rely exclusively on a study by M. S. Gill reported in 1962[24]. According to this report, the increase in yield per acre in case of tractor farming as against bullock-power farming, amounts to five maunds of maize and four maunds of wheat (about 25-30 per cent).

Except for the possibility of increasing the intensity of cropping and, therefore, increasing *yield per acre per year*, it is not obvious that tractor mechanization *per se* has much of an effect on yield (per acre per crop) as compared with animal draft power. Experiments in Japan indicate that yield per acre does not increase from mechanization *per se*[25]. These results seem to be confirmed by experiments at the International Rice Research Institute. Moreover, the availability of water is the most binding constraint in West Pakistan's agriculture for increasing the intensity of cropping[26]. Increases in the cropping intensity with or without tractors become possible, only if additional supplies of water can be made available.

It is certainly true that good seedbed preparation, weed-pest control, and uniform planting depth assume much greater importance with the new

[24]The study [7] refers to experiments performed during 1952-1954. Lacking in detailed data which formed the basis of various tables presented by Gill, it is not possible to use the results for the purpose of meaningful economic calculations. The total cultivation charges per acre with the use of different tractors and bullocks are ranked in the report. However, the acreage on which these operations were performed is not given. It is common knowledge that on smaller plots of land, less expensive power (draft animals and small tractors) is economical and that in larger acreage the reverse is true. It is also reported that among various farming systems, as defined by the author, the so-called "direct mechanized farming" used the maximum amount of manual labour per year. Unless the cropping intensity is increased, or the number of operations (say weeding, fertilizing, *etc.*) in cultivation of a single crop is made larger, or both, it does not make sense to say that the input of labour was larger under mechanized farming than under bullock farming. This particular set of data serves to point out what the author intended, namely, that machines do not necessarily displace labour under the given situation in Lyallpur in 1952-54. Of course, however, it cannot be used for the purpose of demonstrating that machines use more labour per single operation required in growing of crops, nor that "direct mechanized farming" is the economically most efficient method of combining resources. The same is true with the report on yield performance of mechanized farming and bullock farming as discussed in text. For the purpose of strict comparison only the motive power should be different in the two situations, given other conditions approximately equal.

[25]*See* text below.

[26]The cropping intensity (as defined as the percentage of the holding cropped) of the farms with tubewells exceeds that of the non-tubewell farms by a substantial margin. Ghulam Mohammad reported that in the Multan and Montgomery districts the non-tubewell farmers had an average cropping intensity of about 99 per cent, whereas the tubewell farmers had a cropping intensity of about 131 per cent. In the Gujranwala district, the intensity of cropping was about 115 per cent in the case of non-tubewell farmers and about 146 per cent in the case of tubewell farmers [10, pp. 25-26].

varieties and heavier fertilizer applications. However, these operations can be accomplished by more economic combinations of factors. Ultimately, the answer depends on how well land preparation and other operations are carried out by animal-drawn equipment and small power machines in Pakistan, whose development, improvements, and diffusion among the farmers may well be as effective as all-out tractor-mechanization of Pakistani farms[27].

Total cost incurred in crop production consists of the following items: *i*) cost of the use of land and other fixed assets on land; *ii*) costs of the current inputs, such as seeds, water, fertilizer, pest control, *etc*; *iii*) cost of power equipment and machinery; *iv*) cost of labour. It is safe to assume that the magnitude of the first two items would be approximately the same, irrespective of type of power used in producing a single crop. The last two items would depend on the field operations required and, crucially, on acres covered as well as on the type of soil.

Cost of the use of farm machinery consists of charges for depreciation (by use and by obsolescence), interest payments on investment (regardless of whether the money invested was borrowed or not, since the fund could have been used otherwise and yielded returns), other fixed charges (such as housing, taxes and insurance), and variable costs which depend on the actual use of the machinery (*e.g.*, repairs, costs of fuel and oil). Since fixed charges are large for large machinery, comparative costs of the use of machinery per acre between different size machines depends on the acreage on which they are operated.

According to an experiment carried out at the Central Agricultural Experiment Station of Japan in 1963[28], the minimum acreage, the "threshold-acreage", required to make the use cost of 35-HP tractor equal to that of a 15-HP tractor, was between 25 to 30 hectares. (1 ha. = 10,000 m^2 = 2.47 acres). For a larger acreage the use cost of a 35-HP tractor declines more rapidly than the smaller one but, unless farm size exceeds 50 hectares, it does not come down to the level of the use cost involving smaller machinery and animals in the customary method of cultivation. Because "large-scale" or "medium-scale" mechanization requires a larger quantity of investment, the cost of machine use per hectare with mechanized farming is greater than that in the customary methods of cultivation.

However, the Japanese experiment found that the direct cost of production per hectare in mechanized farming was less than that of the customary method due mainly to the saving in the cost of labour involved. For a larger

[27]There is no question that the bullock-drawn implements can be much improved. It is suggested, furthermore, that the draft power of the animals can be increased considerably by improving the harness and the quality of feed given to the animals. *See* below, "Emphasis on Divisible, Farm-Resource Augmenting Inputs", in Section V.

[28]The experiment involved rice production on well-drainable field [21].

tractor the "threshold areage" in this case was between 10 and 15 hectares and that for a smaller tractor was less than 10 hectares. Because of the *decrease* in yield by mechanized farming, the Japanese experiment found that the use of 35-HP tractor gives greater returns (value of output minus cost) than the customary method only when the operating acreage is more than 30 hectares, and that the use of 15-HP tractor was not justifiable under the circumstances[29].

It is to be noted that the calculation was made on the basis of the Japanese price structure of the wage rate and the cost of capital. It goes without saying that the ratio between the market prices of labour and capital is higher in Japan (especially, in the 1960's) than in the present-day Pakistan. And, therefore, if one is to use the market (in the sense of "shadow" or "accounting") prices of capital and labour for Pakistan, the "threshold acreage" for the use of a larger tractor is expected to increase. It is a well-known proposition that when the opportunity cost of labour is low and the rate of interest is high, the threshold acreage will be large and labour-using and capital-saving techniques will be optimal.

According to the agricultural census of 1960, only 8 per cent of the farms in West Pakistan exceeded 25 acres (of cultivated land). Since there were 37.2 million acres of cultivated area and 4.86 million farms, on the average only 7.6 acres of cultivated area was available per farm. If we add the reported cultivable waste of 24 million acres, and assume that the number of farms remained constant, total land area available per farm would be 12.7 acres.

Accordingly, the Government of West Pakistan has been advised recently to pursue a programme of rapid tractor-mechanization especially for farms holding more than 25 acres. On the average, these large farm-owners operate 54 acres. Given the present structure of output and input prices in Pakistani agriculture, these large farmers may very well be able to reap *private* profits from tractor-mechanization. We have seen, however, that the present price structure is the product of artificially inflated prices of output and similarly deflated prices of farm machinery. The question regarding the future price structure, therefore, has to deal squarely with the probable future prices of agricultural products. If the output prices were to decline, or more precisely, if the relationship between capital cost and labour cost in terms of output prices should move against capital, the "threshold acreage" will have to rise above the level now being assumed for *private* profitability of tractor-mechanization.

[29]The yield per hectare was 3,320 kg. with 35-HP tractor and 3,150 kg. with 15-HP tractor, in comparison with 4,360 kg. obtained by the customary method. In the Japanese study the decrease in yield by mechanization is attributed to the grain loss in the use of a combine. Mechanization-enthusiasts would argue for combines because of their alleged virtue of reducing grain losses. Their argument can be disputed by Japanese experiments. But even if they were right, adoption of combines may not be economical. Grain losses can be reduced in post-harvest operations elsewhere too, say, storage and transportation, which may well be more economical to attack than adoption of combines.

Economic Implications of "Bi-Modal" Pattern of Agricultural Development

The "bi-modal" pattern of agricultural development being recommended, where the programme of mechanization is to be concentrated on the farms with more than 25 acres of cultivated area, calls for serious thinking in the perspective of Pakistan's agriculture and economy. There are both international and domestic dimensions in this subject regarding the output and the inputs of the agriculture of Pakistan.

Because of the favourable conditions in West Pakistan regarding the availability of irrigation water and abundance of solar energy, and due to the unusually favourable weather in 1967/68 in particular, the "green revolution" seems to have spread most rapidly in West Pakistan. However, the dwarf varieties of Mexican wheat and the dwarf varieties of rice developed by the International Rice Research Institute are being made available to other developing countries in Asia, and their impact is just beginning to be felt. In Pakistan a supply shortage of the new seeds and limited availability of fertilizers severely limited planting until the 1967/68 season. But, Pakistan was not an isolated example. According to the 1968 annual report of the IBRD (World Bank), India and the Philippines show a rapid expansion in acreage planted to the new varieties of wheat and rice during the past season. Good progress in introducing the new seeds is also reported in Afghanistan, Ceylon, Indonesia, Malaysia and Turkey. It can be reasonably expected that a growing number of countries in Asia and elsewhere will soon feel the impact of the so-called "miracle seeds"[30]. There is no question that these countries are as anxious as Pakistan to achieve self-sufficiency in foodgrains. The spread of the "green revolution" to many countries, thus, diminishes the prospects of a long-run expansion of grain exports from Pakistan, and the poor quality of grain processing here severely limits the possibility of expanding the export markets (except for the traditional *basmati* rice) in the near future[31]. The monetary return from the

[30]The IBRD report is not unique. In his foreword to the 1968 annual report of the Food and Agriculture Organization, the director-general states that the "world food and agriculture situation is now in a stage of transition and hope".

According to the *Financial Times*, the Organization for Economic Cooperation and Development (OECD) forecasts colossal imbalances in major foodstuffs in the periods up to 1975 and 1985 if the current trends in agricultural production continue unaltered in industrial countries. The most serious of the prospective surpluses are wheat and coarse grains (also rice). These supplies are many times the prospective demand from outside sources, and even the Communist bloc, excluding China, could well become a net exporter. Of the underdeveloped countries, all except India are capable of self-sufficiency. These increases will come from existing land and labour resources and take into account population increases and rising living standards. The main factor responsible for the increases is improved yields due to better varieties and farming techniques [3].

[31]*See* a study on this problem by J. Norman Efferson [4].

One of Efferson's conclusions is that "most of the medium-grain rice now being produced in West Pakistan is of such poor quality that it will not be accepted in world markets". Facilities for handling wheat are physically different from those handling rice but they are not much different in quality standards. In fact, the concensus of experts in this field is that Mexi-Pak wheat, as prepared here, cannot be given even the lowest commercial grading in international market.

potential increases in the grain production in Pakistan depends crucially on effective demand. Inasmuch as 70-80 per cent of Pakistan's population are members of self-supplying farm households, the growth of domestic demand for purchased foodgrains is severely limited[32]. Increase in effective demand, commensurate with the growth in potential supplies of foodgrains, therefore, is very questionable.

It is indeed difficult to imagine the problem of a foodgrain glut in a country characterized by chronic under-consumption and hunger in recent years. However, the maintenance of a government guaranteed price of foodgrains will become increasingly difficult as the marketed surplus of foodgrains increases. In anticipation of the excellent 1968 wheat crop and a fall in wheat prices after harvest, the government announced its intention to purchase "at least 5 lakh tons of wheat" in order to prevent the prices from falling below the support level [18, p. 44]. At this time, it is not known whether purchase of that much wheat was enough to guarantee the floor price after harvest. It is worth noting, however, that government purchases would cost 231.9 million rupees for 5 lakh tons[33]. This amount is about equal to the public-sector development expenditure on education and training for all Pakistan during the 1966/67 period [18, p. 20].

The "bi-modal" pattern of agricultural development will not only create a subsector of agriculture which is large-scale and capital-intensive but would also promote commercial sales of output more than the growth in total output. If effective demand cannot be expected to increase as rapidly, and/or if the government cannot purchase all that is brought to the markets over and above the absorption by regular commercial channels, the prices of foodgrains must decline below the favourable level existing now. Consequences of such a development are not difficult to imagine. The great bulk of the farmers left out in the programme will face a decline in their net incomes due to the worsened terms of trade for their small marketable surpluses. Large farmers will find that in order to cut the costs of operation per acre their operating acreage has to be further expanded and their operations made more commercially oriented. Expansion of acreage would take place, in the absence of the effective legal restrictions, so long as mechanical engineering economies of scale outweigh managerial diseconomies of large-scale operation. The economic logic of this process is simple but hard. Once investments are made on fixed assets (such as

[32]The figure would be about 60 per cent for West Pakistan only. Even if West Pakistan can successfully "dump" surplus wheat on East Pakistan, the domestic market there will be limited by the fact that a larger proportion of the population are members of farm households and that they are traditional rice-eaters. Of course, there are many difficult political as well as economic problems in selling surplus wheat from the West to the East wing.

[33]Five lakh tons equal 500,000 long tons. One long ton = 27.286 maunds and the support price of wheat is 17 rupees per maund. The current floor prices for foodgrains are guaranteed for three years from 1967/68 to 1969/70. There are reports that, in fact, the government have purchased 8 lakh tons so far.

tractors), the short-run cost function becomes "lower" than the long-run cost function. Since fixed costs are costs foregone in the short run, it does not affect the short-run supply of output. Prices of the product can fall to the levels that cover only variable costs and not fixed costs. The impact of such a situation can be disastrous to small farmers whose total costs are largely variable[34].

A vicious circle of the large getting larger and the small getting smaller will set in until the rural population is polarized into the large, rich farmers and small, poor farmers. The tragedy is not only that the small will suffer, as they will suffer, but that the small will have nothing to look forward to despite the apparently promising future with the dawn of the "green revolution". The undesirable effects of massive grain imports from developed countries (say, under the PL 480 programmes) will be reproduced in the domestic scene. Only difference is the change in the actor who plays the role of surplus exporter and, more importantly, in the use of funds generated into the hands of the new large supplier[35]. The agricultural sector is very lightly taxed. Of course, this means that the mobilziation of increased cash incomes in the hands of large farmers becomes difficult, if not impossible. Despite certain undesirable effects, the foodgrain imports provided Pakistan with needed foodgrains as well as the counterpart funds that the government has relied on to finance a substantial fraction of its development programme.

V. BASIC CONSIDERATIONS FOR THE STRATEGY OF AGRICULTURAL DEVELOPMENT IN WEST PAKISTAN

Beyond Self-Sufficiency in Foodgrain Production

The goal of recent agricultural policy in Pakistan has been self-sufficiency in foodgrain production. Measures ranging from input subsidies to output price-support programme have all been designed and executed for the purpose of substituting domestic production for the import of foodgrains. The development of tubewell irrigation since the second-plan period and the more recent "green revolution", however, have ushered in a new situation. One can confidently state that the substantial increase in yields obtainable by the progress of the "green revolution" will make it possible for the mass of the nation's farmers to achieve satisfactory increases in output and solve the problem of foodgrains deficits within a short period of time. As a consequence, it is now

[34]It may be pointed out that tractor-mechanization is not economically justified to initiate and that once initiated it is not easy to recover from. In fact, it creates a new problem of working off the excessive capitalization in agriculture.

[35]Direct taxes on agriculture have been increasing in quantum since independence. However, the land taxes are mostly based on the land revenue assessments made thirty or forty years ago and incomes originating in agriculture are largely exempt from the general income tax imposed by the government. It is reported that in the Punjab the agricultural income tax is assessed in reference to the amount of land taxes payable rather than on the actual income of the tax payer in any particular year [13].

necessary to re-examine the basic orientation of the agricultural policy of the country.

Since the foodgrain is one of the cheapest sources of calories, it is only natural that the emphasis has been placed on the rapid increase in its output when there is a widespread shortage in food energy intake. Simply eliminating the foodgrain deficits, however, does not provide a final solution to the food problem of the country. There is a whole range of other problems of which those in the areas of production and marketing stand out.

In the sphere of production, there is an increasingly difficult problem of producing an improved output mix to provide the nation with a more *nutritional* diet. Pakistan's deficits in high-quality proteins, edible oils, vegetables, fruits, and sugar are obvious even today. As the pattern of food consumption changes in response to increase in per capita income or in response to improvements in education and communication, the overwhelmingly large proportion of calories currently derived from starchy staples in Pakistani diets will have to decline. Effective demand for "protective foods" that are rich in vitamins, minerals, and high-quality proteins, such as fruits, vegetables, meats and dairy products, will surely increase. If Pakistan were to dissipate valuable foreign exchange on imports of these food items, the attainment of self-sufficiency in foodgrains and the consequent "savings" of the scarce resource would lose much of its meaning.

Diversification of Pakistan's agriculture is rightly the next order of business; policy measures should be designed to change the cropping patterns to bring forth this result. As the rapid spread of new varieties of rice and wheat has shown beyond any doubt, farmers respond strongly to the comparative net cash return of various crops. The major determinants of the net profitability being the physical yield per acre and the price per unit of output, a new set of comparative yield performance and a new set of relative prices among crops have to be developed. The current system of support prices needs re-examination and determined efforts to improve yields of crops other than rice and wheat are called for[36].

The improvement of food storage, processing and distribution systems in Pakistan is as important as increasing production. It is said that losses caused by micro-organisms, insects, rodents, and other factors amount to some 10 to 15 per cent of the output of foodgrains. Reduction of such losses by better storage facilities is an immediate necessity. As the marketable surplus of farm products increases, and as the proportion that perishable commodities occupy in the total output of farm increases, the problem of adequately handling

[36]The argument here is cast in terms of food commodities . However, the same line of reasoning can be applied to the case of fibre crops. It is reported that the distinctive disadvantage in the yield per acre of cotton relative to other crops is driving cotton out of the Punjab. In fact, the urgency of maintaining or increasing fibre crop output would seem greater than that of increasing the output of protective foods.

farm products after harvest becomes increasingly important. Improved food protection practices should be made available at reasonable costs to the farmers. The improvement of marketing systems assumes a unique importance, furthermore, if the emphasis is placed on the production of crops which will provide the farmer with the largest cash return. A price-incentive scheme can work only if it is coupled with a highly developed marketing system.

The improvement of food storage, processing and distribution systems in Pakistan will require a substantial amount of foreign exchange and will be costly in terms of domestic resources. In view of the pressing need for improving these facilities and for strengthening the existing facilities which supply farm inputs, the priority currently given to the tractor-mechanization in West Pakistan should be carefully re-examined.

Selective Mechanization

Mechanical engineering technology in agriculture can embrace a wide range of different configurations involving motive power, machines, and implements. There are many ways in which one may classify mechanical engineering technology in agriculture. Most important from our point of view, however, are the following two types of distinctions: *i*) "mechanization" as applied to each specific operation and "mechanization" as applied to several or all of the farm operations; and *ii*) "mechanization" as introduced into a given socio-economic organization of agriculture and calling for minor adjustments and "mechanization" calling for a highly sophisticated organization and cooperation not easily introducable into a given situation.

The first distinction recognizes the many different operations related to growing and harvesting of crops, such as levelling of land, irrigation/drainage, ploughing, seedbed preparation, planting and fertilizing, crop protection, harvesting, and preparation of products. Machines and implements can be designed specifically for a limited number, or for many, or all, of these operations. Aside from implements relying on human or animal power, tubewells, low-lift pumps and power threshers are examples of machines used specifically for limited tasks as are Japanese power tillers, dusters and sprayers. On the other hand, the development of the tractor and the so-called power take-off, together with the development of various implements, make possible the more direct and widespread application of engine power to many different operations. In the United States the total cultivation processes came under the aegis of mechanical power; also the harvesting processes and many post-harvest operations became thoroughly mechanized with the advent of the self-propelled combine harvester. Nonetheless, it should be clear that a tractor is by no means the only way to mechanize agriculture. Mechanization of selected processes of cultivation and post-harvest operations, as in the case of Japan, may prove to be the most beneficial for the agriculture of Pakistan given the circumstances it faces now and in the decades to come.

The increase in size and specialization of farms has been one of the most significant changes in farm structure and organization associated with the adoption of tractor-mechanization in the United States. Modern equipment and machines are so expensive in many instances that it is advantageous for the farmer to develop larger farms and enterprises (*i.e.*, specialize) to make full use of the new resources and to hold down unit costs. The typical relationship between acreage and unit-cost is a curve that shows a steep decline in costs until utilization reaches about one-fourth to one-half the maximum possible with the machine and, thereafter, a very moderate reduction in costs with greater use. High costs per acre or per hour with limited use reflect, of course, the fixed charges unrelated to the actual use of the machine. Introduction of larger machines and implements, therefore, necessitates large management units, output standardization, and uniform cultural practices, which call for highly sophisticated organization and cooperation[37]. Organizational problems loom as large as technical problems, solution of one not necessarily guaranteeing the solution of the other. Smaller-scale mechanization programmes embracing machines for a few selected operations would be much easier to introduce into the given organization of agriculture without the necessity of a wholesale substitution of "modern" for "traditional" practices. It also has the advantage of involving a bulk of the nation's farmers in the process of agricultural innovations.

Emphasis on Divisible, Farm-Resource Augmenting Inputs

Biological and chemical innovations that have brought forth the "green revolution" are, by their very nature, neutral to the scale. They can, therefore, be incorporated into the existing institutional framework of Pakistani agriculture without drastic adjustments. Small-scale peasant farms can adopt these innovations with relatively minor adjustments in contrast to technical innovations involving tractors and combines. Undoubtedly, this aspect of recent innovations has contributed to the very rapid diffusion of technology in the Punjab as elsewhere. The benefits of the "green revolution" have not been limited to a few large farmers. As with the recent private tubewell development in the Punjab, many small farmers are taking advantage of the development.

Tubewell water, new seeds and increased applications of fertilizers, which dramatize the "green revolution" on the input side, are basically complementary to the farm resources of labour and land. By making it possible to grow more crops, more lucratively, per acre of cultivated area, these inputs have increased the use of labour on farms as well as the incomes of farm workers concerned.

[37]On the basis of management units we may classify "mechanization" into three general types: *i*) Self-employment, owner-operated mechanization, necessarily smaller to medium sizes; *ii*) absentee ownership (including corporate farms), with hired managers and hired workers, conducive to large-scale mechanized agriculture; and *iii*) mechanization on the basis of cooperative or collective farm organizations. Under the usual circumstances it is safe to say that the first category would minimize the problems of organization.

In contrast to investments in tractors and combines, that are fundamentally labour-displacing, investments in inputs such as seeds, fertilizers and even tube-wells are much more conducive to augmenting the income of the bulk of the nation's farmers. Emphasis on these inputs, furthermore, would retard the polarization of the rural population and land holdings, and make it possible for the mass of the nation's farmers to achieve satisfactory increases in output at modest costs in terms of scarce resources of capital and foreign exchange.

Much can be done to "make animals more effective by improving the equipment they power" [6, p. 24]. It is often said that the farmer's reluctance in accepting the improved animal-drawn equipment is an evidence of the inertia existing in the present situation and that a drastic improvement, such as tractor mechanization, is needed for breaking this situation. In view of the progress of private tubewell development and the green revolution and the increasing rewards they offer, we may expect the majority of farmers to accept voluntarily new technology developed in this area. The development and diffusion of the mouldboard plough, various harrows, the seed-cum-fertilizer drills, all of which are animal-drawn equipment, and knapsack power sprayer-cum-duster, hand weeders, and small stationary threshers are highly desirable. These kinds of equipment can remove bottlenecks and increase the economic efficiency as well as engineering efficiency of the agriculture of West Pakistan[38].

Interrelationship Between Agriculture and Nonagricultural Sectors

The economic relation between agriculture and nonagricultural sectors involves exchange of products, flows of productive factors, and diffusion of ideas. Typically, an underdeveloped economy is fragmented, heterogeneous, and lacking in the cohesive forces emanating from adequate transportation and communication systems. Although they are not obvious under these circumstances, the intersectoral flows of products, productive factors, and ideas characterise a two-way relationship between agriculture and industry.

The importance of each sector for the other is appreciated first by looking at exchange of products. On the one hand, there is the interdependence of sectors through direct intermediate deliveries; both sectors buy products as intermediate inputs for further production from each other. Obvious examples are cash crops, such as cotton, jute and sugar on the agricultural output side and machines, implements, fertilizers and pesticides on the industrial output side.

[38]The "problems of success" revealed by the recent developments in the agriculture of West Pakistan are nowhere more visible than in the harvesting and post-harvest operations. If indeed a bottleneck exists in the crop-production processes, it is more likely in harvesting and post-harvest operations than anywhere else. The delay involved in field preparation for the next crop is as much a result of "inefficient" threshing operations as that of the "inefficiency" of bullock cultivation. Moreover, the loss of grains involved in the traditional threshing operations is appalling: Giles reports that losses, from the maturity of the grain in the field onward, are estimated by experts at 25 per cent [6, p. 30].

On the other hand, each sector is a source of effective demand for the final products of the other. It is important to have consistency and compatibility in industrial planning; it is equally important to recognize this interdependence and to exploit positive intersectoral relationships that promote rapid economic development.

A broad-based agricultural development is essential for creating a domestic market for the developing indigenous industries. A conscious effort to develop agricultural technology will foster domestic industries and will return a handsome reward. It is appropriate here to recall one such example in the recent experience of West Pakistan. In reference to the spontaneous, private development of tubewells during the second-plan period, W.P. Falcon and G.H. Gotsch observed that [5, p. 12]:

> These 25,000 (tube) wells represented an initial investment on the order of Rs. 250 million, a sum thought impossible in West Pakistan's traditional agriculture. Moreover, this investment was an important stimulus to the small-scale machine industry. Whole streets in such cities as Multan, Lyallpur, Lahore, Gujranwala, Sialkot, and Daska have been devoted to the manufacture of pumps and engines, and the skill, ingenuity, and training demonstrated in these shops have been impressive[39].

There is undoubtedly a similar opportunity for a rapid expansion of indigenous production of improved farm implements. The emphasis on selective mechanization would, as in the case of tubewells, nurture indigenous industries catering directly to the agricultural sector of the country. The development of such industries, in turn, would make it possible for the farmers to acquire the machines and implements at increasingly favourable terms, encouraging further use of such inputs. It would be a clear mistake to minimize this type of positive interaction between agricultural and industrial development by using large amounts of capital and foreign exchange for tractor-mechanization. The progress of the "green revolution" has increased the attractiveness of investments in improved farm implements. Investments of this type will grow, the alleged intertia and reluctance of the farmer notwithstanding, unless aborted by large-scale, heavily subsidized imports.

SUMMARY AND CONCLUSIONS

In summary, let us recapitulate some of the highlights of the paper.

1. Given the present share of the agricultural labour force in the total labour force and the growth rate of the total labour force of 3 per cent per

[39]The latest estimate of private tubewells installed in the Punjab exceeds 60,000.

annum in West Pakistan, even if the nonagricultural employment grew at the very high rate of 4.6 per cent per year, the absolute number of the agricultural labour force will continue to grow for several decades to come.

2. On the other hand, in view of the fact that the marginal capital labour ratio is expected to increase (due to the need for capital-intensive investments in infrastructure and in large-scale manufacturing industries), the economy's ability to absorb a growing labour force into productive nonagricultural employment will be limited.

3. In contrast to the decades of the 1950's, the output increasing effects of the tubewells in the second-plan period and the "green revolution" of the more recent years have shown, without doubt, distinctive alternatives to tractor mechanization for a rapid agricultural development in West Pakistan. These alternatives are inexpensive in terms of the scarce resources of capital and foreign exchange. Moreover, they increase output without displacing the employed labour force in agriculture, thus enabling the mass of the nation's farmers to share satisfactory increases in output.

4. "The world food and agriculture situation is now in a stage of transition and hope". The "miracle" seeds and the increased application of fertilizers are spreading all over the world. In view of the poor quality of foodgrain processing, marketing and distribution systems, and the grave uncertainty regarding the world markets for Pakistani foodgrain exports, the prospects for earning foreign exchange by exporting the surplus grains are at best problematical.

5. The economic argument against a rapid tractor-mechanization in West Pakistan is as follows:

a) It uses more of the nation's scarce resources and reduces the use of the abundant resource.

b) Since water is the limiting factor in West Pakistan, the strategy that maximizes output per unit of water (or per unit of irrigated acreage) is the most economical strategy. We do have well-known technology in this regard, thanks to the tubewell development and the green revolution.

c) There is no evidence that tractor-mechanization *per se* will increase yields; output per worker will rise only by causing unemployment.

d) Tractor-mechanization will not "earn" foreign exchange, nor "save" it.

6. A rapid tractor-mechanization programme will create social and political problems.

a) Given the economic-demographic characteristics of West Pakistan, it is important for the agricultural sector to absorb the residual increase in the labour force over and above those finding employment in the nonagricultural sectors.

b) The pervasiveness of the green revolution cannot take place with tractor-mechanization. The polarization occurs in the ranks of the farming population because of the impossibility of maintaining the support prices. The large will get larger, the small will get smaller.

c) Tractor-mechanization is an error from which it is difficult to recover because of the nature of short-run fixed costs associated with investment in tractors and creation of bottlenecks elsewhere.

7. Tractor-mechanization diverts capital from other vitally needed areas. There is no overemphasizing the fact that capital is needed in building up infrastructure, education and transportation systems. Even within the agricultural sector it is of vital importance to increase the provision of water and biological-chemical inputs, such as fertilizers and pesticides. The fact that imported foodgrains feed the urban population rather than the rural in West Pakistan has geared the marketing and distribution systems to handling imported foodgrains exclusively. In Pakistan the marketing system, grading and processing procedures as well as transportation and storage facilities remain antiquated — a situation tolerable so long as the marketable surplus of agriculture remains meagre. The situation in West Pakistan has now changed. A rapid increase in output has now raised the marketable surplus and taxes the facilities for handling it. Attacks on these problem areas will compete for the scarce resources of capital and foreign exchange.

8. Capital formatio.. . agriculture should most appropriately be in the form of small-scale, divisible, easily adaptable units to *a*) remove bottlenecks, *b*) involve the bulk of the nation's farmers, and *c*) generate employment opportunities in agriculture. Instead of tractors and combines, serious attention should be paid to the machines designed for selected processes of farm operation, such as threshers, winnowers, sprayers, engines and pumps as well as improved animal-drawn implements.

9. The strategy of emphasizing the agricultural inputs of the nature outlined in the point 8 above will also generate investment opportunities for local industry and, therefore, employment opportunities also in that sector. This, in turn, will have beneficial effects on the agricultural sector by providing it with inputs at increasingly favourable terms and encouraging the use of them.

10. There is a pressing need to plan for changes in cropping patterns by shifting attention to crops such as cotton, pulses, oilseeds and sugarcane and by re-examining the structure of output prices.

Water is still the major constraint for the full realization of the agricultural potential for this area. Despite the remarkable increase in the number of tubewells and the expansion of surface water supplies, many farms cannot yet realize the full benefits of the "green revolution"[40]. There are reports that the acreage of water-consuming crops, such as rice and sugarcane, is held back and even that the acreage planted under these crops has been ploughed under because of the shortage of water. Moreover, in many regions the needed fertilizer is not available at the right time. The recent growth in fertilizer consumption is indeed impressive, but the amounts being distributed come nowhere near the level required for the optimum performance of the agricultural sector. In short, there is an ample scope for *further exploiting well-known techniques and factor combinations* for the benefit of the agricultural development of West Pakistan. Further development of the farm implement and tubewell industries, improvements in the seed/fertilizer distribution systems, investment in marketing and storage facilities — all of these things — may cost as much as tractor mechanization and may even press available domestic and foreign developmental resources to the limit. The returns to be reaped from such investment, however, would not only be more widespread, they would exceed by far that which is possible by tractor-mechanization.

[40]The development of tubewells requires, of course, not only the installations of pumps, engines and motors, but more importantly, the provision of electricity or diesel fuel at the well site.

REFERENCES

1. Aresvik, Oddvar, *Possible Export Price for Wheat.* Mimeographed memorandum to Mr. M. K. Bakhsh, ex-Minister for Food and Agriculture, Government of West Pakistan, 1968.

2. Bean, L. L., M.R. Khan and A. R. Rukanuddin, *Population Projections for Pakistan, 1960-2000.* Monographs in the Economics of Development, No. 17. (Karachi: Pakistan Institute of Development Economics, 1968).

3. *The Dawn,* December 7, 1968.

4. Efferson, J. N., *Prospects for Expanding Export Markets for West Pakistan Rice.* Mimeographed. (Lahore: Planning Cell, Agriculture Department, Government of West Pakistan, 1968).

5. Falcon, W.P. and C. H. Gotsch, *Agricultural Development in Pakistan: Lessons from the Second-Plan Period.* Mimeographed. (Cambridge: Harvard University Economic Development Series, Report No. 6, 1966).

6. Giles, G.W., *Toward a More Powerful Agriculture.* Mimeographed. (Lahore: Planning Cell, Agriculture Department, Government of West Pakistan, 1967).

7. Gill, M.S., "Economics of Farm Mechanization", *West Pakistan Journal of Agricultural Research*, Vol. 1, No. 1, December 1962.

8. Johnston, B.F., "Agriculture and Economic Development: The Relevance of the Japanese Experience", *Food Research Institute Studies*, Vol. 6, No. 3, 1966.

9. Kaneda, Hiromitsu, "The Soucres and Rates of Productivity Gains in Japanese Agriculture as Compared with the U.S. Experience", *Journal of Farm Economics*, Vol. 49, No. 5, December 1967.

10. Mohammad, Ghulam, "Private Tubewell Development and Cropping Patterns in West Pakistan", *Pakistan Development Review*, Vol. V, No. 1, Spring 1965.

11. Pakistan, *Population Census of Pakistan, 1951.* (Karachi: Manager of Publications).

12. Pakistan, *Population Census of Pakistan, 1961.* (Karachi: Manager of Publications).

13. Pakistan, Taxation Inquiry Committee, *Taxation Inquiry Committee Report.* (Karachi: Manager of Publications, 1960).

14. Pakistan, Central Statistical Office, *Pakistan Statistical Yearbook, 1964.* (Karachi: Central Statistical Office, 1966).

15. Pakistan, Ministry of Food and Agriculture, *The Report of the Pakistan Agricultural Inquiry Committee, 1951-52.* (Karachi: Manager of Publications, 1952).

16. Pakistan, Ministry of Food and Agriculture, *The Report of the Pakistan Food and Agriculture Commission.* (Karachi: Manager of Publications, 1960).

17. Pakistan, Planning Commission, *The Third Five-Year Plan (1965-1970).* (Karachi: Manager of Publications).

18. Pakistan, Planning Commission, *The Annual Plan, 1968-1969.* (Karachi: Manager of Publications).

19. Parker, W. N. and J. L. V. Klein, "Productivity Growth in Grain Production in the United States, 1840-60 and 1900-1910", in *Output, Employ-*

ment, and Productivity in the United States after 1800. (New York: Columbia University Press, 1966).

20. Sawada, Shujiro, "Innovations in Japanese Agriculture, 1880-1935", in W. W. Lockwood (ed), *The State and Economic Enterprise in Japan.* (Princeton: Princeton University Press, 1965).

21. Seko, Hideo, *Lowland Rice and Upland Farming in Japan.* (Tokyo: Central Agricultural Experiment Station, 1966).

22. United Nations, Food and Agriculture Organization, *Monthly Bulletin of Agricultural Economics and Statistics*, Vol. 17, July-August 1968.

23. United States, Agency for International Development, *Statistical Fact Book: Selected Economic and Social Data on Pakistan.* (Washington: United States Agency for International Development, 1968).