Empirical Studies on Pakistan Agriculture

Sayed Mushtaq Hussain and Mohammad Irshad Khan
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EMPIRICAL STUDIES on PAKISTAN AGRICULTURE

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Introduction to the Series

The Pakistan Institute of Development Economics has compiled a series of *Readings* on various aspects of the development problems of Pakistan. These *Readings* consist of important studies relevant to the subject-matter to which the different volumes in this series pertain. It is hoped that the studies presented in these volumes will go a long way to fill in the lacunae in the field of economic literature for Pakistan.

All of the studies included in this volume were originally published in the Institute's quarterly journal, *The Pakistan Development Review*. The Institute has now been in existence for over a decade and *The Pakistan Development Review* is in the ninth year of its publication. During this period, the Institute has made very significant contribution in various fields of applied economic research. The studies carried out at the Institute have been of immense value to the planners, researchers and academics. Most of these studies were published in one form or the other in *The Pakistan Development Review* which is widely recognized, both in Pakistan and abroad, as one of the outstanding journals in the field of Development Economics.

In recent times we have been receiving suggestions from outside and have been increasingly becoming aware ourselves of the desirability of compiling in a number of volumes the significant contributions of the Institute in particular areas of research in development economics. We have come to recognize that this would be of significant use not only to those planners and researchers who would like to have important pieces of analyses in any particular area to be collected in a single volume, but also to the teachers and students at the advanced levels at the universities who have been handicapped in the teaching of courses in economics of Pakistan because of the lack of analytical and empirically oriented studies. It is in the hope of fulfilling these needs that we have embarked on the project of compiling books of readings selected from the studies published by the Institute.

It may be noted that we have confined ourselves to the studies actually undertaken by the members of the research staff at the Institute. *The Pakistan Development Review* regularly attracts contributions from eminent economists outside the Institute, both national and international. Many of these contributions are highly competent and relevant. But we have found it useful to confine ourselves to the studies carried out *at the Institute* because one of our purposes is to highlight the contribution of the Institute in specific areas of applied economic research.

Nurul Islam
Director
Pakistan Institute of Development Economics

EMPIRICAL STUDIES on PAKISTAN AGRICULTURE

Introduction

Sayed Mushtaq Hussain
and
Mohammad Irshad Khan*

The recent developments in the agricultural sector (specially in the western wing) have brought Pakistan on the threshold of an agricultural revolution. The changes that took place in Pakistan's agriculture attracted several researchers at the Institute to write on problems and prospects for agricultural development in Pakistan. The Institute has, therefore, published many articles, research reports, notes, and monographs which analyse and interpret the developments in the agricultural sector. Some of these studies are being presented in this volume.

The present volume is divided into three parts. Part 1 deals with the strategic factors in agricultural production. In Part 2, the economic behaviour of the farmers is discussed. Institutional arrangements in agriculture are analysed in Part 3.

I

STRATEGIC FACTORS IN AGRICULTURAL PRODUCTION

Agricultural production is conditioned by physical and economic constraints operating on the farmers. In West Pakistan, rainfall is inadequate

*Section II of the Introduction is written by Mr. Hussain and Sections I and III are written by Mr. Khan.

for crop cultivation while East Pakistan receives heavy rainfall resulting in floods which cause considerable damage to crops in the monsoon season. Irrigation is, therefore, essential for cultivation in West Pakistan while flood control may be necessary to increase agricultural production in East Pakistan.

There are four articles included in Part 1 which deal with the problems of irrigation and rainfall in East and West Pakistan as well as the general strategy for agricultural growth. The late Ghulam Mohammad made three studies on the strategy of agricultural development in East and West Pakistan. The fourth article, written by Sarfraz Khan Qureshi, is a statistical analysis of wheat production in *barani* areas in West Pakistan where agriculture is dependent on whatever little rainfall occurs.

In his first article on strategic problems in agricultural development, Ghulam Mohammad takes a stand which is out of line with the thinking of the advocates of "package programme" for solving the problems of low agricultural productivity in Pakistan. He would like to concentrate on only two vital inputs, *viz.*, water and fertilizer, because a very large increase in agricultural production can be brought about by giving cheap fertilizer and adequate water supply to the farmers in East and West Pakistan. He, however, makes himself clear that efficient extension service, seed of improved varieties, plant-protection equipment and chemical, improved implements, credit and other factors of production will be needed in the long run. But, in the short run, priority should be given to fertilizer and water.

The second article, written by Ghulam Mohammad, discusses the role of private tubewells in changing the cropping intensity and cropping patterns in nonsaline areas of West Pakistan. The role of private tubewells in the agricultural development of West Pakistan is by now well recognised. Ghulam Mohammad shows that the installation of tubewells has been very rapid in areas where electricity was made available because the cost of installation of an electric tubewell is less than that of a diesel tubewell by about three thousand rupees. The tubewell farmers are getting extremely high returns in nonsaline groundwater areas because they can increase the depth of irrigation, increase cropping intensity, grow crops like cotton, rice, fruits and vegetables which fetch better price than other crops, increase the use of fertilizer, and increase the intensity of the use of bullock and manpower. The tubewells are also having a powerful influence on the saving and investment habits of the farmers. The saving which was used to buy additional land is now being utilized to install tubewell, a low-cost investment with extremely high returns.

In his article on irrigated agriculture in East Pakistan, Ghulam Mohammad argues that flood control in East Pakistan will need massive investment and may not be the efficient method of increasing agricultural production in the short run. In his opinion, winter irrigation in East Pakistan is the best strategy for increasing agricultural production. He recommends small low-lift pumps to lift water from rivers and small tubewells to utilize the groundwater in East Pakistan not only because the capital cost and annual operation cost of large gravity canal and large government tubewells are higher than those of small low-lift pumps and small tubewells but also because the former group has much longer gestation period than the latter group. Moreover, since no flood-protection works are needed for low-lift pumps and small tubewells which have been used in flooded areas, the costly flood-protection works proposed for East Pakistan can be, in his opinion, postponed till a large part of East Pakistan can be provided with irrigation facilities by these means. He, however, makes himself clear that flood-protection works will be required in the long run in order to increase the production of summer crops.

The fourth article is written by Sarfraz Khan Qureshi. He used regression-analysis technique to find out the effect of rainfall in presowing and sowing period on acreage and production of wheat in three districts of West Pakistan, namely, Rawalpindi, Jhelum, and Campbellpur, where agriculture is dependent on rainfall. His analysis shows that rainfall during the presowing and sowing periods is an important determinant of wheat acreage in any cropping season while wheat production in any cropping season is heavily influenced by the quantity and distribution of rainfall in the presowing, sowing, and growing periods. His findings imply that wheat acreage and production in the *barani* areas can be accurately predicted by observing the rainfall in presowing and sowing period. Thus, reliable estimate of wheat production in *barani* areas can be obtained by mid-April every year whereas the official estimates are not available before September.

II

ECONOMIC BEHAVIOUR OF THE FARMER

Part 2 of this volume contains articles on farmer response to price and factors that influence the marketable surplus of agricultural produce. Both of these aspects are connected with farmers' behaviour in relation to the opportunities provided by the market.

The study of farmers' behaviour in exploiting market opportunities is of vital importance in countries where economic incentives rather than direct methods are used to encourage agricultural production, and its availability to the nonagricultural sector. Such studies are also badly needed as a guide to policy-making and resolving some of the entangled issues in development theory.

S. M. Hussain's article, published in Spring 1964, relates to the response of farmers to price. It uses a simple model and tries to estimate the price elasticity of acreage supply (η_A) for rice and jute in East Pakistan for the period 1948/49 to 1962/63. The η_A for jute was estimated earlier by Ralph Clark and Venkataramananan, but Hussain's attempt was the first one for rice crop.

Some of the important conclusions of the study are that in the case of the cash crop (*i.e.*, jute), the farmer response to price as reflected by the η_A is higher than that for the food crop (*i.e.*, rice). Although the farmer response to price in the case of rice is found to be low yet it is significantly positive.

Results of this study can be related to other studies on Pakistan, most notable of which are by W. P. Falcon [4], Raj Krishna [9], Ralph Clark [3] and A. K. M. Ghulam Rabbani [10]. These studies were conducted outside the Pakistan Institute of Development Economics and hence are not included in this volume.

The studies by W.P. Falcon and Raj Krishna cover parts of West Pakistan and find that farmer response to price is significantly positive and the η_A for cash crops (*e.g.*, cotton) is much higher than the η_A for subsistence food crops (*e.g.*, wheat). These results are quite consistent with Hussain's findings.

Studies by Ralph Clark and A. K. M. Ghulam Rabbani covering East Pakistan found that the jute growers respond to price very well. Study by Rabbani is a more elaborate one in terms of the estimating equations used to compute area response. He discards the idea of using the so-called naive model (as adopted by Hussain) in which the coefficient of price expectation (K) is unity. Rabbani has tried Nerlove's adjustment model and price expectation model in which $O < K < 1$ and on the criteria of serial correlation and R^2 found that the adjustment model gives the best results. It is, however, ignored that the use of price expectation and adjustment models generates estimating equations with lagged endogenous variables which may complicate the interpretation of the Durbin-Watson test.

Hussain in, a more recent study [7], has shown that the naive price expectation model does very well provided other variables having time behaviour (*e.g.*, constraint of subsistence farming) are properly included in the models.

In general, it can be said that farmers respond to the price incentives insofar as the market opportunities provided by the land allocation are concerned. On the basis of the price elasticities of area supply, it can also be said that the economic incentive responses on the part of the farmers in Pakistan are as strong as that of farmers in some of the developed countries. The results of this and other similar studies have provided enough empirical evidence to reject the old-fashioned belief that farmers in underdeveloped countries lack economic incentives[1].

It is worth noting that the study by Hussain, like most studies on farmer response to price, has estimated the price elasticity of area/output supply for various crops, regions, and time periods. The results show that the price elasticities of area supply vary over crops, regions and time periods[2]. As a step forward the research effort should be directed in discovering factors that may be responsible for the variation in farmers' response to price. Some work has already been done in this direction at the Institute [5;7][3].

We now turn to another aspect of farmers' economic behaviour, namely, production for the market. This aspect is of extreme importance in countries where food problem is acute and where the development effort is heavily financed through the marketable surplus originating from the agricultural sector.

The study by Azizur Rahman Khan and A.H.M.N. Chowdhury on the marketable surplus function is the first attempt in Pakistan to throw light on factors influencing the marketable surplus of various crops. The authors also try to test two main hypotheses: *i*) the farmers sell all the produce in excess of their minimum consumption and, hence, the main determinant of the marketable surplus is output; and *ii*) the farmers sell only that much produce in the market which would satisfy their cash requirements; hence, the marketed quantity should vary inversely with the availability of cash and cash incomes from other sources.

1Reference to some of the other well-known studies can be found in Hussain [7].

2More recently, an attempt has been made to explain the phenomenon of the declining farmer response to price, *see* Hussain [7]. It was found that the main reason for the decline in the farmers' jute area response in East Pakistan had been the growing constraint of subsistence farming.

3For an analysis of the differences in price elasticity for cash and subsistence food crops, *see* Ahmad [I, Pp. 16-18] and Hussain [5, Pp. 46-50].

The data used is derived from a subsample of 87 households from the National Sample Survey of Family Expenditure (First Round, 1959) conducted by the Central Statistical Office.

The authors apply regression analysis to pinpoint the important determinants of the marketable surplus. Distinction is made between farmers who are marketers and nonmarketers of food, and also between those who are in most irrigated and less irrigated areas. The rationale of the former distinction is that the average farm size and productivity per acre of marketers was found to be higher than that of the nonmarketers.

The study finds output and rent as the main determinants of the marketed quantity in the case of those farmers who market and to a lesser degree for others. The authors find indirect evidence in favour as well as against the cash-requirement hypothesis.

A more recent study is done by M. Raquibuzzaman on the marketed surplus function of major agricultural commodities in Pakistan. This study extends the work of Khan and Chowdhury by including East Pakistan in addition to West Pakistan, and also by introducing additional explanatory variables like tenurial status, size of holdings, family size, and consumption of cash goods.

The study analyses data from the National Sample Survey of Family Expenditure (Second Round, 1960).

The methodology used is slightly different in that physical quantities rather than value are used.

The analysis shows that in the case of owner farmers, both in East and West Pakistan, the marketed surplus of foodgrains per family is mainly determined by the output and family size. In the case of tenant farmers, rent becomes an additional important explanatory variable. It was noted that almost all the quantities produced are marketed in the case of cash crops. Further, the consumption of cash goods was found to have little relationship with the marketed surplus of foodgrains.

In contrast to the studies on farmer response to price, the studies on marketable surplus fail to underline any common factors influencing the behaviour of marketable surplus. This is due to the conceptual differences regarding the explained variable used.

In general two observations can be made on the research work done both at and outside the Institute about farmers' economic behaviour. *First*, whereas the empirical studies on farmer response to price have been highly aggregative in time series, the studies on marketable surplus have been cross-sectional in nature. There is a great need to supplement the former type of studies with less aggregative and cross-sectional analysis, and the later type studies with the time-series analysis[4]. *Secondly*, in order to sort out and interpret empirical results more meaningfully, sound theoretical farmeworks as a foundation are badly needed. As a general rule, it can be suggested that in the study of marketable surplus of food crops, and area/output response to price where some subsistence food crop is involved, theoretical frameworks should treat the farmer as a producer-consumer unit[5]. It will be quite useful if the estimating equations used in the supply functions and the marketed surplus functions are derived from theoretical models in which farmer is given the role of a producer and a consumer[6].

III

INSTITUTIONAL ARRANGEMENTS IN AGRICULTURE

Institutional arrangements like rental arrangements, credit facilities and extension services play a vital role in agricultural development. One of the articles selected in this part deals with credit requirements and credit availabilities to farmers from institutional source while the other article discusses the 1959 land reform in West Pakistan from the point of view of its impact on ownership pattern' and subdivision and fragmentation of holdings in the former North West Frontier Province of West Pakistan.

In his paper on agricultural credit in Pakistan, M. Irshad Khan provides a new method of estimating credit requirements for agriculture; his method is based on the best available estimates of production parameters in contrast with earlier attempts by Credit Enquiry Commission to estimate agricultural credit requirements through informed guess. Khan's analysis shows that credit requirements of the farmers in Pakistan are far greater than the credit supplied by institutional sources; and agencies like Agricultural

[4]The only studies available on marketable surplus in the context of time are of theoretical nature. The theoretical work, so far, has not led us *very far except in generating* some untested hypotheses. *See*, Hussain [6], Behrman [2], and Krishna [8].

[5]Some of the theoretical and empirical work recognising the farmer as a producer and consumer can be found in Krishna [8], Behrman [2], and Hussain [6].

[6]It may be noted that the study by Hussain, included in this volume, gives farmers the role of a producer only, whereas one of the competing crops is a subsistence food crop.

Development Bank which have been created specially for granting loans to farmers, follow the same traditional criteria for granting loans as are followed by commercial banks, *e.g.*, security in terms of tangible assets specially land rather than the incremental production which will result from the loan. The study also shows that Partition and the subsequent departure of non-Muslim financier class had a profound effect on the then existing credit institutions, specially in East Pakistan where there was a complete collapse of cooperative credit structure.

In the second article, Christoph Beringer shows that in North West Frontier Province only a few landlords will be affected by the ceilings placed on the ownership by 1959 land reforms and, therefore, only a small number of landless agricultural labourers and tenants would become landowners in their own right. And, since the majority of the cultivators' holdings are already below the size of a "subsistence holding" as defined in 1959 land reform report, the provision for restraining further subdivision and fragmentation of these holdings is out of place; the law should have provided for consolidation and upgrading of the size of cultivator's holding to a level which would allow an adequate level of living for the cultivator and his family.

Lastly, we must say that selections presented here are only a few of the vast number of publications dealing with agriculture in Pakistan. The unsatisfied reader has no alternative but to ask for a list of Institute's publications in order to quench his thirst for more knowledge on these and other aspects of agriculture in Pakistan. We, however, shall be satisfied if the present volume is able to fulfil the need of those who are interested in the broad issues facing the agricultural development in Pakistan.

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Part I

Strategic Factors in Agricultural Production

Some Strategic Problems in Agricultural Development in Pakistan

Ghulam Mohammad

This chapter originally appeared as an article in the Summer-1964 issue of *The Pakistan Development Review* and is the result of research carried out by the author during his association, in the capacity of a Senior Research Economist, with the Pakistan Institute of Development Economics, where he was on deputation from the Planning Commission of Pakistan from March 1963 to July 1967.

Valuable comments were made on earlier draft by Drs. Mark W. Leiserson, Stephen R. Lewis Jr., both of the Institute, and Mr. Carl Gotsch of the Harvard Advisory Group in the Planning Commission of Pakistan.

Mr. Ghulam Mohammad breathed his last in Rome in September 1967 while on a short-term deputation to the Food and Agriculture Organization of the United Nations.

Some Strategic Problems in Agricultural Development in Pakistan

Ghulam Mohammad

INTRODUCTION

Crop yields in Pakistan are amongst the lowest in the world. Food intake is less than 2,000 calories per capita per day; the diet is not balanced and consists mainly of cereals. The average intake of animal protein is only one-half of the absolute minimum recommended by the FAO [14]. Similarly, yields of export crops are low and foreign-exchange earnings are meagre.

So long as yields of crops remain low, the great bulk of the land will continue to be devoted to growing of subsistence cereals for the human population and there is very little possibility of crop diversification to include more of such nutritive foods as fruits and vegetables. Under such conditions, there is virtually no possibility of diverting any significant acreage from food and cash crops to fodder and feed crops for the animal population.

The major problem in Pakistan is, therefore, to increase the yields of the main food and cash crops. The main proposals under execution or discussion so far have involved two elements: *i*) the provision of increased water supplies through large-scale governmental projects, both in East Pakistan and West Pakistan; and *ii*) increased provision of all inputs, *i.e*, pure seed of improved varieties of crops, pesticides, fertilizers, tractors and improved implements, credit, and so on in a package programme for the intensive development of various project areas, involving the complete reorganization of the work of the various organizations with responsibilities in agriculture.

This paper takes a different point of view and argues that the immediate need of Pakistan is to make available to farmers large quantities of those low-priced inputs that can bring about large increases in crop production in relation to the cost incurred. We argue that the two sectors on which efforts should be concentrated for this purpose are the increased availability of fertilizers and the increased availability of water over large parts of the country. We argue that both of these goals can be achieved in a relatively short period without radical structural reorganization of the government, through greater use of the private sector and of the incentives for gain of the farmers themselves.

It is not the intent here to minimize the contribution of other factors of production or the mass of educational and organizational difficulties that beset the agricultural sector, but it will be shown in the sections that follow that substantial increases in agricultural productivity can be brought about *within* the framework of existing rural institutions by concentrating on these two sectors and by making only moderate provision for other factors of production.

II. INCREASING THE CONSUMPTION OF FERTILIZERS

One of the most important developments of the last century has been the creation of the chemical-fertilizer industry which has made possible large increases in crop production in many countries of the world. Very little advantage, however, has so far been taken of this great opportunity in Pakistan or in any other underdeveloped country. It is true that countries with high consumption of fertilizer have paid attention to other factors such as irrigation, varietal improvement, and disease control and have organized an efficient extension service. Nevertheless, available data do suggest that supply of nutrients is a necessary condition for obtaining high yields, and up to a certain limit, the greater the quantity of nutrients that can be added, the greater the yield [12, Pp. 96-109].

Fertilizer Trials in Pakistan

The most extensive series of tests on the effects of fertilizers in East Pakistan were conducted by Drs. Islam and Sulaiman of the Agricultural Research Institute, Tejgaon, Dacca, in collaboration with Dr. Vermaat of the Food and Agriculture Organization of the United Nations. As a result of more than 4,000 trials run on cultivator's fields on *aus*, *aman* and *boro* rice[1] between 1957/58 and 1962/63, it was concluded that in East Pakistan it was possible to raise paddy[2] output between 7,000,000 and nearly 10,000,000 tons with the help of fertilizers alone [36]. Earlier trials conducted at the Agricultural Research Station, Dacca, indicated that nitrogen fertilizer gave economic returns only when used in combination with farmyard manure. No phosphates were tried in those experiments.

In West Pakistan, results of experiments conducted by the Department of Agriculture during the last 50 years showed that nitrogen gave a positive response on all crops throughout West Pakistan [37]. Further trials conducted with the help of FAO on cultivator's fields during recent years, *i.e.*, 1959/60 — 1962/63, showed that the application of a combination of nitrogen and phosphoric acid increased the yield of wheat and other crops and gave economic returns to the farmers in most districts of West Pakistan [36]. The returns were highest in areas which were free from waterlogging and salinity. Only in areas where salinity was excessive was the use of fertilizer found to be not economical.

Fertilizer Requirements of Pakistan

Based on the results of fertilizer experiments mentioned above and taking into consideration the increases in the cropped areas likely to take place as a result of the irrigation-development programme during the next 20 years, estimates for fertilizer requirements of Pakistan have been prepared by Imhausen International Engineering Company, consultants to the Planning Commission, and by the Revelle Panel. In the *Revelle Report* the requirements of Indus Plains are estimated at 625 thousand tons of nitrogen and 160 thousand tons of phosphoric acid[3] [34, Pp. 103 and 106]. Imhausen estimate the total requirements of nitrogen, phosphoric acid and potash for Pakistan at 2.85 million tons [18, p.56]. Out of this, 1.18 million tons are estimated for West Pakistan and 1.67 million tons for East Pakistan. Imhausen further recommend that about 725-thousand-ton fertilizer capacity be completed during the third-plan period. When added to the existing capacity, this would raise the total capacity to about 870 thousand tons. For the 65 million acres expected to be under crops in 1969/70, this would mean an average consumption of 30 pounds per acre. This may appear excessivein

[1]According to season, the entire rice crop of East Pakistan is divided into three broad groups, namely, *aus*, *aman* and *boro*. The word *aus* means early and refers to the rice crop, sown in March-April and harvested in July-August. The word *aman* means rice and refers to the main rice crop of East Pakistan which is sown in May-June, transplanted in July-August and harvested in November-December. *Boro* rice is adapted to cooler season; it is sown in October-November, transplanted in December-January and harvested in March-April.

[2]Paddy refers to rice in husk. Rice is usually two-thirds of paddy by weight.

[3]Hereafter referred to as the *Revelle Report*.

relation to the existing consumption of 3 pounds per acre but is certainly very low in relation to Pakistan's needs. Efforts should be made to reach or exceed this level in the next 5 years.

This can be done if the following conditions are met:

1) *The price of fertilizer should be low:* Fertilizers must be made available at a low price in relation to the price of farm products. The example of Japan, which uses 100 times the fertilizer that Pakistan uses, is often quoted but the price factor is often overlooked. In Japan it takes 2.4 pounds of wheat to buy one pound of nitrogen (*see*, Appendix Table A-1). In Pakistan, on the other hand, it takes 5.0 pounds of wheat to buy one pound of nitrogen at full cost and 2.5 pounds of wheat at the present subsidized cost. Thus, even the subsidized nitrogen is more costly in Pakistan in terms of wheat than the unsubsidized nitrogen in Japan. In East Pakistan, the position with respect to rice is still worse. While in Japan it takes 1.3 pounds of paddy to buy one pound of nitrogen, in East Pakistan it takes 3.5 pounds of paddy to buy one pound of nitrogen at full cost and 1.7 pounds of paddy when fertilizer is sold at a 50-per-cent subsidy.

That price is indeed an important variable may be seen from the history of fertilizer distribution in Pakistan. The Food and Agriculture Commission, after examining this question, stated: "In the past, government has subsidized fertilizer to various degrees. The rate of subsidy has, however, been so variable from year to year and changed at such short notice that much of the expected impact of the subsidy was lost .... Fertilizer use is still in its initial phase; and to ensure widespread distribution, it is desirable that the subsidy should continue and that the rate should remain unchanged over a number of years so that the farmer may not be left in doubt as to the investment he has to make" [29, p. 177]. As a result of recommendations of the Food and Agriculture Commission, the government decided in 1961 to fix the prices of fertilizers at about 50 per cent of the cost and to keep these prices constant throughout the second-plan period. The use of fertilizer rose from 31 thousand tons in 1959/60 to 55 thousand tons in 1960/61, an increase of 80 per cent in one year. However, at the end of only one year the subsidy was cut from 50 per cent to 25 per cent in West Pakistan and distribution work was passed on from the Department of Agriculture to the newly created Agricultural Development Corporations (ADCs) in both wings. There was only a small increase in fertilizer consumption during the next 2 years. The government was forced to restore the subsidy to 50 per cent in West Pakistan in the beginning of 1964.

There is no doubt that if fertilizer had been continued to be imported (or produced) in adequate quantities and if the lower prices for fertilizer introduced in the western wing in 1953/54 had been continued, the consumption would have been many times what it is today.

It is important that the present subsidy of 50 per cent should continue at least up to the end of the third-plan period. If it continues, consumption can be expected to increase by about 50 per cent a year. Such an increase would mean that the level of consumption, by 1969/70, would rise to some 800 thousand tons of nutrients, provided that certain other conditions are fulfilled.

2) *Adequate credit should be provided:* So long as the use of fertilizer was on a small scale, lack of credit facilities was not a serious problem. However, if consumption is to be increased to a level of about 800 thousand tons of nitrogen, phosphorus and potash a year, as suggested earlier, the total cost paid by the cultivators in both wings of the country in 1969/70 would come to about Rs. 500 million a year. This would require a large expansion in the amount of credit available.

Total loans provided by the government through the Agricultural Development Bank of Pakistan, the Cooperative Credit Societies and the *taccavi*[4] loans by Revenue Department during the last three years are given in Table I.

TABLE I

CREDIT FACILITIES PROVIDED: 1959/60 — 1961/62

Year	*Taccavi* loans by the Revenue Department	Loans by the Agricultural Development Bank of Pakistan	Loans by the Cooperative Credit Societies	Total
	(........................ *in million rupees*	....	....	........................)
1959/60	34	55	100	189
1960/61	35	77	117	229
1961/62	35	95	104	234

Source: Data provided by the Agricultural Development Bank of Pakistan, Karachi.

[4]Loans issued by the Revenue Department under the Agricultural Improvement Act and the Agriculturists' Loans Act are popularly known as *taccavi* loans. The word *Taccavi* means help and strength.

The Agricultural Development Bank maintains a record of loans sanctioned for each purpose. Out of Rs. 95 million sanctioned by them during 1961/62, the amount sanctioned for the purchase of fertilizer was only Rs. 2.6 million or less than 3 per cent [28, p. 10]. The share of fertilizer in loans sanctioned by Cooperative Credit Societies and in *taccavi* loans was probably higher. According to a survey on the utilization of loans in the Comilla Thana, 15.6 per cent of loans sanctioned by the Cooperative Credit Societies were utilized for purchase of fertilizer [27, p. 4]. Assuming the same figure for the *taccavi* loans, the total loans sanctioned for fertilizer in 1961/62 by all the three agencies were about Rs. 26 million. These should be increased to about Rs. 500 million a year in the next few years in order to enable the farmers to expand fertilizer consumption rapidly.

3) *Efficient fertilizer distribution organization should be set up:* Distribution work was in the hands of the Department of Agriculture up to 1960/61 when it was transferred to the Agricultural Development Corporations. The Corporations did not have any field organization for fertilizer distribution. The West Pakistan ADC, therefore, appointed the Cooperative Department as their sale agents which, in turn, organized a Rural Supply Cooperative Corporation for wholesale business and Union Cooperative Societies for retail sale of fertilizer. In 1963/64, it was decided that the West Pakistan Industrial Development Corporation (WPIDC) should appoint its own private agents in addition to the Union Cooperative Societies and agents of the WPADC. The WPIDC has appointed about 500 sale agents at the *mandi* (market) towns.

The East Pakistan ADC, lacking distribution facilities, appointed the Department of Agriculture for retail business, so that instead of one we have now two government agencies handling the same job. The Department of Agriculture had constructed about 4,000 Union stores and had special staff for sale of fertilizer. Performance, however, was unsatisfactory and it was reported that the Thana stores as well as Union stores remained closed for most of the time and the cultivators could not buy the fertilizer. This was probably because the storekeepers got their pay whether they sold any fertilizer or not. In 1963, the Department of Agriculture appointed a number of private agents for sale of fertilizer in addition to sale from the Union stores. Performance improved considerably and, in the first 10 months of 1963/64, 39 thousand tons of fertilizers were sold as compared with 27 thousand tons in the whole of 1962/63 [6]. The decision to pass on the sale of fertilizer to private enterprise is extremely significant. Private agents have a personal stake in sales and if the profit margins are sufficiently high an all-out effort to sell large quantities of fertilizer may be expected.

The actual policy to be followed for insuring appropriate profit margins

could take two different forms. A system of fixed prices for purchase and sale of fertilizers at the factory and at *mandi* towns can be followed; in this case an appropriate rate structure must be determined. At current prices, profit margins on the sale of urea amount to 9 per cent in West Pakistan and 11 per cent in East Pakistan, and dealers have to bear godown rent and some other charges out of this margin of profit. It is unlikely that they will sell much urea under these conditions. Urea is the only fertilizer produced in East Pakistan and the major fertilizer produced in West Pakistan. It is also the major form of nitrogen to be produced in the future. Therefore, it is essential that the profit margin on this fertilizer be increased. The sale of fertilizer can be maximized if it begins to be sold by village shopkeepers. The private agents now appointed at the *mandi* towns will eventually make such arrangements with village shopkeepers if the profit margins are high enough to be shared. A minimum profit margin of 20 to 25 per cent on all fertilizer sales may be necessary.

A second system, probably a better and more efficient policy, would be to fix the price only at one level, appoint a larger number of dealers and let the dealers sell fertilizer at whatever price they can. This is likely to maximize the sales. By having a larger number of dealers there would be keen competition between them and chance of overcharging would be reduced. Even if in some cases they charge higher prices, it is of secondary importance so long as they can sell larger quantities of fertilizers.

4) *Cheapest and the best fertilizers should be produced:* Although the sale of fertilizer is being subsidized and should continue to be subsidized during the next five years or so, ultimately the farmers will have to pay the full price. It is, therefore, of utmost importance that the cheapest form of fertilizer consistent with the needs of soils and crops should be produced in the country. For this purpose, nitrogen in the form of urea should be produced in both wings of the country. For phosphoric acid, rock phosphate may be used as such in East Pakistan and single superphosphate should be produced in West Pakistan. These would provide the cheapest and the best combination for both provinces.

The difference that the distribution of cheap rock phosphate in place of costly triple superphosphate could make to the whole fertilizer programme in East Pakistan is likely to be substantial. Suppose it is proposed to distribute 100,000 tons of phosphoric acid. This is equal to 220,000 tons of triple-superphosphate (46% P_2O_5) and 300,000 tons of rock phosphate (33% P_2O_5). The price of the fertilizer inclusive of distribution charges, total cost, sale proceeds and subsidy to be borne in the two cases is given in Table II.

TABLE II

SALE OF TRIPLE SUPERPHOSPHATE AND ROCK PHOSPHATE CONTAINING 100,000 TONS OF P_2O_5: COMPARATIVE COST, SALE PROCEEDS AND SUBSIDY

	Triple super-phosphate	Rock phosphate
Quantity to be imported (*thousand tons*)	220	300
Price per ton, inclusive of distribution charges (*Rs. per ton*)	580[a]	200[b]
Total cost (*Rs. million*)	127.6	60.0
Sale price (*Rs. per maund*)	7.36[c]	1.00[d]
Total sale proceeds (*Rs. million*)	44.0	8.2
Subsidy borne by government (*Rs. million*)	83.6	51.8

[a]C & F price Rs. 480 per ton. Distribution charges Rs. 100 per ton, *see* [5].

[b]C & F price $ 19 per ton according to Imhausen *Report* [18, p. 130], and $ 16 per ton according to *Revelle Report* [34, p. 104]. Grinding and distribution charges Rs. 120 per ton. Total Rs. 200 per ton.

[c]Existing sale price of triple-superphosphate.

[d]Proposed sale price of rock phosphate to maximize sale of phosphoric acid.

While it may be difficult to sell 220,000 tons of triple superphosphate at Rs. 7.36 per maund it will be comparatively easier to sell 300,000 tons of rock phosphate at Re. 1.00 per maund. The subsidy to be borne by the government will be much less in the case of rock phosphate. Furthermore, for the wet paddy crop on the acid soils of East Pakistan, rock phosphate is likely to be as effective as triple superphosphate per unit of P_2O_5 over a period of years, as is shown in Appendix C. Due to the complimentarity of fertilizers, increased sale of rock phosphate will also boost the sale of urea, and the total sale of all fertilizers may advance beyond expectations of the government. Therefore, a programme for large-scale imports and trials of rock phosphate should be carried out in East Pakistan for the next few years. Contrary to the recommendations of Imhausen International Engineering Company, triple superphosphate should not be produced in East Pakistan unless large-scale trials have been conducted with rock phosphate over a period of years. For West Pakistan, single superphosphate would be better than triple superphosphate and factories should be located in the farming areas and not at Karachi, again contrary to the recommendations of Imhausen. The reasons for this are given in Appendix C.

5) *Transport and storage facilities should be extended:* As fertilizer consumption increases, the tonnage of fertilizer to be handled during the next few years will place a severe burden on the transport facilities in the country. The total tonnage of fertilizer to be handled at the end of next 5 years may be expected to reach one million tons in East Pakistan and 1.5 million tons in West Pakistan.

Demand for fertilizer is seasonal. Therefore, adequate storage facilities with a total capacity of about half a million tons in each wing, located in fertilizer factories at a number of strategic places from distribution point of view, at the *mandi* towns and at the Union level should be constructed so that fertilizer can be moved throughout the year, particularly when rail, road or boat facilities are more readily available.

6) *Demonstration and experiments on cultivators' fields should be arranged:* Fertilizer trials on cultivators' fields have been conducted at 50 centres, roughly one in each subdivision in East Pakistan and in 14 out of 45 districts of West Pakistan. It is essential that these trials be laid out in each Union in East and West Pakistan in order to obtain realistic information on physical and economic crop responses to various fertilizers on various soils under practical farming conditions. All the 4,000 Union Assistants in East Pakistan and 3,000 Field Assistants in West Pakistan as well as the 1,000 Thana Agricultural Officers and Tehsil Agricultural Assistants should be thoroughly trained in laying out these fertilizer trials on cultivators' fields.

An important component of correct fertilizer use is soil testing. This should be done in conjunction with field experiments, and soil-testing laboratories should be established. In addition, soil-testing kits should be provided to the staff at the Thana/Tehsil level. The cost of a soil-testing kit is less than Rs. 100. Total cost for 400 Thana Agricultural Officers and 600 Tehsil Agricultural Assistants would be less than Rs.100,000.

The extension staff has a multiplicity of duties to perform. While all the duties assigned to them are necessary for ideal programme, it may be desirable to put major emphasis on the use of fertilizer alone for the next few years. The extension staff must know exactly what combination of fertilizers to use in different areas for different crops and how and when to apply the fertilizer. They should be able to advise the farmers accordingly. The success of the extension staff should be judged on the basis of correct fertilizer use, and all Union Assistants, Thana/Tehsil Agricultural Officers and District Agricultural Officers who bring about more than 50 per cent increase in fertilizer use year after year should be given bonus or some other form of encouragement.

7) *Improved high-yielding varieties should be evolved:* In order to expand fertilizer consumption on a large scale, it is essential to have varieties of crops which make use of high doses of fertilizer and can, thus, give large increases in yield. Such varieties of rice have not been evolved because there is very little research staff for work on the breeding of rice. Japan with 8 million acres under rice has a National Institute, 7 Regional Institutes and 350 Experiment Stations. Similarly, the Philippines with 8 million acres under rice has the advantage of the International Rice Research Institute at Manila with a competent faculty larger than the whole of research staff in East Pakistan. Against this, East Pakistan with 21 million acres under rice has only one small research section under a Cereal Botanist with a few Assistants who work on rice as well as on seven other crops. Not much can be accomplished under such conditions. It may be more profitable to redesignate the Agricultural Research Institute, Dacca, as Rice Research Institute and to put the whole staff working on all crops, other than jute, under the charge of a Director of Rice Research Institute to concentrate research on rice. High-yielding varieties, which make use of larger doses of fertilizer, should be evolved by introduction of, or hybridization with, Japonica types of rice because there can be no improvement in East Pakistan's agriculture until the yield of rice is increased.

In West Pakistan, the situation is somewhat better, but here too appropriate priorities have not been applied in determining research efforts. Wheat occupies more than 12 million acres in West Pakistan, and again the need is to develop varieties which have as a primary attribute a high tolerance for fertilizers so that the yield of wheat increases and part of the area can be diverted from wheat to other crops.

While much good work on cereals has been done, for example, at Lyallpur where a number of improved varieties of wheat have been evolved, the staff of the Cereal Botanist, Lyallpur, is no larger than that of some other sections concerned with minor crops. Commonsense would seem to indicate the necessity for strengthening sections devoted to major crops, since changes in the agricultural structure of the province hinge on the ability to raise substantially the yields of the main crops.

Prospects

Fertilizer distribution work in the past has suffered from frequent changes in prices resulting from frequent and abrupt changes in the rate of subsidy, lack of availability of fertilizer due to nonavailability of foreign exchange in some years and inefficient organization for distribution work throughout these years. When fertilizer was made available at low prices and extension staff was put on educating the farmers on the use of fertilizer, increases in fertilizer consumption were substantial.

It has been shown in this paper that even the present subsidized prices of fertilizer are higher than the unsubsidized prices of fertilizer in Japan in terms of prices of wheat and rice in the two countries. If fertilizers are sold at a price low in relation to the price of wheat and paddy with which the cultivators have to buy the fertilizer, if an efficient distribution system is organized, if transport and storage facilities are expanded, if the extension staff advises the farmers on the correct use of fertilizer, and if only those fertilizers are produced in the country which are best suited to the needs of soils and crops of Pakistan and which can be supplied to the farmers at the lowest possible prices, sale of fertilizer could expand by about 50 per cent a year and reach a level of 800,000 tons of nitrogen, phosphoric acid and potash by 1969/70. This is against 472,000 tons proposed by the Planning Commission [30, p. 62].

Assuming a total consumption of about 800,000 tons in 1969/70 against 150,000 tons in 1964/65, there will be an increase of 650,000 tons during the third-plan period. Out of this, about 450,000 tons of fertilizer may be expected to be used on foodgrains in both provinces. Assuming an increase of 10 pounds of foodgrains for each pound of plant nutrient applied, as estimated by the FAO [12, p. 108], we may expect an increase of about 4.5 million tons of foodgrains by the use of fertilizer alone. This is compared with an increase of 4 million tons of foodgrains estimated by the Planning Commission from all factors of production.

III. TUBEWELLS FOR ADDITIONAL WATER SUPPLY

A. WEST PAKISTAN

All over West Pakistan, the average yields of crops are very much below what may be considered satisfactory for irrigated land under similar climatic conditions. One basic cause of this is that much less irrigation water is available than is required for consumptive use of crops.

One cusec of water is generally supplied for 333 acres in West Pakistan as against 100 acres or less in the United States of America and other countries under similar climatic conditions [24, p. 10]. Most important changes in the agriculture of West Pakistan can, therefore, be expected from the use of additional irrigation water on the presently cultivated areas.

There are two sources of additional water supply. One is the main river and tributary storage of water, more than 60 million acrefeet of which now passes unused into the Arabian Sea during periods of high run-off and which can be stored for regulated use throughout the year. The other source is the groundwater. The possibilities of the development and use of additional surface supplies are being investigated by the West Pakistan Water and Power Development Authority (WPWAPDA) with the help of the International Bank for Reconstruction and Development and will not be considered here. This section is devoted to the role of tubewell irrigation in the development of agriculture.

Government Tubewells

Underneath the plains of the former Punjab and Bahawalpur lies a vast reservoir of water which can be used to supply large quantities of water by tubewell pumping. In order to make use of this reservoir, installation of tubewells was started on a small scale in the Punjab in 1938 when 20 tubewells were installed in the Shalimar Gardens. After that about 1,500 tubewells were installed in the Rechna and Chaj *Doabs* between 1944 and 1953 and began working in 1954. It was noticed that within a period of 5 to 10 years of the installation of tubewells their discharge declined from an average of 2 cusecs to 1.4 cusecs. Some of these tubewells had to be closed after 8 years' working due to uneconomic yields. In order to determine the causes of decline in the discharge, the strainers of some of the tubewells were recovered and it was found that a thin layer of incrustation on the inside of the strainer had completely blocked the strainer slits [22, Pp. 207-209].

The West Pakistan Water and Power Development Authority prepared in 1961 a masterplan for the control of waterlogging and salinity in West Pakistan by the installation of 31,000 tubewells, 7,500 miles of major drains and 25,000 miles of supplemental drains at a total cost of Rs. 590 crore [43]. In the *Revelle Report*, the total cost for land and water development in the Indus Basin is estimated at $ 2.3 billion or Rs. 11,000 million [34, p. 165]. This includes cost of fertilizer, plant protection and improved seeds. If these are excluded, the cost would be $ 1.8 billion or Rs. 8,600 million [34].

Under the WAPDA masterplan, 1,800 tubewells have been installed in Salinity Control and Reclamation Project Number One (SCARP 1) in the Rechna *Doab*. Another project for the installation of 3,300 tubewells in Salinity Control and Reclamation Project Number Two (SCARP 2) in the Chaj *Doab* has been sanctioned at an estimated cost of Rs. 300 million.

The average cost of the tubewells in SCARP 1 and SCARP 2 is estimated at Rs. 83,000 [45, p. 35] and Rs. 116,000 [42, Appendix G] per tubewell respectively. In SCARP 3, it is proposed to install 1,550 tubewells at a total

cost of Rs. 220 million [41, p. 48]. The average cost of these would, thus, be about Rs. 142,000 per well.

Working of tubewells in SCARP 1 commenced in 1960/61. By September 1963, the watertable had been lowered by about 7 feet [44, p. 6] and the total area cropped had increased by 250,000 acres or about 25 per cent over the pre-operation periods [44, p. 8]. The value of crops was estimated to have increased by 40 per cent [17, p. 47].

Private Tubewells

The farmers of the Punjab, with the help of the Department of Agriculture and private drilling concerns, have installed some 10,000 tubewells with their own funds. The Department of Agriculture started drilling in 1950/51 when 63 tubewells were installed. Tubewells of various sizes have been installed but tubewells of 1 to 1.5-cusec capacity are the most popular. The Department undertake the drilling of bore-holes and installation of pipes and strainers. The remaining work, supply and installation of pump and engine and the construction of the pumphouse, *etc.*, is done by the farmers themselves. Pipes and strainers may be purchased by the farmers from the Department of Agriculture or from the local market.

The Agricultural Engineer, Lyallpur, has installed about 5,000 tubewells during the last 13 years. In addition, the Department of Agriculture have 6 other Agricultural Engineers located at Peshawar, D. I. Khan, Khanpur, Quetta, Khairpur and Hyderabad. These Agricultural Engineers have taken up installation of tubewells for the farmers in recent years. The Department of Agriculture have 150 drilling rigs and plan to have 163 more rigs [31, p. 80]. Their capacity will increase from the existing level of 1,400 tubewells to about 3,000 tubewells within one year[5].

In addition, a number of private firms are engaged in the installation of tubewells. Unfortunately, no statistics on tubewells installed by these firms are available. On the basis of enquiries made in the villages, it seems that these firms are installing at least as many tubewells in a year as the Department of Agriculture. The total number of tubewells installed by the farmers must have exceeded 10,000 by now and the number installed would now be about 3,000 a year. The rate of installation is increasing year by year and could reach 5,000 to 6,000 tubewells a year in the next few years.

The cost of installation of a tubewell of one-cusec discharge with a 10-inch boring rig and 6-inch brass strainer with watertable at 20-foot depth

[5]One drilling rig generally installs one tubewell in a month.

is estimated by the Department of Agriculture at Rs. 14,000 [21, p.18]. Farmers generally spend much less. They use a coir strainer which costs only Rs. 6 per foot for a 6-inch size instead of brass strainer which now costs about Rs. 30 per foot. They use their own labour and, thus, reduce these charges. They spend only a few hundred rupees on the pumphouse instead of Rs. 2,800 estimated by the Department of Agriculture.

The Pakistan Institute of Development Economics has carried out a survey of 32 private tubewells located in different districts of the Punjab[6]. Thirty of these tubewells had coir strainers and the average cost of installation of these was Rs. 8,300 per well (Rs. 9,600 for diesel-driven well and Rs. 7,800 for electric-driven well). These tubewells have about 80 feet of blind pipe and about 90 feet of strainer. They are fitted with an engine or motor of about 18-20 horsepower. Average discharge for all tubewells was 1.25 cusecs. A majority of the tubewells, 26 out of 32, had a discharge between 1 and 1.5 cusecs. They worked about 3,000 hours in a year and pumped about 300 acrefeet of water per well. About 20 per cent of the water was sold to the neighbouring cultivators by the owners.

One holding on each of the 32 tubewells was selected and cropping of these holdings noted. Before the installation of tubewells, these holdings had 84 per cent intensity of cropping which was increased to 134 per cent after the tubewells were installed[7]. Increase in the area cropped was thus 60 per cent over the pre-tubewell period. Fertilizer consumption increased fifteen-fold and the total value of crops increased by more than 100 per cent after the installation of tubewells[8].

Comparison of Government and Private Tubewells

It is a common knowledge that the work done by the Public Works Departments costs much more money than similar work done by private citizens for their own use. This observation is borne out when private tubewells are compared with government tubewells on the basis of equivalent discharges. The cost of government tubewells installed or proposed to be

[6]Fieldwork for this survey was done by Mr. Mohammad Ghaffar, a Research Assistant in the Institute, to whom the author is grateful.

[7]The term "intensity of cropping" is used to denote the areas of land cropped in a given year as a percentage of the cultivated land that could be cropped in one year. If the land is completely sown to crops, both summer and winter, there is 200 per cent intensity.

[8]This is confirmed by the records of yield obtained at the Agricultural Experiment Station, Montgomery, where a tubewell was installed in 1962/63 and yields in one year increased by 30 to 60 per cent over the previous 4 years. This information was supplied to the author in March 1964 by the Manager, Agricultural Experiment Station, Montgomery.

installed in various SCARP areas and the cost of private tubewells is given in Appendix Table B-1, and is summarized below in Table III:

TABLE III

COMPARATIVE COST OF GOVERNMENT AND PRIVATE TUBEWELLS

Item of cost	SCARP-1 tubewells of 3.0 cusecs	SCARP-2 tubewells of 3.55 cusecs	SCARP-3 tubewells of 3.9 cusecs	Private tubewells of 1.25 cusecs
(1)	(2)	(3)	(4)	(5)
	(.............	*rupees*	....	)
1) Cost of installation of tubewell	51,400	54,300	79,700	7,800
2) Cost of drains for removal of saline water	—	20,000	12,300	—
3) Total cost of tubewell (Rows 1 and 2)	51,400	74,300	92,000	7,800
4) Cost of electric-transmission facilities	32,100	41,500	49,800	?
5) Total cost of tubewell inclusive of electric-transmission facilities (Rows 3 and 4)	83,500	115,800	141,800	?
	Apportioned cost for 1.25 cusecs			
6) 1.25-cusec tubewell *without* electric-transmission facilities	21,400	26,200	29,500	7,800
7) Foreign-exchange component of Row 6	13,200	13,500	15,300	?

Source: Appendix Table B-1.

The total cost of government tubewells is 3 to 4 times the cost of private tubewells and has continued to increase over time. In SCARP 1, the cost of a tubewell without electric-transmission facilities was Rs. 21,400 for a discharge of 1.25 cusecs, which was 2.7 times the cost of a private tubewell of the same discharge. In SCARP 2, the cost for the same discharge increased to 3.4 times the cost of private tubewell, whereas in SCARP 3 the cost is estimated to be 3.8 times that of the private tubewell.

On the other hand, private manufacturers are trying to lower the cost of their installation so that a tubewell of 1-cusec capacity can now be installed for 5 to 6 thousand rupees, according to a survey by the Irrigation Research Institute [1, p. 5].

Foreign exchange worth Rs. 13,000 to Rs. 15,000 is required for a government tubewell of 1.25 cusecs, exclusive of electric-transmission facilities. In private tubewells, the foreign exchange required is less than one-fourth of this amount.

The cost of SCARP tubewells is high but they were expected to have a much longer life. The average life of these tubewells was estimated at 40 years by Tipton and Kalmbach [42, p. 80], 30 years in the *Revelle Report* [34, p. 326] and 20 years by Harza Engineering Company International [17, p. 49]. However, a serious problem has come to light regarding the working of SCARP-1 tubewells during the past 3 years. It has been noticed that discharge of tubewells installed in two of the 12 schemes included in SCARP 1 has already been reduced by 26 and 28 per cent respectively [34, p. 317]. Recent studies carried out by the Irrigation Research Institute, Lahore, indicate that in two more schemes in this area the discharge has been reduced by as much as 40 per cent within a period of 3 years [2]. It is, therefore, unlikely that these tubewells will last for 40, 30 or 20 years. Furthermore, according to a Chief Engineer of the Irrigation Department, the economic pumping limit of 40-foot pumping head would be reached in 10 years in these tubewells and pumping beyond that period would be uneconomical [22, p. 209].

The life of private tubewells put in by farmers with the help of Department of Agriculture and private firms is estimated at 10 years [20, p.5]. However, out of the 63 tubewells installed by the Department of Agriculture in 1950/51, 48 (75 per cent) were reported to be in working condition in the 10th year of their life and were giving a discharge of one cusec each. The life of these tubewells may, in fact, turn out to be only slightly less than those put in by the government in SCARP areas.

Working of private tubewells is likely to result in higher additional production as compared to the government tubewells. When a farmer spends Rs. 8,000 and installs a tubewell, he must make the best use of the water. On the other hand, if the government spends the money on tubewells and does not charge anything, the farmer does not have to make the same efforts. This hypothesis is confirmed from the cropping intensity achieved by the farmers of private tubewells who increased their cropping intensity by about 60 per cent after the installation of tubewells as against an increase of only 25 per cent in cropping intensity achieved in the SCARP-1 area. Due to higher yields of crops obtained, the total value of

crops increased by more than 100 per cent on the lands of 32 holdings on private tubewells as against an increase of only 40 per cent reported by Harza Engineering International for SCARP-1 area.

Cost of operation of private tubewells is less than that of the government tubewells. The Pakistan Institute of Development Economics carried out a study on cost of working of 22 electric-driven tubewells in the former Punjab in March 1964. The results, along with the estimates of diesel-driven wells, by the Superintending Engineer, Agricultural Machinery Organization, Lyallpur, are given in Appendix Table B-2. The average cost comes to about Rs. 4 per acre irrigation on private, electric-driven tubewells. This is against Rs. 5 to 6 per acre irrigation on government tubewells[9].

There is one more difference which may be of crucial importance for policy decision in the immediate future. Private tubewells are generally located in nonsaline groundwater areas. A farmer will not invest money in a tubewell from which the water cannot be used for irrigation purposes. Many of the government tubewells are installed in areas where the water is too saline to be used for irrigation. According to a report of the Soil Reclamation Board, out of 1,236 million acres of land in SCARP 1, 0.896 million acres (72 per cent) fall in the brackish water zone and the quality of subsoil water varies from "totally unfit for irrigation purposes to fit for irrigation after mixing with canal water in 1:1 ratio" [39, p.13].

A main consideration for the installation of tubewells in areas with groundwater unfit for irrigation is for lowering the watertable. However, it has been seen that the regional watertable has been lowered in the whole of SCARP-1 area even where tubewells did not start working till the beginning of 1963. Two hundred and forty-three tubewells in SCARP-1 area were commissioned between October 1962 and September 1963. Actually, 100 out of these have not been worked at all. But the regional watertable in the whole of this area has been lowered due to the working of other tubewells in the adjacent areas.

In the light of this extremely significant development, the final proposal of the *Revelle Report* that the entire aquifer of the northern plain of 30 million acres be mined and 56 per cent of the tubewells be located inside the cul-

[9]Cost of pumping water is estimated at Rs. 19 per acrefoot in [34, p. 36]. One acrefoot is equal to 4 acre irrigations. Therefore, the cost per acre irrigation is Rs. 4.75. Life of tubewells is assumed to be 30 years in [34]. If the life were assumed to be 15 years, the cost would be Rs. 6 per acre irrigation. Cost of electricity for government tubewells is charged at Re. 0.065 per kwh, whereas private tubewell-owners have to pay Re. 0.08 per kwh. If the same price were used for government tubewells, their cost would be still higher.

tivated area and 44 per cent be located outside the cultivated area, appears to be highly questionable [34, p. 322]

If canal-water seepage from 19 million acres of culturable commanded area could raise the watertable over the whole area of 30 million acres, it raises the question whether pumping of water from 19 million acres of culturable commanded area would not result in lowering the watertable over the whole area of 30 million acres. Working of SCARP-I tubewells indicates that it may do so and, therefore, it may not be necessary to install any tubewells in areas which are not to be cultivated. It should also be considered whether the government would be able to recover the very high cost involved in installing the tubewells in uncultivated areas and then transporting the water to the cultivated areas when it has not been able to recover the comparatively lower cost of operation of tubewells located inside the SCARP-I area. It seems difficult to justify the recommendation in the final *Revelle Report* on technical or economic considerations.

The total cultivated area of the Punjab and Bahawalpur, where underground water is fit for irrigation, is about 12 million acres[10]. This area would need about 60,000 tubewells of 1 to 1.5-cusec capacity if each tubewell serves about 200 acres for which irrigation water is already available. Probably 10,000 tubewells have already been installed in this area. The farmers of the Punjab and Bahawalpur are now installing about 3,000 tubewells a year in this area and could install about 5,000 to 6,000 tubewells a year during the next few years. Farmers could, therefore, install all the 50,000 tubewells in the next 10 years if the government would let them do it. They could install them in five years if the government would help them.

The most critical problem in the execution of the whole programme by the farmers themselves is likely to be the provision of electric-transmission facilities for the operation of tubewells. The West Pakistan Government should concentrate on providing electric-power facilities to this area of 12 million acres. There are probably about 12,000 villages in this area. If electric-power facilities can be provided to the whole of this area in the next 5 years and electric charges for private tubewells are reduced to the level of government tubewells, the farmers can put in all the 50,000 tubewells during the third-plan period without any cost being incurred by the government on the installation of tubewells.

Another problem likely to arise in the execution of the programme at a fast rate is the availability of blind pipes for the tubewells. These are now being imported and sold by the Department of Agriculture at Rs. 10 per foot.

[10]Estimates made on the basis of [23, Table 1, Pp. 146-147].

The market rate for these is about Rs. 18 per foot. Average length of blind pipe in a tubewell is about 100 feet which would cost about Rs. 1,000. For 50,000 tubewells, the cost would be Rs. 50 million. If blind pipes can be produced in the country, or imported under commodity aid, or if the Department of Agriculture were allocated foreign exchange at the rate of about Rs. 10 million a year for the import of blind pipe and its sale to the farmers, all the 50,000 tubewells could be installed within 5 years.

A third problem would be provision of medium- and long-term credit for the farmers. Out of 32 private tubewells studied by this Institute, only 6 had been installed with funds borrowed from Agricultural Development Bank or other sources. The average amount of loan taken was Rs. 7,500 for these 6 tubewells. For all the 32 tubewells, this gives an average of Rs. 1,400 per tubewell. The farmers are likely to save and invest a major part of the Rs. 400 million required. However, most of the additional tubewells will be installed by the farmers of small means. Therefore, considerable credit will have to be made available.

In order to maximize the pumping of water from private tubewells, charges for electricity should be reduced from the present level of Re. 0.08 per kwh to Re. 0.05 per kwh proposed for the government tubewells in the *Revelle Report* [34]. It may be desirable even to reduce them still further to Re. 0.04 per kwh and subsidize the use of electricity for pumping of water from tubewells to expand the installation programme at a fast rate. Recovery of canal-water rates on the basis of volume of water delivered rather than on the basis of area of crops irrigated will further encourage the installation of tubewells.

In Sind, probably one million acres or more could be developed by similar tubewells[11]. About 5,000 tubewells in all would be required for this purpose. Out of this, the farmers have put in about 1,000 tubewells. Rate of installation of tubewells by the farmers with the help of the Department of Agriculture is about 200 tubewells a year.

The above programme of private tubewells by the farmers would cover about 13 million acres. The groundwaters in the remaining areas are saline. The *Revelle Report* proposes that tubewells should be put in the whole of this area, and that two-thirds of the saline water be used on crops and one-third be exported. Bower and Maasland studied the waters of tubewells in SCARP-I area and found that 39 per cent of these were hazardous because

[11]The *Revelle Report* estimates the total area underlain by good-quality water as 2.5 million acres, out of which 1.3 million acres lie within the bunds of the Indus River [34, p.284]. The actual culturable commanded area fit for tubewells is, thus, only 1.2 million acres.

of the high sodium and carbonate content of the water [3, Pp. 49-61]. They concluded that the sodium hazards of the Punjab groundwaters need further study. It would, therefore, be desirable not to put any tubewells in the saline groundwater areas until the effect of pumping of saline waters on soils in SCARP-I area has been further investigated. For these areas, tiled field drains, combined with open collector drains, may prove to be better than tubewells [24, Pp. 17-23]. Some additional canal-water supplies can be arranged for these areas by enlarging the capacity of canals to use the summer flood-water discharges which now go unused to the sea.

Prospects

A comparative study of the government tubewells installed in the Rechna and Chaj *Doabs* (particularly in SCARP areas) and some tubewells installed by the farmers with the help of the Department of Agriculture and private firms indicates that the cost of installation of private tubewells is only about one-third of the cost of government tubewells when both are measured on the basis of equal discharges. Yet, the increase in agricultural production is far higher in the case of private tubewells than in the case of government tubewells. From an economic point of view, tubewells should, therefore, be installed by the farmers and not by the government.

There are some 12 million acres of cultivated land in the Punjab and Bahawalpur and one million acres in Sind where the groundwaters are fit for irrigation when mixed with canal waters. These areas would need about 55,000 additional tubewells of the type already installed by the farmers. If the government devotes its whole effort on the provision of electric-transmission facilities to this area, the farmers can install all the tubewells without any cost to the government. The increase in agricultural production may be expected to be more than 100 per cent in these 13 million acres. The value of agricultural production in these areas is more than 40 per cent of the total agricultural production of West Pakistan[12]. Installation of tubewells in these areas could raise the value of total agricultural production by over 40 per cent in the whole of West Pakistan. This may take about 10 years if the farmers are left to their own resources or could be done in 5 years if government concentrates on supplying cheap electricity to this area and the farmers are encouraged to install tubewells by making blind pipes available and by providing greater credit facilities.

It may be preferable not to disperse the efforts and to leave out the remaining 8 million acres of culturable commanded area in the Punjab and

[12]Calculated from the *Revelle Report* [34, Tables 1.7 through 1.11.2, Pp. 75-82].

Bahawalpur and 11 million acres in Sind for the present. Experimental work on alternative methods of development of this area should, however, continue during the third-plan period.

B. EAST PAKISTAN

East Pakistan is characterised by heavy rainfall accompanied by high floods from the rivers in summer followed by a long period of drought in the winter. Agricultural practices have adjusted themselves over the centuries to the rhythm of the monsoon. One typical practice is to start an early *aus* paddy crop with the first pre-monsoon showers in March or April to harvest the *aus* paddy in July and to follow immediately with a transplanted *aman* paddy crop which is harvested in December. In small areas, a third winter crop is also obtained. But major part of the area grows only one crop a year. Paradoxically, floods and drought are the main causes of crop failures and low productivity in East Pakistan.

Extensive areas of the province are inundated due to high flood levels of rivers and by abnormal rainfall or by both factors combined together. On the one hand, the early-sown *aus* crop generally suffers from drought before the monsoon sets in. On the other hand, late-sown *aus* usually suffers because the young plants cannot stand the submerged conditions caused by early floods. Rainfall varies from 50 inches in the western part to about 250 inches in the north-eastern part of the province. Prolonged breaks in the monsoon may occur during July and August when the young *aman* crop needs water the most. Also the monsoon may terminate early and drought may often prevent the full maturing of grain and greatly reduce the yield of *aman*. Sometimes flood waters drown young *aman* seedlings. In some years, the flood rises so fast that even deep-water *aman* paddy cannot keep its head above water. During the *rabi*[13] season much of the area remains unsown for lack of moisture. Crops that are sown give very poor yields due to lack of water.

Irrigation, flood control and drainage can provide the solution to the prevention of crop failures. Provision of assured water supply would also provide favourable conditions for extensive use of fertilizers and high yields of crops. It would enable large increase in crop acreage and production in the *rabi* season. According to Teensma, yields of most crops, *kharif*[14] as well as *rabi*, could be increased by 200 per cent if irrigation water and fertilizer use were accompanied by good farm-management practices [32].

[13]*Rabi* means spring. It refers to winter crops which are harvested in spring.

[14]*Kharif* means autumn. It refers to summer crops which are harvested in autumn.

The climate of East Pakistan is suitable for growing 3 crops a year. However, out of 21.6 million acres under cultivation, actual area under crops in 1962/63 was 15.1 million acres in the *aus* season, 16.6 million acres in the *aman* season and 5.1 million acres in the *rabi* season[15]. If floods could be controlled and irrigation facilities provided, the area under crops could be increased by 6.5 million acres in the *aus* season, 5.0 million acres in the *aman* season and 16.7 million acres in the *rabi* season. It should, therefore, be possible to increase the gross area under crops by 28.2 million acres.

Extensive areas in East Pakistan comprising some 8 to 9 million acres are deeply inundated during the monsoon. A general survey of the possibilities of irrigation made by Dr. W. J. Van Blommestein of Food and Agriculture Organization of the United Nations in 1952 indicated that out of 22 million acres under cultivation, 13 million acres are not subject to inundation or are only inundated in part [35]. In Dr. Blommestein's judgement, these 13 million acres could be irrigated by canal system fed by pumping stations or by barrages. However, the Food and Agriculture Organization consider that the whole 13 million acres could be assured of freedom from inundation only with a very complete system of flood control. Where seasonal inundation cannot be avoided, a system of irrigation based on canals is impossible [9, p. 65].

The question of flood control is being studied by the East Pakistan Water and Power Development Authority (EPWAPDA) and is outside the scope of this paper. However, as was pointed out by the 1957 United Nations Technical Mission to Pakistan, the problem of controlling floods in East Pakistan is exceedingly difficult and costly and it will take many years and resolute efforts to plan and implement the major flood-control programme [33]. The International Bank for Reconstruction and Development have now undertaken to form a high-level study group to consider all aspects of the problem and to recommend future development alternatives [19, p. 63].

In the following pages an attempt is made to see what water development projects can proceed in the mean time without very heavy cost involved in relation to the benefits expected. Four major irrigation projects are now under execution in East Pakistan: *i*) canal irrigation in the Ganges-Kobadak area; *ii*) government tubewells in the North-Bengal area; *iii*) low-lift power-pump irrigation in the Dacca-Mymensingh-Sylhet depression; and *iv*) small

15In the above calculations, 6.1 million acres under broadcast *aman*, which is sown in April and harvested in December, are counted both in the *aus* season and *aman* season. Similarly, whole of the jute is counted in the *aus* season and part (which is harvested late) in the *aman* season. Sugarcane, fruits, betelnuts and tea, which occupy the land for the whole year, are counted in all the three seasons.

tubewells in the Comilla area. These schemes and other irrigation development projects in East Pakistan are being studied by the Pakistan Institute of Development Economics. However, a number of tentative conclusions can be drawn which would be of help in the preparation of the Third Plan.

i) *Ganges-Kobadak Project:* The Ganges-Kobadak Project provides for pumping of water for irrigation of land in the Kushtia and Jessore districts through a network of canals. The pumphouse is located in a favourable position below the Harding Bridge, even then considerable difficulty has been experienced in keeping the intake channel clear. Working of the canal in the first season has caused considerable waterlogging because of excessive seepage from canal-distribution system.

The actual area to be irrigated by canals in Phase I of Kushtia unit of the Project is only 57 per cent of the gross area. This low percentage follows from the irregular relief of land. Being a deltaic region formed by deposits from the Ganges, the land surface of the Kushtia unit has quite a pronounced microrelief with considerable differences in elevation over short distances. While on the one hand, this facilitates surface irrigation and drainage, on the other it requires a very irregular pattern of canals and drains and some of the areas cannot be commanded by a canal-distribution system. The area commanded by canals in Kushtia unit has been protected from floods by embankments on all sides.

The total cost of the Kushtia unit of Ganges-Kobadak Project is estimated at Rs. 200 million. The annual costs are estimated at Rs. 12 to Rs. 13 million. The Food and Agriculture Organization deputed an agricultural economist to make an economic analysis of the project. He concluded that from the point of view of overall economic feasibility, the project was only marginal [16, p.149]. From a financial point of view, he estimated that only the operation and maintenance costs were likely to be recovered in the form of water charges and other revenues and there was no likelihood of sufficient revenue to pay either the interest or amortization on capital outlay. While forwarding the agricultural economist's report to the Government of Pakistan, FAO did not agree with the conclusions drawn by the expert and stated that benefit-cost ratio would vary between 1.18 and 1.49 in contrast with the expert's conclusion that Kushtia-I unit was likely to have benefit-cost ratios ranging from 0.76 to 1.08 [16, p. xii].

In view of the high cost involved and low benefits expected from this project, it seems desirable to delay work on other surface canal irrigation works in East Pakistan till all aspects of canal irrigation have been fully investigated.

ii) Groundwater development in North Bengal: Extensive experience of pumping from tubewells in the Ganges Plain in India and tests carried out in West Bengal and East Pakistan indicate that water supply in the Ganges alluvium is abundant. The recharge of the aquifer from heavy rainfall during the monsoon is likely to meet a considerable part of the withdrawal during the rest of the year, and there is likely to be no problem of the water-tables going deep and resulting in high pumping costs.

A project for groundwater development in the North Bengal is under execution at present. This project provides for the irrigation of 91,000 acres by 380 tubewells, and in some other areas by low-lift pumps. A powerhouse has been constructed at Thakurgaon and transmission lines to wells have been laid. Tubewells were expected to commence pumping water in April 1964 when powerhouse was to be put into operation. However, till June 1964, the tubewells had not started pumping water.

The total cost of the project is Rs. 134.6 million [7]. Out of this, the cost of installation of 380 tubewells only is estimated at Rs. 45.6 million which is equal to Rs. 120,000 per tubewell. The cost of electric-transmission lines is Rs. 31.7 million which is equal to Rs. 72,000 per tubewell. Total cost of each tubewell is, thus, Rs. 192,000.

The area to be irrigated by each tubewell is 240 acres. Irrigation charges are proposed to be recovered at the rate of 68.5 per acre. Even then the working of the tubewells is proposed to be subsidized, the subsidy decreasing from Rs. 486 per acre in the first year to Rs. 25 per acre in the 7th year and Rs. 6.6 per acre thereafter. This is based on the assumption that life of tubewells will be 50 years. If a realistic life-period is adopted, the cost per acre would be much higher.

In view of the above, it would be desirable not to plan any more government tubewells in East Pakistan until the working of Dinajpur tubewells demonstrates that it is possible to recover a large part of the cost from the beneficiaries.

iii) Low-lift pump irrigation: Low-lift pump irrigation is particularly suitable for areas subject to floods and laced with channels and ponds in which pumps can be fixed for pumping water in the dry season. In these areas, construction of permanent canals and structures would be difficult. Portable units can be moved to these areas when flood waters recede and taken out of the area before next season's floods. A power-pump irrigation scheme is in operation in East Pakistan for the past many years. Under this scheme about 2,000 pumps with a total capacity of 3,500 cusecs worked during 1962/63 and irrigated 133,000 acres of *boro* paddy [4, p. 4]. For 1964/65, the target is 4,000 power pumps to irrigate 390,000 acres.

According to a survey by the East Pakistan WAPDA, quoted by the East Pakistan Agricultural Development Corporation, an area of about 4.4 million acres can be served by irrigation by such small pumps [4, Pp. 27-31]. Out of this, about 2.5 million acres lie in Mymensingh, Sylhet, Dacca and Comilla districts.

The major problem in the working of the scheme in the earlier years was lack of trained personnel to run the scheme and nonrecovery of hire charges. The training problem has partially been overcome by the East Pakistan Agricultural Development Corporation which achieved a target of 85 per cent in 1962/63 so far as the area to be irrigated was concerned. Recovery of hire charges continues to be the main problem.

The cost of these pumps varies between Rs. 7,000 to Rs. 8,500 for a pump of 2-cusec capacity, which can irrigate about 80 acres of *boro* paddy [4, p. 60]. The cost of pumping water is estimated at Rs. 43 per acre, but only Rs. 27 per acre were charged in 1961/62 and Rs. 30 per acre in 1962/63. Even then the Agricultural Development Corporation were not able to make full recoveries for the hire charges on the pumping of water. For this very reason, the government decided in 1960 that small pumps should be sold to the cultivators. The Corporation have not been able to sell many pumps so far. They now propose that in future the charges should be collected by the Revenue Department under the Public Demands Recovery Act.

It may be better to leave the power pumps to the private enterprise. Instead of the government purchasing the pumps and then trying to sell them, these should be allowed to be imported by private trade free of customs duty and the farmers should be encouraged to buy their own pumps. Sale of pumps even at a subsidized rate would be far cheaper than working of the same by the government and not realizing the working charges from the beneficiaries.

The greatest possibility for extension of low-lift pump irrigation lies in Sylhet-Mymensingh depression and in parts of Dacca, Comilla and Chittagong districts where water is available in the rivers and *khals* during the winter season. In other districts, low supply of water in the winter months is likely to limit the extension of power-pump irrigation.

iv) Small private tubewells: The largest possibility for increase in irrigation in East Pakistan in the immediate future lies in small tubewells which can be installed by the farmers themselves with some assistance from the government. These tubewells can be installed even in areas which are normally inundated to some extent.

The Pakistan Academy for Rural Development in Comilla has prepared a plan to sink 200 tubewells of 6-inch diameter at an estimated cost of Rs. 15,000 each [26, Pp. 70–71]. Eleven of these tubewells were installed in the Comilla Kotwali Thana by January 1964. Working of these tubewells was passed on to the village cooperatives organized by the Academy and all these tubewells were put to use immediately on installation. The average discharge of the tubewells is 1.5 cusecs. The Academy considers that each tubewell will irrigate about 60 acres, but the farmers believe that they can cover as much as 100 acres on each tubewell. Even those tubewells put in at the end of January started irrigation and a late *boro* (*saita*) rice crop was sown. So far no recovery has been made but the farmers have agreed to pay the full cost of the tubewells and to work the tubewells themselves at their own cost.

Comparison of Government and Private Tubewells

A statement showing the comparative cost of a government tubewell of 4.0-cusec capacity installed in the Dinajpur area and that of a private tubewell of 1.5-cusec capacity installed in the Comilla area is given in Appendix Table B-3 and is summarized below in Table IV:

TABLE IV

COMPARATIVE COST OF GOVERNMENT AND PRIVATE TUBEWELLS

Item of cost	Dinajpur tubewell of		Private tubewell of 1.5 cusecs
	4.0 cusecs	Apportioned cost of 1.5 cusecs	
	(..................*rupees*.....................)		
Cost of tubewell	120,000	45,000	14,500
Cost of electric-transmission facilities	72,000	27,000	?
Total	**192,000**	**72,000**	?

Source: Appendix Table B-3.

Total cost of the government tubewell, exclusive of electric-transmission facilities, is more than 3 times that of the private tubewell when both are

measured on the basis of equal discharge. It would, therefore, be preferable to encourage the installation of private tubewells and not of government tubewells.

Installation of private tubewells can be rapidly expanded if 100 hand-drilling rigs are imported annually. In this way, a programme for the installation of 1,000 tubewells a year in the beginning of the third-plan period rising to about 5,000 tubewells a year by the end of the third-plan period and about 10,000 tubewells a year by the end of the fourth-plan period can be achieved. Total number of tubewells can reach about 15,000 in 5 years and about 50,000 in 10 years. The total cost for the third-plan period is likely to be about Rs. 200 million. The cost during the fourth-plan period may reach some Rs. 600 million. Critical problems likely to be faced by the farmers in this programme are:

a) Provision of construction material: Supply of blind pipes, strainers, pumps, motors and engines is likely to be one of the bottlenecks in the installation of tubewells. For rapid expansion of the programme, adequate arrangements should be made for these items.

b) Supply of electric power or diesel oil to run the tubewells: In order to make the best use of existing resources, these tubewells could be first installed along the existing or planned electric-transmission lines. In areas where electric power is not available, provision of diesel oil is likely to be a bottleneck. Arrangements should be made for supply of diesel oil in all such areas.

c) Credit availability: Credit facilities on a scale somewhat larger than that in West Pakistan would be required by the farmers in all areas where tubewells are installed.

It should be possible to cover about 200 acres per tubewell when diversified cropping is adopted. Total area annually irrigated from tubewells would, thus, be about 3 million acres by the end of the third-plan period and about 10 million acres by the end of the fourth-plan period. Including low-lift pump irrigation, the total area would be 4 million acres by the end of the third-plan period and 12 million acres by the end of the fourth-plan period.

Drainage

Removal of excess water by drainage is as important as provision of irrigation water in the time of failure of rainfall in East Pakistan. While the major flood-control and drainage programmes of WAPDA will take time, localized drainage congestion can be improved by digging small drains under the Works Programme which has been underway in East Pakistan during the last 2 years. It already may have had a marked influence on raising the rice yields in 1963/64 season [15]. Digging of drains under the Works Programme should, therefore, be intensified.

Extensive use of fertilizer, small tubewells installed by the farmers, and small drains excavated under the Works Programme may provide an answer to East Pakistan's major agricultural problems of low productivity.

Prospects

Floods and droughts are the principal causes of low crop-production in East Pakistan. However, control of flood in East Pakistan is likely to be exceedingly difficult and costly. It will take many years of resolute efforts to plan and implement major flood-control programmes.

Our examination of the present irrigation projects in East Pakistan indicates that construction of canals will need flood-protection measures in a large part of East Pakistan. Water will have to be pumped from the rivers, only a part of the cultivated area will be commanded by surface canals, and cost of irrigation will be extremely high. Major canal-irrigation projects now planned should, therefore, be held in abeyance until the economics of alternative development programmes have been investigated. Similarly, tubewells installed by the government along the lines of the Dinajpur tubewells are likely to be too costly for farmers to pay the full working cost. On the other hand, low-lift power pumps and small tubewells installed by the farmers with some assistance provided by the government are likely to prove very profitable. Possibility for expansion of low-lift pump irrigation is likely to be limited to Sylhet-Mymensingh depression and Dacca, Comilla and Chittagong districts where perennial water supply is available for winter irrigation. Small tubewells can be installed in almost all areas of East Pakistan. Installation of these tubewells could expand as rapidly in East Pakistan in the next few years as it has in West Pakistan in the past few years. A programme for the installation of 1,000 tubewells a year can be initiated immediately if 100 drilling rigs along with blind pipes, pumps, motors and engines are imported. This programme can be expanded fast enough to cover a major part of the province within the next 10 years. These tubewells can be installed even in areas which are normally inundated to some extent without execution of any flood-control measures.

IV. CONCLUDING REMARKS

We have shown in this paper that the problem of low agricultural productivity in large areas of Pakistan can be solved, to a large extent, by concentrating on two vital sectors, namely, fertilizer and water. This may appear out of line with current thinking on the subject which puts great stress on building up a large and efficient extension service and on providing all factors of production such as seeds of improved varieties, fertilizer, plant-protection equipment and chemicals, improved implements and credit in a "package programme" as recommended by the Food and Agriculture Commission. It may also appear opposed to the proposals for concentrating all the production factors along with a large extension and other staff from all development departments on "project areas" as recommended by the *Revelle Report* or in "selected districts" under the "crash programme" or "model scheme".

It is important that we are not misunderstood at this point. The long-run need of an efficient extension service and of other factors of production is not denied. What is, however, contended is that a very large increase in agricultural production can be brought about with the existing extension services and without making large provision for other complementary factors. Given cheap fertilizer and adequate water supply, farmers in substantial parts of Pakistan are likely to bring about very large increases, probably more than 100 per cent, in agricultural production within a few years with only moderate provision for other factors of production.

In other words, we stress that though all factors are important, priorities still do exist. Time in Pakistan is important and we must take advantage of those factors and those areas where a quick response to key inputs may be expected. Those do not have to be limited to specific project-areas of a million acres or so but can be extended rapidly over a very large part of the country.

If adequate number of demonstration trials are laid out in each Union by training the existing extension staff, the rate of increase of fertilizer consumption will mainly depend upon the profitability of its use and, therefore, the cheapest and the best combination of fertilizers should be made available. If price of fertilizer is high, no extension service can succeed in bringing about a large increase in fertilizer use by the farmers. If the price is low and adequate incentives for distribution are established, the initiative of farmers themselves may be relied upon to bring about substantial increases in consumption with the help of existing extension services.

Similarly, expansion of water use by the farmers will depend upon its profitability. If a tubewell costs Rs. 90,000 (as in SCARP 3) or Rs. 120,000 (as in North Bengal) exclusive of electric-transmission facilities and the annual cost of water comes to Rs. 68.5 per acre, the farmers are not likely to pay and expand the use of such water, no matter how efficient the extension service is. If, on the other hand, cheap tubewells costing Rs. 10,000 each or less are installed and the government can provide cheap electricity to the farmers to run the tubewells, there will be a rapid expansion in the installation of tube-wells and in the use of water.

The present varieties of crops, particularly of rice and wheat, would need replacement with stiff-strawed varieties which can stand high doses of fertilizers and water. Research work in Pakistan should be geared to that end. Whenever seed of such a variety becomes available it will be rapidly taken up by the farmers. The present varieties of crops can, however, use 800,000 tons of nitrogen, phosphorus and potash a year without any difficulty.

As incomes of the farmers increase by the use of fertilizer and water, they will begin to use larger quantities of all other inputs like pesticide and chemicals, better equipment and machinery. Larger areas would be devoted to fruits, vegetables, legumes, fodders and green-manure crops and complex rotations will be followed. A more elaborate extension service would then be needed. But for the present, let us concentrate on providing cheap fertilizer and cheap water to the farmers.

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Appendix A

TABLE A-1

RELATIONSHIP BETWEEN THE PRICE OF NITROGEN, WHEAT AND PADDY IN JAPAN AND PAKISTAN

	Japan	Pakistan
	(dollars per 100 kilogram)	
Nitrogen and wheat		
Price paid by the farmers for nitrogen	26.8[a]	15.8[d]
Price received by the farmers for wheat	11.1[b]	6.2[e]
Ratio between price of nitrogen and wheat	2.4	2.5
Nitrogen and paddy		
Price paid by the farmers for nitrogen	26.8[a]	12.4[f]
Price received by the farmers for paddy	20.4[c]	7.1[g]
Ratio between price of nitrogen and paddy	1.3	1.7

[a]From [11, Table XXVIII].

[b]From [13, Table 126].

[c]From [13, Table 133].

[d]On the basis of actual sale price of ammonium sulphate of Rs. 8.00 per bag of 112 pounds fixed in West Pakistan in January 1964.

[e]On the basis of actual wholesale price of wheat of Rs. 13.75 per maund of 82.3 pound prevailing in Multan market during 8 weeks between May 18 and June 6, 1963. Deduction of 20 per cent made to get the harvest price of Rs. 11.0 per maund. (*Source:* [25, May, June and July 1963]).

[f]On the basis of actual sale rate of Rs. 10.12 per maund (82.3 pounds) of urea in East Pakistan.

[g]On the basis of wholesale price of Rs. 15.81 per maund of paddy in 48 markets of East Pakistan during the first 8 weeks of 1964, published in the *Weekly Price Bulletin* [38]. Deduction of 20 per cent made to arrive at the price received by the farmers.

Appendix B

TABLE B-1

COMPARATIVE COST OF GOVERNMENT AND PRIVATE TUBEWELLS IN THE PUNJAB

Item	SCARP-1 tubewell of 3.0 cusecs	SCARP-2 tubewell of 3.55 cusecs	SCARP-3 tubewell		Private tubewell of 1.25 cusecs
			3.9 cusecs	Apportioned cost for 1.25 cusecs	
	(1)	(2)	(3)	(4)	(5)
	(……………*in rupees*……………)				
1) Tubewell					
i) Drilling	?	9,840	10,450	3,350	660
ii) Electric log	?	560	560	180	—
iii) Housing casing or pipe	?	2,440	2,310	740	1,080
iv) Strainer	?	5,350[a]	7,360[a]	2,360[a]	590
v) Gravel shrouding	?	3,220	3,450	1,110	—
vi) Developing and testing	?	2,630	2,630	840	—
vii) Concrete base and slab	?	640	640	200	—
viii) Pump, motor and controls	?	14,470	14,010	4,490	3,680
ix) Installation of pump and motors	?	1,550	1,550	500	270
x) Pumphouse and operators' quarter	?	2,500	4,240	1,360	1,060
xi) Water distribution system and land	?	2,000	3,140	1,000	—
xii) Spare parts and other items	?	?	1,560	500	460
Total tubewell	40,400	45,200	51,900	16,630	7,800
2) Investigation, planning and project preparation	?	260	4,200	1,350	—
3) Construction, operation, maintenance equipment and facilities	8,930	?	3,760	1,200	—
4) Administration, engineering and supervision	2,030	6,380	6,960	2,230	—
5) Contingencies	?	2,420	6,260	2,010	—
6) Interest during construction	?	?	6,640	2,130	—
Total: Rows 1 to 6	51,360	54,260	79,720	25,550	7,800
7) Drainage works for removal of saline water	—	19,980	12,250	3,930	—
Total: Rows 1 to 7	51,360	74,240	91,970	29,480	7,800
8) Electric-transmission facilities	32,100	41,520	49,810	15,960	?
Grand total: Rows 1 to 8	**83,460**	**115,760**	**141,780**	**45,440**	?

[a]Includes some blind pipe.

Sources: Col. (1): Calculated from [45, Table 2, p. 35].
Col. (2): Calculated from [42, Appendix G, Pp. G.1-G.12].
Col. (3): Calculated from [41, Tables E-2 to E-6, Pp. E-3 to E-5].
Col. (4): Calculated from Col. (3) by dividing each figure by 3.12.
Col. (5): Calculated from data collected from 22 private tubewells in the Punjab.

TABLE B-2

COST OF IRRIGATION FROM PRIVATE TUBEWELLS IN THE PUNJAB

Item	Cost of a diesel-engine tubewell of 1-cusec capacity	Cost of an electric-driven tubewell of 1.25-cusec capacity
	(1)	(2)
	(….*in rupees per day*….)	
1) Interest on capital at 4 per cent	2.12	1.12
2) Depreciation at 10 per cent	5.25	2.84
3) Oil or electric consumption		
i) Diesel oil at Rs. 1.50 per gallon and mobile oil at Rs. 6.00 per gallon	7.19	—
ii) Electricity at Re. 0.08 per unit	—	8.81
4) Pay of driver	3.25	2.25
Total:	17.81	15.02
5) Area irrigated in 8 hours (*acres*)	3	3.75
6) Cost per acre (*rupees*)	5.94	4.00
7) Cost of irrigation per hour (*rupees*)	2.25	1.88

Sources: Col. (1): Cost of working of diesel-engine tubewells, taken from [21, p. 13].
Col. (2): For electric-driven tubewells, estimates prepared by the author on the basis of data collected on the working of 22 tubewells costing Rs. 7,800 each.

Note: The above estimate of cost for diesel tubewells is based on the assumption that tubewell works for 2,200 hours annually (275 days), and diesel oil costs Rs. 1.50 per gallon. The price of diesel oil has increased in recent years. The cost of oil consumption would, therefore, be higher than shown above.

TABLE B-3

COMPARATIVE COST OF GOVERNMENT AND PRIVATE TUBEWELLS IN EAST PAKISTAN

Item of cost	Government tubewells of 4.0-cusec capacity	Apportioned cost for 1.5 cusecs	Private tubewells of 1.5 cusecs
	(...........	*rupees*	)
Field cost			
1) Loading and transport of plant and materials	2,920	1,100	
2) Construction of tubewells	27,520	10,320	6,740
3) Developing and testing	1,860	700	
4) Pump, motors and accessories	13,650	5,120	4,780
5) Pumphouse and pumps	6,670	2,500	1,730
6) Distribution channels	20,000	7,500	—
7) Operators' quarters	2,520	940	—
8) Field headquarters	4,470	1,680	—
9) Transport	640	240	—
10) *Subtotal: Rows 1-9*	80,250	30,100	13,250
11) Contingencies	4,010	1,500	—
12) *Subtotal: field cost, Rows 10-11*	84,260	31,600	13,250
13) Customs duty and sales tax	7,880	2,950	—
14) Engineering and investigation	8,820	3,310	—
15) Establishment	2,530	950	—
16) *Subtotal: Rows 12-15*	103,490	38,810	13,250
17) Land	3,000	1,120	—
18) *Subtotal: Rows 16-17*	106,490	39,930	13,250
19) Overhead	5,320	2,000	1,290
20) Interest during construction	8,260	3,100	?
21) *Total tubewell: Rows 18-20*	120,070	45,030	14,540
22) Electric-transmission lines	72,090	27,030	?
Grand total: Rows 21 and 22	**192,160**	**72,060**	?

Sources: i) Government tubewells: PCI Form in [7, Pp. 7-10].
ii) Private tubewells: [26, Pp. 70-71].

Appendix C

KINDS OF FERTILIZERS SUITED TO PAKISTAN

Urea

The only raw material required for the production of urea is natural gas. Its cost of production per unit of nitrogen is the lowest of all nitrogenous fertilizers[1]. It contains 46 per cent nitrogen, the highest of all fertilizer, and has an advantage of substantial saving in the cost of bagging, handling and transportation per unit of nitrogen compared to other fertilizers. For these reasons, urea is gaining an important position in nitrogen-fertilizer industry in all countries, particularly where sulphur is scarce. In comparative trials in East Pakistan, it has been found to be slightly superior or equal to ammonium sulphate as a source of nitrogen. Although such trials have not been conducted in West Pakistan, it is likely to be as good a source of nitrogen as any other fertilizer. It should, therefore, be the principal nitrogenous fertilizer to be produced in both provinces.

Ammonium Sulphate Nitrate

Ammonium sulphate nitrate contains 26 per cent nitrogen, of which 1/4 is nitrate nitrogen and 3/4 ammonia nitrogen. In experiments carried out in West Pakistan, ammonium sulphate nitrate has given considerably higher yields than ammonium sulphate. Ammonium sulphate nitrate has not yet been compared against urea. If it shows better results than urea, a plant to produce ammonium sulphate nitrate from gypsum may be located in the salt-range area. But there is no justification in producing ammonium sulphate nitrate and ammonium sulphate at Karachi and Mari with costly imported raw material as recommended by Imhausen [18, Pp. 164-168].

Compound Fertilizers

Imhausen recommend production of one million tons of compound fertilizer as a source of nitrogen and phosphoric acid for West Pakistan [18]. The main advantage of compound fertilizer is the saving in the labour cost in the application of fertilizer to the crops. This is not a problem in Pakistan. The main drawback of compound fertilizers is that these can be produced only with imported rock phosphate, imported sulphur and ammonia produced from natural gas. The cost of production per unit

[1]Cost of production per ton of nitrogen is estimated at $162 for urea, $172 for calcium ammonium nitrate, $183 to 187 for ammonium sulphate and $190 for compound fertilizer. *See* [18, Pp. 104-109].

of nitrogen and phosphoric acid in compound fertilizer is higher than single fertilizers, and foreign exchange will be required year after year for the import of raw materials. Another drawback of compound fertilizers is that farmers have no way of prejudging the quality of plant nutrients in relation to the specific needs of crops and soils. Thus, too little of some nutrients and too much of others is applied and the total cost of fertilizer to the farmer becomes high. In West Pakistan even the Department of Agriculture does not yet know where and in what combinations nitrogen and phosphates are necessary. Therefore, until appropriate experimentation under a variety of soil and climatic conditions throughout the province has been done, the production of compound fertilizers would seem to be premature.

Rock Phosphate

Rock phosphate can be used in place of triple superphosphate for the wet paddy crop on the acid soils of East Pakistan. Ordinarily, the effect of rock phosphate is not very spectacular in the first year, but benefits become evident in later years. Therefore, a higher dose is used in the first year to get good results. However, it has been observed in India, the United Kingdom and the Soviet Republics that the application of rock phosphate gives results equivalent to manufactured phosphate under certain conditions [10, p. 77]. In the wet regions of the United Kingdom, spectacular results have been obtained on acid soils in the first year by the use of North-African phosphate rock on turnips. In many instances the increases in yield were almost identical with those obtained from dressings of superphosphate containing an equal amount of phosphorus. Similarly, on some acid soils in India, phosphate rock and bone meal have proved to be even better than superphosphate for wet paddy. It is, therefore, very probable that on wet paddy crop grown on the acid soils of East Pakistan, rock phosphate will prove as effective as triple superphosphate over a number of years. Since it costs only one-third as much as triple superphosphate in foreign exchange, the best policy would be to import the rock phosphate, grind it finely, and supply it to the farmers. It can be sold very cheaply and is likely to boost the sale of all fertilizers.

Single Superphosphate

For West Pakistan, single superphosphate is likely to be better than triple superphosphate. Its cost of production per unit of P_2O_5 is lower than triple superphosphate and it contains more than 50 per cent calcium sulphate, which is likely to be of great value for crops on the irrigated areas of West Pakistan. Insufficient calcium is considered to be one of the major causes of low yields in the irrigated areas of West Pakistan [8]. Application of calcium sulphate or gypsum should, therefore, increase crop yields in West Pakistan. It was recommended in 1953 by FAO that gypsum should be supplied to farmers for use on the most productive and well-drained soils all over West Pakistan. Unfortunately, no action has been taken on this by the West Pakistan Government. Application of single superphosphate would provide one way of adding the much needed calcium to the soil in addition to the phosphoric acid. Single superphosphate is, therefore, likely to be much more profitable than the triple superphosphate for West Pakistan.

It may be pointed out that triple superphosphate is produced mainly in the United States where the manufacturing plants are able to use low-grade rock phosphates which have lower commercial value for the manufacture of single superphosphate. The main advantage of triple superphosphate is in saving in transport cost of the finished material. The triple superphosphate plants are usually located near the rock phosphate mines and the concentrated superphosphate can be transported long distances because of lower transport cost per unit of the phosphoric acid. The single superphosphate plants are on the other hand located in the areas where the fertilizer is to be used. The phosphate content of rock phosphate is about 33 to 37 per cent which is nearly twice that of the single superphosphate and it is, therefore, cheaper to transport the rock than the single superphosphate. The single superphosphate plants should, therefore, be located throughout the farming area of West Pakistan.

It may be mentioned that more than one-half of the phosphoric acid in the world is produced in the form of single superphosphate. The lower manufacturing cost per unit of phosphorus, the simplicity of the process, and the generally high nutrient value of the product are the principal factors that have enabled single superphosphate to maintain its superior position in the world's phosphate-fertilizer industry.

Private Tubewell Development and Cropping Patterns in West Pakistan

Ghulam Mohammad

This chapter originally appeared as an article in the Spring-1965 issue of *The Pakistan Development Review* and is the result of research carried out by the author during his association, in the capacity of a Senior Research Economist, with the Pakistan Institute of Development Economics, where he was on deputation from the Planning Commission of Pakistan from March 1963 to July 1967. In carrying out this study, the author was helped by the provincial Department of Agriculture; in particular, Mr. Mohammad Shafi Gill, Director of Agriculture, Lahore, and his District Agriculture Officers who carried out a complete enumeration of private tubewells installed in each Union in all districts in the Northern Zone of West Pakistan, without which the present study would have been impossible to carry out.

Mohammad Ghaffar, a Research Assistant in the Institute, carried the burden of interviewing tubewell and nontubewell farmers all over the former Punjab. In compilation and tabulation of data, the author was helped by Mr. Mohammad Ghaffar and Mr. N. H. Nizami.

Drs. Stephen R. Lewis Jr. and Erick Gustafson, Research Advisers at the Institute, made helpful comments on the earlier draft of the study. Mr. Carl H. Gotsch of the Harvard Advisory Group in the Planning Commission of Pakistan travelled along with the author many a time to villages and made useful suggestions for improving the work.

Mr. Ghulam Mohammad breathed his last in Rome in September 1967 while on a short-term deputation to the Food and Agriculture Organization of the United Nations.

Private Tubewell Development and Cropping Patterns in West Pakistan

Ghulam Mohammad

INTRODUCTION

One of the most significant phenomena in agricultural development in Pakistan has been the installation of private tubewells by the farmers of West Pakistan at an exceedingly fast rate during the second-plan period. Installation of these tubewells has enabled the farmers to intensify irrigation and make important changes in cropping patterns in order to maximize the income from their crop production. In this article we present results of two surveys conducted recently on private tubewells and the cropping pattern followed by farmers in area where tubewells are being installed. The results of these surveys indicate that West Pakistan is likely to attain a rate of increase in agricultural production which will be unparalleled in the history of agriculture. To achieve and maintain such a rate of increase, however, considerable revision will be necessary in the programme for land, water and power development proposed for the next ten years and that included in the Third Five Year Plan.

In Sections II and III of this paper, we present the results of our survey on the number of tubewells and the cost of installation and operation of tubewells in different parts of the former Punjab. In Section IV are presented the results of our survey on the cropping patterns and other characteristics of the tubewell and nontubewell farmers. A summary and the conclusions of the paper are given in Section V where some policy issues arising out of this study are also raised.

II. TUBEWELL INSTALLATION IN WEST PAKISTAN

The average yield of crops in the irrigated areas of West Pakistan is much lower than the yields obtained in the irrigated areas in other countries under similar conditions. One basic cause of this is that much less irrigation water is available than is required for consumptive use of crops. One cusec of water is generally supplied for 350 acres in West Pakistan, compared to 70 acres or less in the United States of America and other countries under similar climatic conditions [15, p. 22]. The most important improvement in the agriculture of West Pakistan can, therefore, be expected from the use of additional water on the lands presently irrigated with inadequate water supplies.

Government Tubewells

Under the plains of the former Punjab and Bahawalpur lies a vast reservoir of water which can be used to store and supply additional water by tubewell pumping. The former Punjab government installed 20 tubewells between 1938 and 1940 in an area close to Shalimar Gardens for irrigation purposes [2, p. 50]. The next big schemes for pumping groundwater were the Rasul Project and the Central Tubewell Project under which about 1,500 tubewells were installed in the Rechna and Chaj *Doabs* between 1944 and 1953 with a view to lowering the watertable and providing additional water for irrigation [2, Pp. 50-53]. More recently, the West Pakistan Water and Power Development Authority (WP-WAPDA) has installed about 2,000 tubewells in Salinity Control and Reclamation Project Number One (SCARP-1) in the Rechna *Doab* [1, p. 261]. These tubewells were installed in 1959 and 1960 and commenced operation in 1961/62. About 400 additional tubewells have been installed in SCARP-2 area in the Chaj *Doab* between 1961/62 and 1963/64.

Private Tubewells

Hand pumps to draw water for domestic purposes have been used in Pakistan for more than one hundred years. Installation of tubewells for agricultural use is, however, of more recent origin. The Department of Agriculture has been helping the farmers in installing tubewells for the last thirty years. The Department undertakes the drilling of bore-holes and installation of pipes and strainers. The remaining work, *i.e.*, supply and installation of pump and engine and the construction of pumphouse, *etc.*, is done by the farmers themselves. Pipes and strainers may be purchased from the Department of Agriculture or from the local market. Private drillers have also been drilling wells for the last twenty-five years or so, but have entered this field in a big way during the last six years.

The Department of Agriculture, Punjab, had an Agricultural Engineering Section at the Agricultural College and Research Institute, Lyallpur, which installed about ten to twenty tubewells a year between 1939/40 and 1949/50. The *Annual Report* of the Department of Agriculture, Punjab, for the year ending June 1939, states the following:

> During the year, 17 power-operated tubewells were completed and handed over to their owners .... There is a constantly increasing demand for both large and small power-operated tubewells particularly where cheap hydroelectric power is available [19, p. 54].

It appears that both the Department of Agriculture and private drillers were installing some tubewells before 1938/39. However, complete records of these installations are not available. It is recorded that the Department of Agriculture installed 177 tubewells between 1938/39 and 1949/50 [12, Pp. 1-2]. The number installed by the private drillers is not known.

The work of the Agricultural Engineering Section of the Department of Agriculture was expanded in 1950/51 and it installed 624 tubewells in the next four years. The rate of installation was further increased in 1959/60 and it exceeded 1,000 tubewells a year between 1961/62 and 1963/64

Number of Private Tubewells According to Revenue Department

The Revenue Department published the figures of the number of tubewells in the former Punjab for the first time in 1953/54 when 990 tubewells were reported in existence [20, p. xix]. Out of these, the Department of Agriculture had installed 801 tubewells (177 *plus* 624). The remaining 189 tubewells were installed either by private drillers up to 1953/54 or by the Department of Agriculture prior to 1938/39. In any case, the rate of installation by private drillers prior to 1953/54 must have been very small.

The total number of tubewells as recorded by the Revenue Department for the Northern Zone of West Pakistan, the number of private tubewells installed by the Department of Agriculture and the estimated number installed by private drillers between 1953/54 and 1963/64 is given in Table I. The total number of tubewells increased from 1,200 in 1954/55 to 4,200 in 1959/60, showing an increase of 3,000 tubewells during the first-plan period. The number further increased to 13,600 by 1963/64, showing an increase of over 9,400 during the first four years of the second-plan period.

TABLE I

NUMBER OF PRIVATE TUBEWELLS INSTALLED BY THE DEPARTMENT OF AGRICULTURE AND BY PRIVATE DRILLERS IN THE NORTHERN ZONE OF WEST PAKISTAN, 1953/54 to 1963/64

Year	Total number of private tubewells at the end of the year	Total number installed during the year	Number installed by the Department of Agriculture	Number installed by private drillers
(1)	(2)	(3)	(4)	(5)
1953/54	990	*n.a.*	*n.a.*	*n.a.*
1954/55	1,216	226	258	(a)
1955/56	1,495	279	307	(a)
1956/57	1,911	416	329	(a)
1957/58	2,168	257	371	(a)
1958/59	3,295	1,127	388	739
1959/60	4,214	919	489	430
1960/61	6,904	2,690	817	1,873
1961/62	9,757	2,853	1,040	1,813
1962/63	12,404	2,647	1,088	1,559
1963/64	13,646	1,202	1,410	(b)

Sources: Column (2): Director, Land Records, West Pakistan, Lahore.
Column (3): Calculated from Column (2).
Column (4): Letter from the Director of Agricultural Engineering, West Pakistan.
Column (5): Column (3) *minus* Column (4) for years 1958/59 through 1962/63.

Notes:

(a) Differences between Column (3) and Column (4) before 1958/59 are judged to be too small to be of significance in view of the fact that the data in the two columns come from different sources.

(b) Data for 1963/64 appear to be incomplete as far as the total number of tubewells shown in Column (2) is concerned.

n.a. means not available.

A comparison of figures of Columns (4) and (5) of this Table I indicates that up to 1957/58, the total number of tubewells installed in any year was almost equal to the number installed by the Department of Agriculture. Thus, the Department of Agriculture installed 1,265 tubewells in the 4 years between 1954/55 and 1957/58. The revenue records showed an increase of only 1,178 tubewells in the same 4 years. The difference of 87 tubewells (1,265 *minus* 1,178) is probably due to the fact that it takes some time for the farmer to have his tubewell recorded with the Revenue Department. This number would probably be noted in the next year's revenue records. In any case, it seems that the private drilling trade did not install any significant number of tubewells up to 1957/58 but it entered the field in a big way after that.

Comparison of number of tubewells recorded by the Revenue Department in each district between 1953/54 and 1963/64, given in Appendix Table A-1 with the number installed by the Department of Agriculture given in Appendix Table A-2, shows that private drillers installed 730 tubewells in Gujranwala and Sialkot districts in 1958/59. In other districts the number of tubewells installed in 1958/59 was almost equal to the number installed by the Department of Agriculture. The question naturally arises as to why private drillers entered the field of tubewell installation in such a large way in 1958/59 and in two districts only. The most probable explanation for this appears to be the provision of electricity to these two districts in 1958/59, which gave a great stimulus to the farmers in the installation of tubewells. As the Department of Agriculture had only a limited number of drilling rigs in these two districts, private drillers moved in. In the following year (1959/60), the entire installation of 430 tubewells by private concerns appears to have taken place again in the Gujranwala district (*cf.* Appendix, Tables A-1 and A-2).

The next big increase in the rate of installation of tubewells took place in 1960/61 when 1,873 tubewells were installed by private drillers (Column (5), Table I), compared to 817 by the Department of Agriculture (Column (4), Table I). An examination of statistics for different districts in Appendix Table A-1 indicates that this increase took place mainly in Multan, Gujranwala and Montgomery districts. Emergence of private drillers in the Multan and Montgomery districts in 1960/61 seems to have followed the electric transmission and distribution facilities in these districts on the completion of the Multan Thermal Power Station in 1960. A major increase in installation of tubewells took place again in the next two years, 1961/62 and 1962/63, in the same four districts *viz.*, Multan, Montgomery, Gujranwala, and Sialkot.

This evidence suggests strongly that the availability of electricity acted as a catalyst which led to a wave of private drilling.

A Complete Survey of Private Tubewells

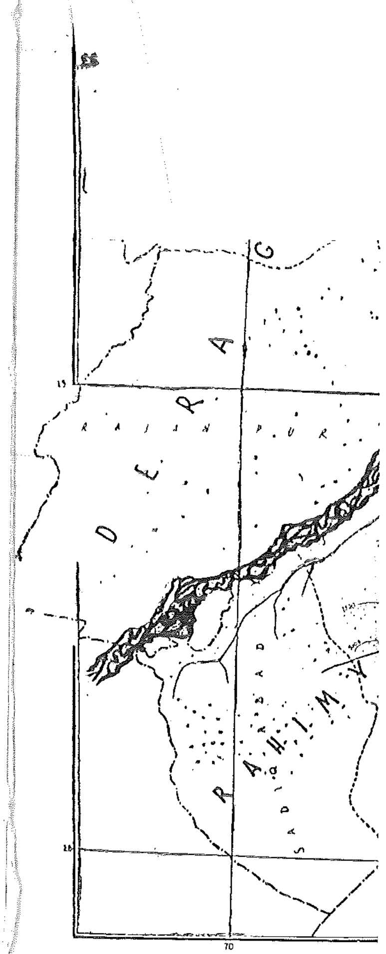
The Pakistan Institute of Development Economics carried out a small survey of private tubewells in a few villages in the former Punjab in March 1964. The results of this survey were published in *The Pakistan Development Review* [3, Pp. 233-243]. While carrying out the survey, the author found that in a large number of cases the tubewell farmers were paying the usual charges for canal water and were not getting any rebate for irrigation by tubewell water[1]. The obvious implication of this was that these tubewells were not recorded by the Irrigation and Revenue Departments. The author, therefore, considered the desirability of carrying out a survey or a complete census of the tubewells in the former Punjab with the help of the Department of Agriculture. The question was discussed with the Director of Agriculture, Lahore. He readily agreed to the proposal and directed his staff to help the author in the proposed survey.

The survey was conducted in the summer of 1964 in each village of sixteen districts in the Northern Zone of West Pakistan. These districts were selected because they had large areas underlain with nonsaline groundwater where the farmers were installing tubewells for irrigation. The survey was carried out through the District Agricultural Officers. The actual count of tubewells was made by the Field Assistants in each village in their Unions and their work was supervised by Agricultural Assistants, most of whom were graduates in agriculture. The author made extensive tours of the villages of these districts when the survey was being done.

The results of the survey are summarized in Table II and shown graphically in the map, where the number of tubewells in each Union is represented by the number of dots. The Union Council boundaries are not shown on the map in order to avoid congestion. A rough estimate of the number of tubewells in other districts has also been prepared and included in Table II. There were in all, in the middle of 1964, 24,000 private tubewells in the Northern Zone and about 25,000 tubewells in the whole of West Pakistan. Out of these, about 6,600 tubewells were installed by the farmers in the year 1963/64 — 6,400 in the Northern Zone and 200 in the Southern Zone.

There are two main areas of concentration of tubewells. One of these is in the Multan and Montgomery districts where electricity was supplied in 1960/61. These two districts had 9,200 tubewells by the middle of 1964. The second is in Gujranwala and Sialkot districts where electricity

[1]In canal-irrigated areas, the government levies charges for the supply of canal water to the farmers. If a farmer does not use canal water, he should not be required to pay for the canal water.



was supplied in 1958/59. These two districts had 6,700 tubewells at the time of the survey. Other important districts are Lahore, Jhang and Lyallpur which had 4,200 tubewells. Parts of these districts have also been supplied with electricity, which seems to have encouraged the installation of tubewells in these districts. Thus, these 7 districts accounted for 20,000 tubewells out of 24,000 tubewells in the Northern Zone of West Pakistan and 25,000 tubewells in the whole of West Pakistan.

Although provision of electricity seems to have been the principal cause of rapid increase in the installation of tubewells in the Gujranwala, Sialkot, Multan and Montgomery districts, it will be seen from Columns (3) and (4) of Table II that the majority of the tubewells in all these districts are run with diesel engines. The position seems to have developed somewhat in the following way. Provision of electricity enabled some farmers to make good profits from the installation of tubewells. When these installations demonstrated the profitability of tubewells, others, even when they could not get electric connections, drilled wells and installed diesel engines. It was, thus, demonstrated that good profits were possible even with diesel engines. More farmers then began to install diesel-engine tubewells and the number increased rapidly.

The map also shows the influence of groundwater quality on the installation of tubewells by the farmers. Most of the tubewells are concentrated in areas having less than 1,000 parts per million (ppm) of dissolved solids. These are located mainly in upper parts of the *doabs* where rainfall is high and along the rivers where the river water during the high-flood season contributes to the groundwater recharge. The number of tubewells decreases with increasing distance from the area of recharge and active circulations. There are, however, many tubewells in areas having 1000 to 3000 ppm of dissolved salts and even in areas having more than 3000 ppm of dissolved salts. We did not study these tubewells in detail. However, here the influence of canal seepage on the quality of water may be important. The salinity lines shown in the map refer to the total dissolved salts in the groundwater between 100 feet and 450 feet below ground surface [6, p. 51]. The water in the upper 100 feet is diluted with seepage from canal water and contains much less salt. It is this water which is mainly pumped by tubewells installed by the farmers. Furthermore, these tubewells are reported to be worked very sparingly. These are used only to meet the critical needs of crops during canal closures, particularly in the sowing and maturing periods and not for increasing the intensity of cropping.

Comparison with Revenue Records

If the number of tubewells installed during 1963/64 is deducted from the total number of tubewells, we can get an estimate of the total number of tubewells at the end of 1962/63. This comes to 17,600 tubewells for the Northern Zone (24,000 *minus* 6,400). The corresponding figure in the revenue records at the end of 1962/63 was 12,400 tubewells (Table I). The revenue records, therefore, appear to have underestimated the total number of tubewells in 1962/63 by 5,200 or about 42 per cent. At the end of 1963/64, our survey showed the number of tubewells to be 10,354 higher than that in the revenue records (24,000 *minus* 13,646). The number in our survey was thus 76 per cent higher than that in the revenue records. The major differences were in the districts of Multan (1,733), Gujranwala (1,710), Montgomery (1,457), Lahore (1,180), Sialkot (1,036) and Jhang (770). These districts accounted for a difference of 7,886 between the revenue records and results of our survey. In our survey, we came across a large number of tubewells in these districts where the farmers were paying the full canal-water charges for areas irrigated jointly from canal and tubewell water. No concession was given for the use of tubewell water. It appears that these tubewells were not recorded in the revenue papers. This may be explained as follows.

When a farmer uses tubewell water along with the canal water, he pays the full charges for canal water. Such a tubewell will not be recorded in the revenue papers. When a tubewell owner digs a separate watercourse for the use of tubewell water and does not apply any canal water to the area served by the tubewell, he still pays the full charges for canal water but becomes eligible for a 25-per-cent rebate. Such a tubewell is recorded in the revenue papers, but a number of farmers with whom we discussed this question considered the procedure for getting this concession as too cumbersome and therefore did not avail of this concession. It appears that after the introduction of electricity the income from tubewells in relation to the concession became so large that most farmers ignored the concession. Their tubewells were, therefore, not recorded by the Revenue Department. In 1963/64, the Revenue Department appears to have recorded only a small fraction of the additional tubewells installed during the year.

Comparison with WAPDA Records

Whereas our survey showed the number of private tubewells to be much higher than that recorded by the Revenue Department, the number of electric tubewells recorded by WAPDA is higher than that recorded in our survey. It will be seen from Table II that out of 25,000 tubewells in West Pakistan, there were 18,800 diesel tubewells and 6,200 electric tubewells at the end of 1963/64. Out of this, 17,800 diesel tubewells and 5,840 electric tubewells were in the Punjab and Bahawalpur. However, WAPDA is reported to have given 9,694 electric connections for private agricultural tubewells and 3,825 electric connections for agricultural tubewells in West Pakistan up to June 1964 (Table III). In the Punjab and Bahawalpur, the

TABLE III

NUMBER OF GOVERNMENT AND PRIVATE AGRICULTURAL TUBEWELL CONNECTIONS BY WAPDA IN VARIOUS DISTRICTS OF WEST PAKISTAN AT THE END OF 1963/64

District	Number of tubewells		
	Private	Government	Total
(1)	(2)	(3)	(4)
A. Punjab and Bahawalpur Area			
1. Campbellpur	133	*nil*	133
2. Rawalpindi	14	*nil*	14
3. Jhelum	16	*nil*	16
4. Gujrat	512	*nil*	512
5. Mianwali	164	*nil*	164
6. Sargodha	678	163[a]	841
7. Lyallpur	242	278[b]	520
8. Jhang	590	32	622
9. Lahore	1,943	*nil*	1,943
10. Gujranwala	146	515	661
11. Sheikhupura	208	2,837[c]	3,045
12. Sialkot	458	*nil*	458
13. Muzaffargarh	2	*nil*	2
14. Multan	1,196	*nil*	1,196
15. Montgomery	1,896	*nil*	1,896
16. Bahawalpur	37	*nil*	37
17. Bahawalnagar	27	*nil*	27
18. Rahimyar Khan	1	*nil*	1
Subtotal: A	8,263	3,825	12,088
B. N-W.F.P. Area			
1. Peshawar	539	*nil*	539
2. Mardan	347	*nil*	347
3. Kohat	196	*nil*	196
4. D. I. Khan	230	*nil*	230
5. Hazara	12	*nil*	12
6. Bannu	4	*nil*	4
7. Malakand	26	*nil*	26
8. Saidu Sharif	17	*nil*	17
Subtotal: B	1,371	*nil*	1,371
C. Sind Area	60	*nil*	60
TOTAL: (A + B + C)	9,694	3,825	13,519

Source: Operational Manager, Electricity, WAPDA, through the courtesy of S. Munawar Ali, Director-General, Planning and Investigations, WAPDA, Lahore, with his letter dated March 8, 1965.

[a]Tubewells in SCARP-2 area.

[b]Tubewells in SCARP-1 area.

[c]Include 971 tubewells in SCARP-1 area. There are reported to be 1,400 tubewells under Rasul Tubewell Scheme by S. E. Tubewell Investigation Circle, Moghalpura, of which no record could be traced from Operational Manager's Office, Electricity, WAPDA.

number of electric connections given by WAPDA for private agricultural tubewells was 8,263 (Column (2), Table III) against 5,840 found in our survey (Column (3), Table II). The main differences were in the Gujrat, Sargodha, Lahore, Montgomery, and Multan districts. The differences suggest that city and cantonment tubewells used for domestic drinking-water purposes and for lawns and gardens attached to houses are included in the list of agricultural tubewells by WAPDA. If these are deducted from the number compiled by WAPDA, the actual number of private agricultural tubewells to which electric connections have been given comes more in line with the number found in our survey. Even then it is possible that the total number of electric tubewells is more than 6,200 and that total of all tubewells is probably larger than 25,000 found in our survey (Table II).

Comparative Role of Agriculture Department and Private Drilling Concerns

As previously stated the total number of tubewells installed by the farmers in the Northern Zone in 1963/64 was 6,400. Out of these, the Department of Agriculture installed 1,410 tubewells[2]. The remaining 4,990 tubewells must, therefore, have been installed by the farmers with the help of private drilling concerns. Thus starting with an insignificant number of tubewells installed prior to 1957/58, the private drillers installed about 5,000 tubewells in 1963/64.

The total number of tubewells recorded by the Revenue Department and number of tubewells installed by private drillers between 1958/59 and 1962/63, as shown in Table I, is probably not correct as the Revenue Department underestimated the total number in 1962/63 and 1963/64 by as much as 42 and 76 per cent respectively. However, as explained on page 53 it appears that the number recorded up to 1957/58 was probably correct. A better (rough) estimate of the tubewells after 1958/59 may be made on the assumption that the revenue records underestimated the total number by 10 per cent in 1959/60, 15 per cent in 1960/61, 25 per cent in 1961/62, 42 per cent in 1962/63 and 76 per cent in 1963/64. The total number of tubewells as adjusted on this basis and the probable number of tubewells installed by the private drillers is shown in Table IV. Thus, the number installed by private drillers increased from practically nil in 1957/58 to about 850 in 1959/60 and to about 4,400 in 1962/63, and to about 5,000 in 1963/64. The private drillers got a big boost in business in 1960/61, after the Multan

[2]Out of 1,410 tubewells, 1,369 tubewells were installed by the Agricultural Engineers, Lyallpur and Bahawalpur and 41 by the Agricultural Engineers, D. I. Khan and Peshawar. This information was supplied to the author by the Director, Agricultural Engineering, Lyallpur, in January 1965 and by the Superintending Engineer, Agricultural Machinery Organization, Peshawar, in February 1965.

TABLE IV

ADJUSTED NUMBER OF TOTAL TUBEWELLS, NUMBER INSTALLED BY THE AGRICULTURE DEPARTMENT AND NUMBER INSTALLED BY PRIVATE DRILLERS IN NORTHERN ZONE OF WEST PAKISTAN

Year	Total number of private tubewells		Total number installed during the year	Number installed by the Agriculture Department	Number installed by private drillers
	As per revenue records	Adjusted			
1959/60	4,214	4,635	1,340	489	851
1960/61	6,904	7,940	3,305	817	2,488
1961/62	9,757	12,200	4,260	1,040	3,220
1962/63	12,404	17,600	5,400	1,088	4,312
1963/64	13,646	24,000	6,400	1,410	4,990

Thermal Power Station began to supply some electricity for tubewells. They have made great progress since then. The contribution of private drilling concerns at present far exceeds that of the Department of Agriculture. Preliminary results of a survey of private drilling concerns in the former Punjab and Bahawalpur undertaken by the Pakistan Institute of Development Economics indicate that a larger number of drilling concerns have entered the field in the last two to three years. This lends some support to the increases shown in the above figures of tubewells installed by private drilling concerns.

The private drilling concerns appear to be capable of increasing their capacity very rapidly and should be able to install all the tubewells required by the farmers in the coming years without much difficulty.

The Department of Agriculture had 150 drilling rigs up to 1963 [17, p. 80]. With these they installed 1,620 tubewells in 1963/64. Additional drilling rigs have been imported in 1963/64 and 1964/65. The Department of Agriculture now has 304 hand-drilling rigs and 18 power rigs [22, p. 33]. These are expected to be in commission throughout the third-plan period. Each hand-drilling rig and power rig installs 11 and 9 tubewells respectively in a year[3]. On this basis, the presently available 304 hand-drilling rigs and 18 power rigs will install 3,500 tubewells in a year throughout the third-plan period[4] [22, p. 33]. The Department of Agriculture has put up a proposal for the acquisition of 300 additional hand-operated drilling rigs and 10 additional power rigs for the third-plan period [23, p. 3]. In order to expedite drilling operations and to enable the farmers to install their tubewells as rapidly as possible, provision for additional rigs should be included in the Third Plan. This additional equipment will increase the capacity of Department of Agriculture drilling in the third-plan period, with a lag, to an annual rate of about 6,800. By the time this equipment comes into use, private drillers may very well have achieved a similar capacity.

[3]One hand-drilling rig drills on an average one tubewell in one month or about 11 tubewells in a year. The power rigs are used in the mountainous areas, hence their outturn is less than that of hand rigs which are used in the plains.

III. COST OF INSTALLATION AND OPERATION OF PRIVATE TUBEWELLS

For estimating the cost of installation and working expenses of tubewells, we selected about 200 tubewells distributed over 100 villages in 50 Union areas in the nonsaline groundwater areas of Multan, Montgomery, Gujranwala, Sheikhupura, Sialkot, Gujrat, Jhang, and Sargodha. We did not select any tubewells in the saline groundwater areas for this purpose. Furthermore, due to limitation of trained staff and time and attitude of many of the farmers, it was not possible to take a random sample. Some of the farmers refused to give information on such items as operating expenses, electricity used and hours worked. We had no alternative but to leave them and select other farmers who were prepared to supply this information. This may have introduced bias into the results. However, the size of the sample was sufficiently large and its distribution over different parts of the former Punjab was quite wide, so that a fairly good sample of the tubewell farmers in the nonsaline groundwater areas was selected.

Cost of Installation

The average cost of installing a tubewell came to about 8,700 rupees per well in the whole of the former Punjab and Bahawalpur. It varied from an average of 12,000 rupees for diesel-engine tubewells in the Multan and Montgomery districts to an average of about 5,400 rupees for electric tubewells in the Gujranwala and Sialkot districts. Most of these tubewells were of 6-inch diameter. The details of the cost of installation of tubewells in Multan and Montgomery districts and for Gujranwala and Sialkot districts are given in Appendix Table B-1 and are summarized in Table V. The difference in cost between different districts is mainly due to the depth of watertable and avail-

[4]In the shorter run, on the basis of only slightly increased drilling capacity of the Department of Agriculture (but particularly of the private drilling concerns), we may expect some 8,000 to 9,000 tubewells to be installed in 1964/65, compared to 6,600 in 1963/64. This will increase the total number of tubewells at the end of the second-plan period to about 33,000 to 34,000.

ability of suitable water-bearing sand. In the Gujranwala and Sialkot districts the watertable is high, averaging about 10 feet in depth. These two districts had about 34,000 open-surface wells distributed throughout the cultivated area which were used for irrigation before the installation of tubewells. The farmers have installed most of their tubewells in these open-surface irrigation wells. Furthermore, these two districts are in the upper parts of the the Rechna *Doab* and, therefore, have a greater proportion of medium and coarse sands. The strainer does not have to be very long in these districts to give an adequate discharge. The length of the strainer averages about 70 feet only. Since the watertable is high, the lining pipe is also not very long and averages about 40 feet only. The wells are fitted with an engine or motor of 14 to 18 horse power. The average cost of electric motor-driven tubewells in these districts is about 5,400 rupees while that of diesel-engine tubewells is about 8,500 rupees per well.

TABLE V

COST OF INSTALLATION OF A DIESEL AND ELECTRIC TUBEWELL IN DIFFERENT DISTRICTS

Cost	Multan and Montgomery districts		Gujranwala and Sialkot districts	
	Diesel tubewell	Electric tubewell	Diesel tubewell	Electric tubewell
Cost of tubewell exclusive of engine or motor	6,250	6,250	3,360	3,360
Cost of engine or motor	5,750	2,550	5,140	2,040
Total cost	12,000	8,800	8,500	5,400

Source: Appendix Table B-1.

In the Multan and Montgomery districts, on the other hand, the watertable is deeper, averaging about 25 feet. Although there are some 38,000 open-surface wells in these two districts, these wells are concentrated mainly in nonperennial areas[5]. In the perennial areas the farmers have to dig wells

[5]Canals flowing all the year round and fed from a permanent barrage or diversion dam spanning the source river are called perennial canals. Those which run during the summer months only when there is more water in the rivers are called nonperennial.

about 25 feet deep so that the centrifugal pump can be fixed close to the surface of the groundwater. The lining pipe has also to be longer, the average length being about 80 feet. The strainer is also of greater length, being about 105 feet. The motor or engine also must be of greater horse power. For these reasons the cost of installation of tubewells is high in these districts and averages about 8,800 rupees per well for electric tubewells and about 12,000 rupees per well for diesel tubewells.

Overall average cost for the 4 districts combined comes to about 8,700 rupees per tubewell. The average cost of electric tubewells is about 7,100 rupees and that of diesel tubewells is about 10,300 rupees per well[6].

Discharge of Private Tubewells

The discharge of private tubewells was estimated by comparing it with the discharge of the canal outlet. The method of calculating the discharge is explained in Appendix C.

The average discharge of the tubewells in various districts is given in Table VI. The average of the tubewells in the Multan, Montgomery, Gujranwala, and Sialkot districts varies between 1.12 and 1.24 cusecs. The average for Gujrat district is less and that for Jhang district is more. The weighted mean for the 6 districts comes to 1.19 cusecs. As these districts account for about 72 per cent of all tubewells, we have used this figure as the average for the whole province.

Water Pumped by Tubewells

The number of hours worked by tubewells in the nonsaline groundwater areas in different districts varied between 1,900 and 2,600 hours a year, as shown in Table VI. On the average the tubewells worked for 2,350 hours during 1963/64. Thus, if we assume the average discharge of the tubewells to have been 1.19 cusecs, the tubewells pumped about 233 acrefeet of water per well. Out of this, about 220 acrefeet were delivered in the fields, the balance being lost in the watercourse. According to limited enquiries made by us after the main survey was over, it appears that in the saline groundwater areas the tubewells work much less time and pump much less water. On a rough calculation, out of the 25,000 tubewells in West Pakistan about 20,000 are located in the nonsaline groundwater areas. These would have pumped about 4.7 million acrefeet (MAF) of the water during 1963/64 out of which about 4.4 MAF was delivered in the fields.

[6]Harza Engineering Company estimated the average cost of a private electric tubewell as 7,090 rupees and that of a private diesel tubewell as 9,100 rupees, *see* [11, p. 9].

TABLE VI

WORKING HOURS AND DISCHARGE OF TUBEWELLS

District	Average number of hours worked in 1963/64	Average area irrigated in 12 hours	Estimated average discharge at the field	Estimated average discharge at the tubewell head[a]
(1)	(2)	(3)	(4)	(5)
	(hours)	*(acres)*	*(cusecs)*	*(cusecs)*
Multan	2,250	4.70	1.18	1.24
Montgomery	2,560	4.25	1.06	1.12
Gujranwala	2,260	5.55	1.16[b]	1.22
Sialkot	2,470	5.50	1.15[b]	1.21
Gujrat	1,920	3.35	0.70[b]	0.74
Jhang	2,410	5.17	1.29	1.36
Overall weighted average	**2,350**	**4.89**	**1.13**	**1.19**

Source: Survey conducted by the PIDE.

[a]It is assumed that 5 per cent of the water is lost in the watercourse between the tubewell and the fields irrigated.

[b]It is assumed that the depth of the irrigation or delta of water is 2½ acreinches per acre in the Gujranwala, Sialkot, and Gujrat districts where tubewells are used mostly for rice irrigation. For other districts, the depth of water for one irrigation is assumed as 3 acreinches per acre.

By the end of the second-plan period (mid-1965), the number of tubewells in West Pakistan is expected to increase to about 33,000, out of which about 28,000 may be in the nonsaline groundwater areas. These tubewells will pump about 6.5 MAF of water in 1964/65. If we include 2.5 MAF of water likely to be pumped by WAPDA tubewells, the total pumping will be about 9.0 MAF, out of which about 8.5 MAF will be delivered in the fields. This would mean a 14-per-cent addition to the 60 MAF of river water likely to be delivered by canals at the fields in West Pakistan in 1964/65.

Annual Working Expenses of Tubewells

The annual working expenses of diesel and electric tubewells for the *i*) Multan and Montgomery districts and *ii*) Gujranwala and Sialkot districts are shown in Appendix Table B-2. To the annual working expenses have

been added the depreciation and interest charges. These are calculated on the assumption that life of the tubewell including pipes, strainers, pumps and other materials, is ten years and that of the motor and engine is fifteen years. Interest is calculated at the rate of 8 per cent per year on the average value of the tubewells. Some of the farmers were able to borrow funds at 6 per cent rate of interest from the Agricultural Development Bank (ADB), but their number was relatively small. We consider that 6 per cent rate of interest is low as a measure of opportunity cost and have, therefore, used 8 per cent in our calculations. According to Mahbubul Haq: "It would seem that a shadow price of capital between 8 to 10 per cent would be ... appropriate..." [7, p. 47].

A summary of the total annual cost is given in Table VII. For the Gujranwala and Sialkot, districts the annual operating cost of diesel tubewells is about 4,700 rupees and of electric tubewells about 2,700 rupees. Annual operating cost of electric tubewells is, thus, about 2,000 rupees less. The cost per acrefoot of water pumped is about 19 rupees from diesel tubewells and 14 rupees from electric tubewells. The cost per hour is 2.0 rupees for diesel tubewells and 1.2 rupees for electric tubewells.

TABLE VII

ANNUAL COST OF OPERATION OF A DIESEL AND ELECTRIC TUBEWELL IN DIFFERENT DISTRICTS

Cost	Multan and Montgomery districts		Gujranwala and Sialkot districts	
	Diesel tubewell	Electric tubewell	Diesel tubewell	Electric tubewell
Annual operating cost	4,670	2,750	3,720	2,040
Interest and depreciation	1,490	1,150	1,020	700
Total annual cost	**6,160**	**3,900**	**4,740**	**2,740**
Cost per acrefoot of water	24.0	18.1	19.3	14.3
Cost per hour worked	2.6	1.7	2.0	1.2

Source: Appendix Table B-2.

In the Multan and Montgomery districts, the average cost of operation of a diesel tubewell comes to about 6,200 rupees during the year. This is equal to 24 rupees per acrefoot of water pumped or 2.6 rupees per hour worked[7]. Working of the electric tubewells costs about 3,900 rupees per year which is 2,300 rupees less than that of diesel tubewells. This cost is equal to about 18 rupees per acrefoot of water pumped or 1.7 rupees per hour of tubewell run.

For all the 4 districts combined, the cost of pumping water from diesel tubewells comes to 21.8 rupees per acrefoot of water. For the electric tubewells, the cost comes to 16.4 rupees per acrefoot of water. The cost of pumping water from diesel tubewells is, thus, 33 per cent higher than that from electric tubewells.

Canal-water charges are very low, compared to the cost of pumping water from tubewells. Water rates vary with the crop grown. For the Lower Chenab Canal in the former Punjab, the rates for different crops are given in Column (2) of Table VIII. In order to estimate the cost per acrefoot of water, we have prepared rough estimate of the amount of water used by each crop. This is given in Column (3) and the cost per acrefoot of water is worked out in Column (4).

TABLE VIII

CANAL-WATER CHARGES FOR DIFFERENT CROPS

Crop	Water rate per acre cropped	Estimated water use	Water rate per acre-foot of water
(1)	(2)	(3)	(4)
	(rupees)	*(acrefeet)*	*(rupees)*
Sugarcane	21.6	4.4	4.9
Rice	10.4	3.8	2.7
Cotton	10.4	2.2	4.7
Maize	6.4	1.6	4.0
Wheat	6.4	1.1	5.8
Oilseeds	8.0	0.6	13.3
Gram	4.8	0.8	6.0

Sources: Column (2): From [28, Pp. 138-140].
Column (3): Our estimates.
Column (4): Col. (2) ÷ Col. (3).

7The Department of Agriculture has estimated the cost of pumping water from diesel tubewells at 2.25 rupees per hour or 27 rupees per acrefoot for one-cusec capacity tubewell [13, p. 13].

Canal-water rates vary from 4.8 rupees to 21.6 rupees per acre cropped or between 2.7 and 13.3 rupees per acrefoot of canal water delivered as compared to 16.4 rupees per acrefoot of water pumped from electric tubewells and 21.8 rupees per acrefoot of water pumped from diesel tubewells.

Sale and Purchase of Tubewell Water

In almost all villages visited by us, water was sold by the tubewell farmers to neighbouring cultivators. In villages where there was only one tubewell, water was usually sold at 4 to 5 rupees per hour. Where more tubewells were installed, water was usually sold at about 3.0 to 3.5 rupees per hour from diesel tubewells and about 2.5 to 3.0 rupees per hour from electric tubewells. In some villages the water was sold at 8 rupees per acre irrigated. As it took about 2.5 to 2.8 hours for one acre to be irrigated, this rate was equal to about 2.8 to 3.2 rupees per hour.

In the Gujranwala and Sialkot districts, the value of water sold was usually realized in the form of a share of the crop produce. Rice was the most commonly grown crop on the tubewell water in these districts. For this crop, the usual practice was to charge one-third of the gross produce as the cost of tubewell water. For all other crops, one-fourth of the gross produce was charged. Charges were high in the case of rice because it required much more water as compared to other crops.

When land was occupied by tenants, the usual practice in the canal-irrigated areas was to share the produce on a fifty-fifty basis between the landlord and the tenant. Where the landlord had installed a tubewell in a canal-irrigated area he typically got 60 per cent of the produce and the tenant got 40 per cent. The additional 20 per cent by the landlord was assumed as the cost of operation of the tubewell. Where no canal water was available the landlord installing the tubewell typically got two-thirds of the produce and tenant got one-third.

IV. CROPPING PATTERNS AND OTHER CHARACTERISTICS OF TUBEWELL AND NONTUBEWELL FARMERS IN THE FORMER PUNJAB

Cropping patterns and other characteristics were studied for the same tubewell farmers for whom details of cost of installation and cost of operation were studied and which have been reported in Section III. Crops grown by the owners of these tubewells during the year 1963/64 were recorded. An equal number of farmers not having tubewells in the same village and on the same canal outlets were selected for noting their cropping pattern for comparison with the tubewell farmers. An effort was made to select nontubewell farmers who had the same kind of soil, exactly the same canal-water supply and about the same size of holding. It was difficult, however, to get nontubewell farmers who had the same size of holding as the tubewell farmers since the former usually had smaller size of holdings. Furthermore, most of the nontubewell farmers purchased some tubewell water. Those farmers who purchased tubewell water equal to or more than 20 per cent of their canal-water supply were not considered in calculating the cropping pattern of nontubewell farmers.

The work of interviewing the farmers was done by one of the research assistants of the Pakistan Institute of Development Economics, who spent about 6 months in the tubewell villages of the former Punjab[8]. The Department of Agriculture deputed their field staff in the Montgomery and Gujranwala districts to help the Institute in this work. The results of the survey on the size of the tubewell and nontubewell holdings, loans taken by the farmers for tubewell installation, bullock labour and manual labour used on tubewell and nontubewell holdings and the cropping pattern followed by them are presented in this section.

Size of Holdings and Tubewell Installation

Table IX shows the number of tubewells installed by farmers having different sizes of holdings in different districts of the Punjab. Out of 136 tubewells considered in this section, 101 had been installed by single farmers whereas 35 were installed jointly by 104 farmers, 2 to 4 farmers joining to install one tubewell. Thirty-one tubewells, or 23 per cent of the total, were installed by farmers having less than 25 acres each and 55 per cent of all tubewells were installed by farmers having less than 50 acres each. The remaining 45 per cent were installed by farmers having holdings of 50 acres and above.

Loans Taken for Tubewell Installation

Out of a total of 136 tubewell farmers, only 24 farmers or 18 per cent of the total had borrowed any funds for installation of tubewells (Table X). The remaining 82 per cent had installed the tubewells with their own resources. For the farmers who obtained loans for tubewell installation the average amount of loan taken was about 9,500 rupees per farmer.

For the sake of comparison, it may be pointed out that the Agricultural Development Bank (ADB) has reported that it sanctioned and disbursed

[8]Mr. Mohammad Ghaffar, a Research Assistant in the Agriculture Section of the Institute, did this difficult task. But for his perseverance and hard work it would not have been possible to complete this study.

TABLE IX

NUMBER OF TUBEWELLS INSTALLED SINGLY AND JOINTLY BY FARMERS HAVING DIFFERENT SIZE OF HOLDINGS IN DIFFERENT DISTRICTS OF THE FORMER PUNJAB

District	Size of holding				Total
	Below 25 acres	25–50 acres	50–150 acres	Above 150 acres	
(1)	(2)	(3)	(4)	(5)	(6)
	Number of tubewells installed by single farmers				
Montgomery	3	2	4	1	10
Multan	2	7	17	3	29
Gujranwala[a]	4	7	11	1	23
Sialkot	5	5	2	*nil*	12
Gujrat	6	1	1	*nil*	8
Jhang	*nil*	5	9	1	15
Sargodha	1	1	1	1	4
Subtotal	**21**	**28**	**45**	**7**	**101**
	Number of tubewells installed jointly and number of farmers[b]				
Montgomery	2(6)	5(24)	3(6)	*nil*	10(36)
Multan	*nil*	3(8)	3(6)	*nil*	6(14)
Gujranwala[a]	4(13)	3(6)	1(2)	*nil*	8(21)
Sialkot	3(7)	1(2)	*nil*	*nil*	4(9)
Gujrat	1(6)	*nil*	*nil*	*nil*	1(6)
Jhang	*nil*	3(10)	1(3)	*nil*	4(13)
Sargodha	*nil*	1(2)	1(3)	*nil*	2(5)
	10(32)	**16(52)**	**9(20)**	**nil**	**35(104)**
Total number of tubewells	31	44	54	7	136
Total number of farmers	53	80	65	7	205
Percentage of tubewells in different size of holdings	23	32	40	5	100
Percentage of farmers in different size of holdings	26	39	32	3	100

Source: Survey conducted by the PIDE.

[a]Actual number of tubewells studied in the Gujranwala district was 69 installed by single farmers and 24 installed by farmers jointly. As the size of holdings is smaller in Gujranwala district than in most other districts, only one-third of the number of tubewells studied is included in this table so as not to distort the picture for the whole province. In all other districts the sample size was in roughly the same proportion to total number of tubewells as the "deflated" Gujranwala sample is to that district's total.

[b]Figures in parentheses represent the number of farmers.

loans totalling 16.6 million rupees for the installation of 1,219 tubewells in the whole of West Pakistan in 1963/64 [16, p. 31]. The total number of tubewells installed during the year according to our survey was 6,600 (Table II). Thus, ADB figures imply that 20 per cent of all farmers who installed tubewells in West Pakistan in 1963/64 borrowed funds from the ADB compared to 18 per cent found in our survey. The average amount of loan issued by ADB was 13,600 rupees compared to 9,500 rupees for the farmers in our survey.

Bullocks and Men on Tubewell and Nontubewell Holdings

While making enquiries on the cropping pattern followed by tubewell and nontubewell farmers, we noted the number of family workers working on

TABLE X

LOANS TAKEN FOR INSTALLATION OF TUBEWELLS IN DIFFERENT DISTRICTS

District	Total number of farmers who installed tubewells	Number of farmers who got loans	Amount of loans taken
(1)	(2)	(3)	(4)
Multan	35	12	131,000
Montgomery	20	7	72,000
Gujranwala	31	5	26,000
Sialkot	16	*nil*	*nil*
Gujrat	9	*nil*	*nil*
Jhang	19	*nil*	*nil*
Sargodha	6	*nil*	*nil*
Total:	136	24	229,000
Average amount of loans for farmers who actually obtained loans (Col. (4) ÷ Col. (3))			9,500
Average amount of loans on total number of farmers who installed tubewells (Col. (4) ÷ Col. (2))			1,700

Source: Survey conducted by the PIDE.

the holding as well as the hired labourers employed on the holding. Similarly, the number of bullocks on each holding along with the area of the holding was recorded. These details are summarized in Table XI separately for the Multan and Montgomery districts and for the Gujranwala and Sialkot districts. In the Multan and Montgomery districts, the average size

TABLE XI

AVERAGE SIZE OF HOLDING, AREA OPERATED PER PAIR OF BULLOCKS AND PER MAN ON TUBEWELL HOLDINGS AND NONTUBEWELL HOLDINGS IN DIFFERENT DISTRICTS OF THE FORMER PUNJAB

Characteristics of holdings	Multan and Montgomery districts		Gujranwala and Sialkot districts	
	With tubewell	Without tubewell	With tubewell	Without tubewell
(1)	(2)	(3)	(4)	(5)
1. Holdings studied (*number*)	42	32	42	47
2. Pairs of bullocks per holding (*number*)	4.2	2.2	3.1	2.7
3. Workers per holding (*number*)	7.0	4.0	6.4	6.0
4. Average area operated per holding[a] (*acres*)	54.9	28.1	42.0	28.3
5. Average area cropped[b] per holding (*acres*)	72.1	27.9	63.5	35.6
6. Average area operated per pair of bullocks Row 4 ÷ Row 2 (*acres*)	13.1	12.8	13.4	10.5
7. Average area cropped per pair of bullocks Row 5 ÷ Row 2 (*acres*)	17.2	12.7	20.5	13.2
8. Average area operated per man Row 4 ÷ Row 3 (*acres*)	7.8	7.0	6.6	4.7
9. Average area cropped per man Row 5 ÷ Row 3 (*acres*)	10.3	7.0	9.9	6.0

Source: Survey conducted by the PIDE.

[a] Area operated is the actual area of the holding.

[b] Area cropped represents the acres of crops raised on the holdings. This may be more or less than the area operated, depending upon the intensity of cropping.

of tubewell holdings was about 55 acres whereas that of nontubewell holdings was about 28 acres. The number of bullocks kept on the average was 4.2 pairs on tubewell holdings and 2.2 pairs on nontubewell holdings. The operated acreage per pair of bullocks was, therefore, about the same in both cases (about 13 acres). However, the area cropped per pair of bullocks was much higher (17.2 acres) in the case of tubewell farmers than in the case of nontubewell farmers (12.7 acres). This means that installation of tubewells increased the efficiency of bullocks by more than 35 per cent. This is because the bullocks are underworked at present. They generally work for about 120 to 130 days in the canal-irrigated areas [5, p. 37]. With the installation of tubewells the farmers were able to work them for longer hours or for more days and thus covered more area. Similarly, the area cropped per man was 7.0 acres in the case of nontubewell farmers and 10.3 acres on tubewell holdings. This means that output per man was higher by about 50 per cent on tubewell holdings. In this calculation it is assumed that yield per acre remained the same. Actually, yield per acre on tubewell holdings was higher than that on nontubewell holdings. Output per man, therefore, was more than 50 per cent higher on tubewell holdings compared to nontubewell holdings.

In the Gujranwala and Sialkot districts, the area operated per pair of bullocks was about 10.5 acres on nontubewell holdings and about 13.4 acres on tubewell holdings. However, the area cropped on tubewell holdings was about 20.5 acres per pair of bullocks compared to only 13.2 acres in the case of nontubewell farmers, indicating a much higher efficiency of bullock use on tubewell holdings. Area cropped per man was 6.0 acres in nontubewell holdings and 9.9 acres in the case of tubewell holdings, showing 65 per cent higher output per man even if it is assumed that the yield per acre remained constant. Actually, yield per acre also increased resulting in a still higher output per manual worker.

Tubewells and Fertilizer Use

Table XII shows the fertilizer used by tubewell and nontubewell farmers during 1963/64. The tubewell farmers used on the average about 0.9 bags[9] of fertilizer when calculated on the basis of total area cropped. Not all the crops, however, received the fertilizer. The crops to which fertilizer was actually applied received on the average about 1.8 bags per acre.

The nontubewell farmers, on the other hand, applied 0.4 bags per acre cropped on the basis of the entire holding or 1.4 bags per acre for the area to which fertilizer was actually applied.

[9]Nitrogen was the main fertilizer used. A bag contained 112 pounds of ammonium sulphate or 87 pounds of ammonium nitrate or 51 pounds of urea. Each of these contained about 23 pounds of nitrogen.

TABLE XII

FERTILIZER USE BY TUBEWELL AND NONTUBEWELL FARMERS

Districts	Tubewell farmers				Nontubewell farmers			
	Number of farmers	Average area cropped	Average area to which fertilizer applied	Fertilizer applied	Number of farmers	Average area cropped	Average area to which fertilizer applied	Fertilizer applied
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		(....*acres*....)		(*bags*[a])		(....*acres*....)		(*bags*[a])
Multan	26	87	49	87	31	25	11	19
Montgomery	19	44	20	34	12	37	10	11
Gujranwala	29	73	20	26	32	45	11	13
Sialkot	15	46	26	63	15	16	3	6
Gujrat	9	23	11	13	8	11	*nil*	*nil*
Jhang	14	70	62	124	18	21	11	17
Sargodha	6	95	12	21	2	97	3	4
Total/average	118	65	31	56	118	30	9	13
Bags of fertilizer applied on the total area cropped				0.9				0.4
Bags of fertilizer on the area to which fertilizer was actually applied				1.8				1.4

Source: Survey conducted by the PIDE.

[a]Each bag contained 112 pounds of ammonium sulphate or 87 pounds of ammonium nitrate or 51 pounds of urea. Each of these had about 23 pounds of nitrogen.

⊛ Fertilizer bags per acre of area over which applied.

The dose of fertilizer for the crops to which fertilizer was actually applied was, thus, about 30 per cent higher in the case of tubewell farmers. On the basis of total area cropped, the tubewell farmers used more than twice the fertilizer as compared to nontubewell farmers.

The farmers who have installed tubewells are progressive farmers and were probably using a higher quantity of fertilizer even before the installation of tubewells. But the influence of tubewells in modernization of the whole of agriculture needs to be stressed. When a farmer saves or borrows some 6 to 12 thousand rupees and installs a tubewell, his whole outlook on agriculture as a business changes. He wants to grow more valuable crops, to apply fertilizer and to use other modern inputs to increase his income. We will surmise this hypothesis further in the following pages.

Cropping Patterns of Tubewell and Nontubewell Farmers

Table XIII shows the area under each crop as a percentage of the area o the total holding of the tubewell farmers and of the nontubewell farmers In the Multan and Montgomery districts, the nontubewell farmers had an average cropping intensity[10] of about 99 per cent (Column (2)). In the same villages, the farmers who had installed tubewells had a cropping intensity of about 131 per cent (Column (3)). In other words, they had about 32 per cent higher intensity of cropping compared to nontubewell farmers. On their holdings, the area under *kharif* crops was 67.6 per cent compared to 49.0 per cent for nontubewell farmers. And their area under *rabi* crops was 63.5 per cent compared to 50.2 per cent for nontubewell farmers. This reflects the fact that tubewell farmers have a larger area under *kharif* crops than under *rabi* crops whereas the opposite is the case for nontubewell farmers. The main difference was in the area under cotton, fruits and vegetables in the *kharif* season and wheat and fodder in the *rabi* season. On the other hand, their area under sugarcane, maize and gram was (proportionately) less than that of nontubewell farmers.

In the Gujranwala district, the intensity of cropping was about 115 per cent in the case of nontubewell farmers and about 146 per cent in the case of tubewell farmers. The main difference (27 per cent) was in the area under *kharif* crops and only a small difference (5 per cent) in the area under *rabi* crops. Almost the whole of the difference in the *kharif* season was in the area under rice, while in the *rabi* season the main difference was in the area under fodder.

[10]Cropping intensity is defined as the percentage of the area of the holding cropped in either *kharif* or *rabi* season. For example, a farmer who grows crops on 45 per cent of his holding in *kharif*, and 60 per cent of holding in *rabi*, has a cropping intensity of 105 per cent. If the land is completely sown to crops, both in *kharif* and *rabi*, there is 200 per cent intensity.

TABLE XIII

CROPPING PATTERNS FOLLOWED BY TUBEWELL AND NONTUBEWELL FARMERS IN THE MULTAN AND MONTGOMERY DISTRICTS AND GUJRANWALA DISTRICT

Crop	Multan and Montgomery districts		Gujranwala district	
	Nontubewell farmers	Tubewell farmers	Nontubewell farmers	Tubewell farmers
(1)	(2)	(3)	(4)	(5)
	Per cent of the area under each crop			
Cotton	27.5	38.2	2.7	1.8
Rice	0.2	0.7	36.0	62.2
Sugarcane	3.5	2.8	5.8	6.5
Maize	3.1	1.9	2.5	0.8
Kharif fodder	12.3	12.6	10.7	10.8
Fruits	1.6	7.9	0.7	2.7
Vegetables	0.2	2.5	0.9	1.1
Other *kharif* crops	0.6	1.0	1.1	1.1
Total *kharif*:	49.0	67.6	60.4	87.0
Wheat	33.9	35.8	32.3	31.7
Oilseeds	0.7	1.1	2.1	1.2
Gram	1.5	1.2	3.5	2.2
Rabi fodder	11.9	14.1	14.1	18.9
Fruits	1.6	7.9	0.7	2.6
Vegetables	0.3	2.0	0.4	1.5
Other *rabi*	0.3	1.4	1.4	0.9
Total *rabi*:	50.2	63.5	54.4	59.0
Grand total:	99.2	131.1	114.8	146.0

Source: Survey conducted by the PIDE.

Cropping Pattern Derived from Revenue Records

The cropping pattern determined in our survey is in line with the cropping patterns that may be calculated from the area under crops, as reported by the Revenue Department and compiled by the West Pakistan Bureau of Statistics [24]. We have calculated the percentage of area under each crop from the records of Bureau of Statistics for *rabi* 1962/63 and *kharif* 1963 for the Multan, Montgomery, and Gujranwala districts. The Bureau of Statistics classifies the area under each crop into irrigated and unirrigated. The irrigated area is further classified as irrigated from *i*) canals, *ii*) wells, *iii*) tubewells, *iv*) canals *plus* wells, *v*) canals *plus* tubewells, and *vi*) other sources. We have taken their figures of total irrigated area and compared it with area irrigated from tubewells and canals *plus* tubewells.

Data for Multan and Montgomery districts are given in Table XIV whereas those for the Gujranwala district are given in Table XV. Columns (2) and (3) of these tables give the actual area under each crop as copied from the records of the Bureau of Statistics. Columns (4) and (5) show the percentage of composition of the crops taking the total cropped area to be 100 per cent. Three things come out clearly from these tables:

a) With the installation of tubewells, the proportion of area under *kharif* crops increased whereas that under *rabi* crops decreased.

b) The proportion of area under cotton increased in the Multan and Montgomery districts whereas the proportion of area under rice increased in the Gujranwala district.

c) The proportion of area under all other crops decreased except in the case of fruits and vegetables in the Multan and Montgomery districts.

Cropping patterns shown in Tables XIV and XV for the total irrigated area are comparable to the nontubewell farmers in our survey, as both have an intensity of cropping of about 100 per cent on the total area. The results for area irrigated from tubewells and canals *plus* tubewells are, however, not comparable with the cropping pattern of tubewell farmers in our survey because we recorded the area of the holdings and were, thus, able to calculate the intensity of cropping on the basis of area of the holdings studied. The records of the Bureau of Statistics do not give the total area of holding and, therefore, we cannot calculate the total intensity of cropping. We have assumed in this paper that tubewell farmers in the whole district had the same intensity of cropping as the tubewell farmers in our survey and have recalculated the area under each crop on this basis. The results are shown in Table XVI for the Multan and Montgomery

TABLE XIV

TOTAL IRRIGATED CROPPED AREA, CROPS IRRIGATED FROM TUBEWELLS AND CANALS *PLUS* TUBEWELLS AND THE COMPOSITION OF CROPS IN THE MULTAN AND MONTGOMERY DISTRICTS

Crops	Actual area under crops		Composition of crops	
	Total irrigated area	Area irrigated from tubewells and canals *plus* tubewells	Total irrigated area	Area irrigated from tubewells and canals *plus* tubewells
(1)	(2)	(3)	(4)	(5)
	(.... '00' *acres*....)		(.... *per cent* ....)	
Kharif 1963				
Cotton	11553	1504	23.2	33.6
Rice	1505	88	3.0	2.0
Sugarcane	1497	115	3.0	2.6
Maize	781	66	1.6	1.5
Kharif fodder	5210	367	10.5	8.2
Fruits and vegetables	357	71	0.7	1.6
Other *kharif* crops	1931	97	3.9	2.2
Total *kharif*:	22834	2308	45.9	51.7
Rabi 1962/63				
Wheat	17136	1524	34.5	34.1
Oilseeds	1184	103	2.4	2.3
Gram	1906	65	3.8	1.5
Rabi fodder	5565	386	11.2	8.6
Fruits and vegetables	616	68	1.3	1.5
Other *rabi* crops	455	13	0.9	0.3
Total *rabi*:	26862	2159	54.1	48.3
Grand total:	49696	4467	100.0	100.0

Sources: *i*): Cols. (2) and (3): From the Bureau of Statistics [23].
ii): Cols. (4) and (5): Calculated from Cols. (2) and (3).

TABLE XV

TOTAL IRRIGATED CROPPED AREA, CROPS IRRIGATED FROM TUBEWELLS AND CANALS *PLUS* TUBEWELLS AND THE COMPOSITION OF CROPS IN THE GUJRANWALA DISTRICT

Crops	Actual area under crops		Composition of crops	
	Total irrigated area	Area irrigated from tube-wells and canals *plus* tubewells	Total irrigated area	Area irrigated from tubewells and canals *plus* tubewells
(1)	(2)	(3)	(4)	(5)
	(......'oo' *acres*......)		(......*per cent*......)	
Kharif 1963				
Cotton	335	52	3.4	2.0
Rice	3758	1361	38.1	51.6
Sugarcane	370	73	3.7	2.8
Maize	102	80	1.0	0.5
Kharif fodder	301	52	3.1	2.0
Fruits and vegetables	44	7	0.4	0.2
Other *kharif* crops	467	15	5.0	3.1
Total *kharif:*	5386	1640	54.7	62.2
Rabi 1962/63				
Wheat	2599	566	26.4	21.4
Oilseeds	201	29	2.0	1.1
Gram	167	41	1.7	1.6
Rabi fodder	1329	323	13.4	12.2
Fruits and vegetables	67	12	0.7	0.4
Other *rabi* crops	106	28	1.1	1.1
Total *rabi:*	4469	999	45.3	37.8
Grand total:	9855	2639	100.0	100.0

Sources: i) Columns (2) and (3): From the Bureau of Statistics [23].
ii) Columns (4) and (5): Calculated from Columns (2) and (3).

districts and in Table XVII for the Gujranwala district. The results of our survey are also repeated in these tables for the sake of comparison.

The following conclusions emerge from an examination of these tables:

i) For the total area irrigated, the proportion of *kharif* crops was less than that of *rabi* crops for the whole of the Multan and Montgomery districts (Table XVI, Column (3)), as well for the nontubewell farmers selected in our survey (Table XVI, Column (2)).

ii) For the area irrigated from tubewells and canals *plus* tubewells, the percentage of area under *kharif* crops was higher than that under *rabi* crops for the whole of these two districts as well as for tubewell farmers selected in our survey.

iii) For the Gujranwala district, the proportion of area under *kharif* crops was higher than that under *rabi* crops for the whole district (Table XVII, Column (3)) as well as for nontubewell farmers in our survey (Table XVII, Column (2)). For the area irrigated from tubewells and canals *plus* tubewells, however, the area under *kharif* crops was much higher than that under *rabi* crops. In these areas, the intensity of cropping in the *kharif* season reached as high as 87 to 90 per cent compared with about 55 to 60 per cent in the *rabi* season.

iv) In the Multan and Montgomery districts, the area under cotton was about 25 per cent for total irrigated area and for nontubewell farmers in our survey. For area irrigated from tubewells and canals *plus* tubewells, the area under cotton was about 40 per cent.

v) In the Gujranwala district, the area under rice was about 40 per cent for the total irrigated area and for nontubewell farmers in our survey and about 60 to 75 per cent in areas where tubewells were installed.

vi) In the Multan and Montgomery districts, the area under fruits and vegetables, wheat, and *rabi* fodders was much higher where tubewells were installed. In the Gujranwala district, the area under *rabi* fodders was considerably higher but the area under wheat was only slightly higher where tubewells were installed compared to the total irrigated area.

vii) The area under other crops such as sugarcane, maize, other *kharif* crops, gram, and other *rabi* crops was either the same or slightly less in tubewell-irrigated areas than in the total irrigated area.

TABLE XVI

CROPPING PATTERN OF SELECTED FARMERS (PIDE SURVEY) AND WHOLE DISTRICT (BUREAU OF STATISTICS RECORDS) FOR TOTAL IRRIGATED AREA AND AREA IRRIGATED FROM TUBEWELLS AND CANALS *PLUS* TUBEWELLS IN THE MULTAN AND MONTGOMERY DISTRICTS

Crop	Total irrigated area		Area irrigated from tubewells and canals *plus* tubewells	
	Selected farmers (PIDE survey)	Montgomery and Multan districts (Bureau of Statistics)	Selected farmers (PIDE survey)	Montgomery and Multan districts (Bureau of Statistics)
(1)	(2)	(3)	(4)	(5)
	(................. *per cent*		.................)	
Cotton	27.5	23.0	38.2	44.0
Rice	0.2	3.0	0.7	2.6
Sugarcane	3.5	3.0	2.8	3.4
Maize	3.1	1.6	1.9	2.0
Kharif fodder	12.3	10.4	12.6	10.8
Fruits	1.6	0.5	7.9	1.6
Vegetables	0.2	0.2	2.5	0.5
Other *kharif*	0.6	3.8	1.0	2.9
Total *kharif*:	49.0	45.5	67.6	67.8
Wheat	33.9	34.2	35.8	44.8
Oilseeds	0.7	2.4	1.1	3.8
Gram	1.5	3.8	1.2	2.0
Rabi fodder	11.9	11.1	14.1	11.3
Fruits	1.6	0.5	7.9	0.8
Vegetables	0.3	0.8	2.0	1.2
Other *rabi*	0.3	0.9	1.4	—
Total *rabi*:	50.2	53.7	63.5	63.3
Grand total:	99.2	99.2	131.1	131.1

Sources: *i*) Columns (2) and (4): From Table XIII, Columns (2) and (3).
ii) Column (3): Calculated from Table XIV, Column (4) multiplied by 99.2 per cent.
iii) Column (5): Calculated from Table XIV, Column (5) multiplied by 131.1 per cent.

TABLE XVII

CROPPING PATTERN OF SELECTED FARMERS (PIDE SURVEY) AND WHOLE DISTRICT (BUREAU OF STATISTICS RECORDS) FOR TOTAL IRRIGATED AREA AND AREA IRRIGATED FROM TUBEWELLS AND CANALS *PLUS* TUBEWELLS IN THE GUJRANWALA DISTRICT

Crop	Total irrigated area		Area irrigated from tubewells and canals *plus* tubewells	
	Selected farmers (PIDE survey)	Whole district (Bureau of Statistics)	Selected farmers (PIDE survey)	Whole district (Bureau of Statistics)
(1)	(2)	(3)	(4)	(5)
	(............... *per cent*		.................)	
Cotton	2.7	3.9	1.8	2.9
Rice	36.0	43.7	62.2	75.3
Sugarcane	5.8	4.2	6.5	4.1
Maize	2.5	1.1	0.8	0.7
Kharif fodder	10.7	3.6	10.8	2.9
Fruits and vegetables	1.6	0.5	3.8	0.3
Other *kharif* crops	1.1	5.8	1.1	4.6
Total *kharif*:	60.4	62.8	87.0	90.8
Wheat	32.3	30.3	31.7	31.2
Oilseeds	2.1	2.3	1.2	1.6
Gram	3.5	1.9	2.2	2.4
Rabi fodder	14.0	15.4	18.9	17.8
Fruits and vegetables	1.1	0.8	4.1	0.6
Other *rabi* crops	1.4	1.3	0.9	1.6
Total *rabi*:	54.4	52.0	59.0	55.2
Grand total:	114.8	114.8	146.0	146.0

Sources: *i*) Columns (2) and (4): From Table XIII, Columns (4) and (5).
ii) Column (3): Obtained by multiplying Column (4) of Table XV by 114.8 per cent.
iii) Column (5): Obtained by multiplying Column (5) of Table XV by 146.0 per cent.

Comparison with Harza Intensity of Cropping

In the above analysis, it was assumed that tubewell farmers in the whole of Multan, Montgomery and Gujranwala districts had the same intensity of cropping as that found for the tubewell farmers in our survey in these districts. It may be mentioned that similar results would be obtained if any other intensity of cropping is assumed for the areas where tubewells are installed. For example, Harza Engineering Company International propose an intensity of cropping of 60 per cent in *kharif* and 80 per cent in *rabi* or a total of 140 per cent in areas where tubewells are to be installed [9, p.30][11].

TABLE XVIII

PERCENTAGE AREA UNDER MAJOR CROPS ASSUMING INTENSITY OF CROPPING TO BE 140 PER CENT BASED ON RECORDS OF THE BUREAU OF STATISTICS FOR AREAS IRRIGATED FROM TUBEWELLS AND CANALS *PLUS* TUBEWELLS

Crop		Multan and Montgomery districts	Gujranwala district
(1)		(2)	(3)
		(......*per cent*....)	
Cotton		47.0	2.8
Rice		2.8	72.2
Other *kharif* crops		21.6	12.1
	Total *kharif:*	72.4	87.1
Wheat		47.7	30.0
Rabi fodder		12.0	17.1
Other *rabi* crops		7.9	5.8
	Total *rabi:*	67.6	52.9
	Grand total:	140.0	140.0

Sources: *i*) Column (2): Calculated from Table XIV, Column (5).
ii) Column (3): Calculated from Table XV, Column (5).

11Actually, Harza Engineering Company International give the intensity of cropping as 150 per cent, but they count the 10-per-cent area under sugarcane twice, once in the *kharif* season and once in the *rabi* season. In line with the practice in the Revenue and Agriculture Departments, we count the area under sugarcane only once. Therefore, Harza's intensity of cropping comparable to the figures in our tables is 140 per cent.

For an intensity of 140 per cent, the area under each crop can be calculated from the records of the Bureau of Statistics for areas served by tubewells and canals *plus* tubewells in the Multan, Montgomery, and Gujranwala districts. This has been done in Table XVIII. In the preparation of this table, we have multiplied the area shown against each crop in Column (5) of Table XIV and Column (5) of Table XV by 140 per cent. The results show that in the Multan and Montgomery districts, for 140-per-cent intensity of cropping, the area under cotton will increase to 47 per cent of the area of the holdings and the total *kharif* acreage will increase to over 72 per cent. The *rabi* acreage will, however, be limited to below 68 per cent. In the Gujranwala district, the area under rice will increase to over 72 per cent and that under all *kharif* crops to about 87 per cent. The area under *rabi* crops will be limited to about 53 per cent. These results are very similar to the results found in our survey but are quite inconsistent with Harza's proposal of 60-per-cent intensity in *kharif* and 80-per-cent intensity in *rabi*.

Comparison with Intensity of Cropping in SCARP-1

Our results in the previous sections are based on a cross-section study of tubewell and nontubewell farmers. In the Salinity Control and Reclamation Project Number One (SCARP 1) results are available for 12 scheme areas covering 1.14 million acres for the years 1962/63 and 1963/64. These results are presented in Table XIX. Columns (1) to (5) of this table show the actual area irrigated in *rabi* and *kharif* during the last two years and are taken from Appendix VI of *Salinity Control and Reclamation Project One (SCARP-1) Progress Report* for the period October 1963 to September 1964 [26]. Column (6) of Table XIX shows the percentage increase in the irrigated area in *rabi* 1963/64 over *rabi* 1962/63, whereas Column (7) shows the percentage increase in *kharif* 1964 over *kharif* 1963. In 6 schemes out of 12, the area under *rabi* crops in 1963/64 increased, whereas in the remaining 6 schemes it actually decreased. On the whole, there was an increase of about 1 per cent only in *rabi* 1963/64 compared to the previous year. On the other hand, there was an increase of about 18 per cent in the area under *kharif* crops in 1964 compared to 1963.

The very small increase in the *rabi* acreage was in spite of the fact that the farmers had access to all the water that they needed, but they did not use the water. In the *kharif* season they did and substantially increased the area cropped. This lends support to the results of our study.

It may be pointed out that when the operation of tubewells in SCARP-1 area started in 1961/62, there was at first a large increase in the area under *rabi* crops during the first two years. This was because parts of the SCARP-1 area were not getting much canal water in the *rabi* season. This is borne out by the fact that total intensity of cropping in the *rabi* season in 6 scheme areas in SCARP-1, for which records are available for pre-operation period, was 34.6 per cent[12]. Comparable intensity in the lower Chenab Canal as a whole was 55.5 per cent [28, p.108]. Thus, when the farmers got tubewell water they increased their *rabi* intensity in the first two years till it reached

TABLE XIX

COMPARATIVE IRRIGATION FIGURES OF RABI AND KHARIF 1962/63 AND 1963/64 IN SALINITY CONTROL AND RECLAMATION PROJECT NUMBER ONE (SCARP-1)

Scheme	1962/63		1963/64		Percentage increase or decrease in 1963/64 over 1962/63	
	Rabi 1962/63	*Kharif* 1963	*Rabi* 1963/64	*Kharif* 1964	*Rabi* Col.(4) ÷ Col. (2)	*Kharif* Col.(5) ÷ Col. (3)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
	(.......*hundred acres*.......)				(..*per cent*..)	
1) Harse Sheikh	166	111	155	134	—7	21
2) Beranwala	508	332	518	414	2	26
3) Hafizabad	682	616	693	774	2	26
4) Khangah Dogran	521	533	586	564	13	6
5) Sangla Hill	665	581	675	644	2	11
6) Shahkot	1326	999	1318	1186	—1	19
7) Shadman	339	324	297	363	—12	12
8) Zafarwal	1326	1022	1336	1254	1	23
Subtotal: Rows 1 to 8	5533	4518	5578	5333	1	18
9) Chuharkana	57	48	51	49	—11	2
10) Chichoki Mallian	23	38	11	35	—52	—8
11) Pindi Bhatian	55	24	34	28	—36	17
12) Jaranwala	554	454	623	557	13	23
Subtotal: Rows 9 to 12	687	564	719	669	5	19
Total: Rows 1 to 12	6220	5082	6297	6002	1	18
Per cent of culturable area of 1,411 thousand acres	54.5	44.5	55.2	52.6		

Sources: *i)* Columns (2) to (5): From [25].
ii) Columns (6) and (7): Calculated from Column (2) to (5).

[12] These 6 schemes were Harse Sheikh, Beranwala, Hafizabad, Khangah Dogran, Sangla Hill and Shadman areas. Total culturable area of these schemes was 581 thousand acres. Area under *rabi* crops before operation of tubewells was 201 thousand acres (34.6 per cent) and that under *kharif* crops was 219 thousand acres (37.6 per cent). Similar figures for other 6 schemes of SCARP-1 are not available.

54.5 per cent in 1962/63 (Table XIX, last row). After that there was very little increase in the area under *rabi* crops. However, the area under *kharif* crops increased from 44.5 per cent of the culturable area in 1963 to 52.6 per cent in 1964. Results of our survey indicate that the area under *kharif* crops may be expected to increase substantially during the next few years whereas area under *rabi* crops may not increase to the same extent.

Income and Expenditure of Tubewell and Nontubewell Farmers and Net Income due to Tubewell

According to the Department of Agriculture, each private tubewell will serve about 150 acres of canal-irrigated area [22, p. 65]. The present intensity of cropping, according to the Department of Agriculture, is 100 per cent in the former Punjab and Bahawalpur and about 60 per cent in the former Sind and N-W.F.P. With the installation of tubewells these intensities will increase to about 150 per cent in the former Punjab and Bahawalpur and to about 120 per cent in former Sind and N-W.F.P. [22, p. 60]. According to our estimates, each tubewell will serve only about 100 acres and not 150 acres in the canal-irrigated areas of the former Punjab and Bahawalpur. Our estimate is prepared as follows.

The present canal-water supply provides about 1.8 acrefeet per acre at the heads of the watercourses [8, p. II-5]. The water requirements of crops for a 140-per-cent intensity of cropping are estimated to vary from 2.98 acrefeet per acre to about 4.72 acrefeet per acre in different canal systems in the former Punjab [8, p. II-9]. The overall average for the Punjab canals comes to about 4.0 acrefeet per acre. The deficiency in canal-water supply is, thus, about 2.2 acrefeet per acre (4.0 *minus* 1.8). As one private tubewell pumps about 220 acrefeet of water in a year, it will cover about 100 acres of canal-irrigated area.

On the basis of the present cropping patterns followed by the farmers in the whole irrigated area in Multan and Montgomery districts (Table XVI), the present yields of crops as reported by the Department of Agriculture for the irrigated areas in these two districts, and the prevailing harvest prices as reported by the Director of Land Records, we have prepared an estimate of the gross income for a 100-acre nontubewell farm in these two districts. Similarly, on the basis of cropping patterns followed by the tubewell farmers in these two districts, the higher yields expected from the use of additional water on existing crops and increase in crop acreage expected with the installation of tubewells (Table XVI), an estimate of the gross income for a tubewell farmer operating a 100-acre farm has been prepared. These estimates are shown in Table XX.

While we were able to get reliable information on the area under each crop on tubewell holdings and on nontubewell holdings, we could not do so for the yield of crops. We did not have the time or the resources to have the crops harvested in our presence and did not make an effort to get accurate information from the farmers on the yields obtained by them. Therefore, for nontubewell farmers, we have used the average yields of irrigated crops as reported by the Department of Agriculture for the Multan and Montgomery districts. For tubewell farmers, we have prepared an estimate of the yield per acre on the assumption that each crop will get about 30 to 40 per cent additional water from tubewells and that this, with a small amount of additional fertilizer, will increase the yield by about 20 to 30 per cent. Increases in yield will be different for different crops. In our survey, the tubewell farmers used, on the average, 0.9 bags of fertilizer per acre for the entire area cropped, compared with 0.4 bags per acre used by nontubewell farmers. With the use of the 30 to 40-per-cent additional water and 0.5 bags per acre of additional fertilizer, we have assumed the following additional acre yields on tubewell holdings in the nonsaline groundwater areas of the Multan and Montgomery districts:

Crop	Increase in yield	
	Maunds per acre	Per cent
Cotton	3.0	30
Rice	2.5	25
Sugarcane (*gur*)	8.0	21
Maize	3.0	22
Wheat	3.0	22
Fruits and vegetables	15.0	21
Oilseeds	1.3	20
Gram	1.6	20

With the availability of additional water supply, yields are now limited by the amount of fertilizer available. If more fertilizer were available, much higher yields would be possible in the nonsaline groundwater areas.

TABLE XX

INCREASE IN THE INCOME BY INSTALLATION OF A TUBEWELL ON A 100-ACRE FARM IN COTTON-GROWING AREAS IN THE PUNJAB

Crop	Without tubewell					With tubewell			
	Area	Yield per acre	Production	Price per maund	Value	Area	Yield per acre	Production	Value
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	(*acres*)	(*maunds*)		(..*rupees*..)		(*acres*)	(*maunds*)		(*rupees*)
Cotton	25	10.0	250	31.0	7,750	43	13.0	559	17,329
Rice	2	10.0	20	20.0	400	3	12.5	38	760
Sugarcane	4	38.0	152	16.5	2,508	4	46.0	184	3,036
Maize	2	13.5	27	13.5	365	2	16.5	33	446
Kharif fodder	11				1,760[a]	11			2,200[b]
Fruits and vegetables	1	70.0	70	11.0	770	3	85.0	255	2,805
Other *kharif* crops	2	6.0	12	12.0	144	2	7.5	15	180
Total *kharif*:	**47**				**13,697**	**68**			**26,754**
Wheat	34	13.6	462	14.0	6,468	43	16.6	714	9,996
Oilseeds	2	6.5	13	23.0	299	3	7.8	23	529
Gram	4	8.0	32	14.4	461	2	9.6	19	274
Rabi fodder	11				2,200[a]	12			3,000[b]
Fruits and vegetables	1	70.0	70	11.0	770	3	85.0	255	2,805
Other *rabi* crops	1	6.0	6	18.0	108	1	8.0	8	144
Total *rabi*:	**53**				**10,306**	**64**			**16,748**
Grand total:	**100**				**24,003**	**132**			**43,502**

Share of the landlord at 50 per cent of gross produce	12,000 at 60 per cent of gross produce	26,100
Less expenses of the landlord (one-half of land revenue, water rate, *etc.*)	2,000	2,600
Net share of landlord before deducting annual operating cost of tubewell	10,000	23,500
Annual operating cost of tubewell	*nil*	6,160
Net income after deducting annual cost of tubewell	10,000	17,340
Income due to tubewell	*nil*	7,340

Source: see text.

[a]No data on price of fodder in the rural areas are available. Harza use a price of one rupee per maund [10, p. 48]. In the absence of market for fodder in the rural areas, we are using lower price of 160 rupees per acre for *kharif* fodder (about 0.64 rupee per maund) and 200 rupees per acre for *rabi* fodder (about 0.50 rupee per maund).

[b]Yield and value assumed to be 25 per cent higher on tubewell holdings.

Present yields of crops are shown in Column (3) of Table XX, and our estimates of the per acre yields on tubewell holdings are given in Column (8) of Table XX. On the basis of these figures, the gross income for the non-tubewell farmer comes to 24,000 rupees from 100 acres or 240 rupees per acre. The gross income from a 100-acre tubewell holding raising 132 acres of crops comes to 43,500 rupees. This is equal to about 330 rupees per acre cropped.

In the absence of adequate data on cost of production of crops in recent years, we have used in this study the difference between the rent or share of crop produce received by a tubewell farmer compared to a nontubewell farmer in calculating the net income due to tubewell. As stated on page 67, the general practice in the canal-irrigated areas is to share the produce between the landlord and the tenant on a fifty-fifty basis. When a landlord installs a tubewell in a canal-irrigated area, he gets 60 per cent of the produce and the tenant gets 40 per cent.

In our calculations on the above basis, the share of the landlord who does not have a tubewell comes to 12,000 rupees for a 100-acre farm in the Multan and Montgomery districts. Out of this, the landlord pays one-half of the land revenue and water rate and one-half of the cost of fertilizer, improved seed and payment to village artisans. These changes come to about 20 rupees per acre or about 2,000 rupees for the total area[13]. The net share of the landlord, thus, comes to 10,000 rupees for the farm or 100 rupees per acre. This is quite consistent with the cash rent prevailing in these two districts which is about 100 rupees per acre in villages not too close to the towns.

For a farmer who has installed a tubewell, the share of the produce comes to 26,100 rupees which is 60 per cent of the gross produce. After deducting charges for land revenue, water rates, improved seeds, fertilizer, *etc.*, the net share of the landlord comes to 23,500 rupees or 178 rupees per acre cropped. Out of this he has to bear the cost of operation of the tubewell. The annual cost of operation of a diesel tubewell including interest and depreciation in these districts comes to 6,160 rupees. Deducting this from the share of the

[13]Gill estimated the gross share of a landlord in the Lyallpur district in 1953/54 as 118.38 rupees per acre, share of expenditure of the landlord on land revenue, improved seed *etc.*, as 20.86 rupees per acre and net income of the landlord as 97.52 rupees per acre [5, p. 6]. For peasant proprietors the gross income, expenditure and net income per acre in the Lyallpur district in 1953/54 were estimated as 230.68 rupees, 97.29 rupees and 133.39 rupees respectively in the same study [5, p. 25]. Expenditure in this case, however, did not include value of family labour, interest and depreciation on bullocks and implements and value of farmyard manure. Gill imputed a sum of 48.75 rupees per acre as the value of these items. When these are deducted, the net income would be reduced to 84.64 rupees per acre.

TABLE XXI

INCREASE IN THE INCOME BY INSTALLATION OF A TUBEWELL ON A 100-ACRE FARM IN RICE-GROWING AREAS IN THE PUNJAB

Crop	Without tubewell					With tubewell			
	Area	Yield per acre	Production	Price per maund	Value	Area	Yield per acre	Production	Value
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	(*acres*)	(*maunds*)		(*rupees*)		(*acres*)	(*maunds*)		(*rupees*)
Cotton	4	8.0	32	30.0	960	3	9.3	28	840
Rice	42	11.0	462	25.0	11,550	72	13.8	944	24,850
Sugarcane	4	30.0	120	16.5	1,980	4	36.0	144	2,376
Maize	1	11.0	11	13.5	150	1	13.0	13	175
Kharif fodder	5				600[a]	5			720[b]
Fruits and vegetables	1	60.0	60	11.0	660	2	70.0	140	1,540
Other *kharif* crops	5	6.0	30	12.0	360	3	7.5	22	264
Total *kharif*:	**62**				**16,260**	**90**			**30,765**
Wheat	31	10.5	326	14.0	4,564	32	12.5	400	5,600
Oilseeds	2	5.0	10	23.0	230	2	6.0	12	276
Gram	2	7.0	14	14.4	202	2	8.0	16	230
Rabi fodder	15				3,000[a]	17			4,080[b]
Fruits and vegetables	1	60.0	60	10.0	660	2	70.0	140	1,540
Other *rabi* crops	1	6.0	6	18.0	108	1	7.0	7	126
Total *rabi*:	**52**				**8,764**	**56**			**11,852**
Grand total:	**114**				**25,024**	**146**			**42,617**
Share of the landlord at 50 per cent of gross produce					12,500	at 60 per cent of gross produce			25,570
Less expenses of landlord on land revenue, water rate, *etc.*					2,300				2,920
Net share of landlord before deducting annual operating cost of tubewell					10,200				22,650
Annual operating cost of a diesel tubewell					*nil*				4,740
Net income after deducting annual cost of tubewell					10,200				17,910
Income due to tubewell					*nil*				7,710

Source: see text.

[a]*See* note *a* to Table XX. In the rice-growing areas, demand for fodder in the villages is much less than that in cotton-growing areas in the *kharif* season. We are, therefore, using a price of 120 rupees per acre for *kharif* fodder. For *rabi* fodder, the price assumed is the same as that in cotton-growing areas, namely, 200 rupees per acre.

[b]Yield and value assumed to be 20 per cent higher on tubewell holdings.

landlord, the net share of the tubewell landlord comes to 17,340 rupees, compared with 10,000 rupees for the nontubewell landlord. The net income due to tubewell is, thus, 7,340 rupees which means that the landlord recovers more than the full cost of the diesel tubewell (12,000 rupees) in 2 years.

The cost of installation of an electric tubewell is 8,800 rupees (Table V) and the cost of operation of the same is 3,900 rupees for a year (Table VII). The net income of farmer having an electric tubewell, thus, comes to 19,600 (*i.e.*, 23,500 *minus* 3,900) rupees and income due to tubewell as 9,600 rupees. This means that a 100-acre farmer installing an electric tubewell recovers his full cost within one year.

Similar estimates for gross and net income for a 100-acre farm in the Gujranwala district are shown in Table XXI. The net share of produce of a nontubewell landlord growing 114 acres of crops on a 100-acre farm comes to 10,200 rupees or 90 rupees per acre cropped. An increase of 25 per cent in the yield of rice and 10 to 20 per cent in the yield of other crops has been assumed on tubewell holdings. On this basis the share of tubewell farmer growing 146 acres of crops on a 100-acre farm comes to 22,650 rupees or 155 rupees per acre from a similar area. After deducting the annual operating cost of 4,740 rupees for the diesel tubewell, the net income of the landlord comes to 17,910 rupees and income due to tubewell 7,710 rupees. This means that the cost of installation of 8,500 rupees for a diesel tubewell in the Gujranwala district (Table V) is realized in just over one year. The cost of an electric tubewell is realized in less than one year.

Income due to Tubewells from Different Sizes of Holding

In the above calculations the size of the holding was assumed to be 100 acres. Actually, farmers having all sizes of holding from below 25 acres to above 100 acres are installing tubewells (Table IX). We have, therefore, prepared an estimate of the gross income and net income for a 50-acre and a 25-acre tubewell holding in the Multan and Montgomery districts and in the Gujranwala district. This is given in Table XXII. In preparing this table it is assumed that 50 per cent of the water on a 50-acre holding and 75 per cent on a 25-acre holding is sold to neighbouring cultivators.

For a 50-acre tubewell holding, the net income due to tubewells varies between 4,100 and 4,400 rupees for a diesel tubewell. For an electric tubewell it comes to about 5,700 rupees (Row 8, Table XXII). The diesel tubewell owner, thus, recovers his cost in 3 years in the Multan and Montgomery districts and in 2 years in the Gujranwala district. The cost of the electric tubewell is recovered in less than 2 years in Multan and Montgomery districts and in less than one year in the Gujranwala district.

TABLE XXII

GROSS AND NET INCOME AND INCOME DUE TO TUBEWELL ON A 50-ACRE AND 25-ACRE HOLDING IN THE MULTAN, MONTGOMERY AND GUJRANWALA DISTRICTS

Holding	Multan and Montgomery districts			Gujranwala district		
	Without tubewell	With diesel tubewell	With electric tubewell	Without tubewell	With diesel tubewell	With electric tubewell
(1)	(2)	(3)	(4)	(5)	(6)	(7)
50-Acre Holding						
1) Area cropped	50	66	66	57	73	73
2) Net share of landlord per acre cropped	100	178	178	90	155	155
3) Total share of landlord	5,000	11,750	11,750	5,100	11,320	11,320
4) Income from sale of water[a]	*nil*	3,450	2,870	*nil*	2,870	2,300
5) Total income from farming and sale of tubewell water	5,000	15,250	14,620	5,100	14,190	13,620
6) Annual operating cost of tubewell[b]	*nil*	6,160	3,900	*nil*	4,740	2,740
7) Net income after deducting operating cost	5,000	9,090	10,720	5,100	9,450	10,880
8) Net income due to tubewell	*nil*	4,090	5,720	*nil*	4,350	5,780
25-Acre Holding						
9) Area cropped	25	35	35	29	39	39
10) Net share of the landlord per acre cropped	100	178	178	90	155	155
11) Total share of landlord	2,500	6,230	6,230	2,600	6,050	6,050
12) Income from sale of water[c]	*nil*	5,190	4,330	*nil*	4,330	3,460
13) Total income from farming and sale of water	2,500	11,420	10,560	2,600	10,380	9,510
14) Annual operating cost[b]	*nil*	6,160	3,900	*nil*	4,740	2,740
15) Net income	2,500	5,260	6,660	2,600	5,640	6,770
16) Net income due to tubewell	*nil*	2,760	4,160	*nil*	3,040	4,170

Source: see text.

[a]Sale of 1,150 hours of water at 3.0 rupees per hour from diesel tubewells and 2.5 rupees per hour from electric tubewells in the Multan and Montgomery districts and at 2.5 rupees and 2.0 rupees per hour from diesel and electric tubewells respectively in the Gujranwala district.

[b]From Table VII.

[c]Sale of 1,730 hours of water at rates shown in note *a* above.

For a 25-acre farmer, the net income due to tubewell varies between 2,800 and 3,000 rupees for diesel tubewell. For electric tubewell it comes to about 4,200 rupees (Row 16, Table XXII). For such small holdings, the Multan and Montgomery farmers recover their cost in about 4 years for diesel tubewells and about 2 years for electric tubewells. In the Gujranwala district, the farmers recover their cost in less than 3 years for diesel tubewells and in less than 2 years for electric tubewells.

Very probably the smaller farmers having 25 acres or less will install tubewells of lower capacity. Although the cost of pumping per acrefoot of water will be higher from these tubewells, their capital cost for installation as well as total operating cost during the year would be lower. Therefore, they may recover their capital cost in less time than indicated in these calculations. However, we did not study enough of these smaller tubewells to give quantitative estimates.

It may be pointed out that the capital-recovery capability estimated in this section is for the tubewells in the nonsaline groundwater areas of the Multan, Montgomery and Gujranwala districts. We did not select any tubewells in the saline groundwater areas. The capital-recovery capability of tubewells in the saline groundwater areas is likely to be very low and needs careful investigation.

V. CONCLUDING REMARKS

The evidence presented in this paper leads to five important inferences:

1) Provision of electricity to the rural areas of West Pakistan has been one of the main causes of rapid increase in tubewell installation in recent years. This appears to be due to the fact that cost of installation of an electric tubewell is about 3,000 rupees less than that of a diesel tubewell. Furthermore, the annual cost of pumping water from electric tubewells is about 2,000 rupees less than that from diesel tubewell. A very rapid development in tubewell installation may, therefore, be expected if electricity is made available to nonsaline groundwater areas which cover some 12 million acres in the former Punjab and Bahawalpur.

2) Private tubewell drillers have rapidly moved wherever demand for tubewell drilling was created consequent upon the provision of electricity. Therefore, if electricity is extended to all the 12 million acres of nonsaline groundwater areas during the third-plan period, private drillers are likely to rapidly expand their drilling capacity and meet the full demand of the farmers for tubewell installation.

3) Additional water pumped from tubewells enables the farmers to get extremely high returns in nonsaline groundwater areas. It enables them to

i) increase the depth of irrigation for 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.

All these increases enable the farmers to realize the full cost of tubewell installation in a period of two to three years for diesel tubewells and in one to two years for electric tubewells.

4) One of the major conclusions of this study has been that the area under *kharif* crops has increased much more rapidly than the area under *rabi* crops wherever adequate water supply has become available with the installation of tubewells. The largest increase has taken place in the area under cotton and rice. Both of these are valuable foreign-exchange earning crops. Government can assist this process further by making more water available in the *kharif* season by increasing the capacity of canals.

The water discharge of West Pakistan rivers generally begins to increase in April, culminating in high peaks in July and August after which the flow abruptly decreases reaching a low, but fairly constant, level from October to March. About 84 per cent of the annual river flow occurs during the six summer (*kharif*) months and only 16 per cent during the six winter (*rabi*) months. Nearly 44 per cent of the flow occurs during July and August [28, p. 85]. The river system of Pakistan is, thus, suited to a high *kharif* intensity and a low *rabi* intensity. The British engineers who designed the West Pakistan canal system, fixed the capacity of most canals to provide for a cropping intensity of about 25 to 30 per cent in *kharif* and 50 to 55 per cent in *rabi*. In this way, most canals could be fed more or less evenly throughout the year. In order to make use of the extra summer river water supply, additional nonperennial canals were designed to convey water to some areas during the *kharif* season only. The present position is that the winter supply of the rivers is fully utilized in the perennial canals, but during summer, specially from mid-June to mid-September, the rivers carry surplus water over and above the capacity of both perennial and nonperennial canals. This water could not be used in the past because there was not enough water in the rivers during the sowing and maturing period of additional *kharif* crops that could be given water from mid-June to mid-September. Now the tubewells can provide additional water during the sowing and maturing period of *kharif* crops. However, ultimately the pumping from tubewells will have to be limited to the amount of recharge from the surface. Therefore, if the more valuable foreign-exchange earning *kharif* crops are to be grown on a larger and larger scale, the capacity of the canals will have to be increased to divert additional river water during the *kharif* season.

5) From our visit to the villages where tubewells are being installed we have formed an impression that tubewells already installed are having a powerful influence on the saving habits of neighbouring cultivators and most of them are planning to have their own tubewells. So far the only outlet which the farmers had for their savings was purchase of land or construction of houses. The price of land being extremely high, returns on investment were low and there was less incentive for saving. Now for the first time the farmers have got a low-cost investment opportunity which yields extremely high returns. Therefore, they are saving to have their own tubewells in increasing numbers. The less enterprizing farmers of the past are now becoming more enterprizing, and a revolution in agriculture is taking place. The government can assist this revolution in agricultural development in West Pakistan by providing electric-transmission lines to all the nonsaline groundwater areas, making tubewell materials, particularly lining pipes and engines/motors, available on credit and providing other ancillary facilities to the farmers.

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Appendix A: PRIVATE TUBEWELLS

TABLE A-1

TOTAL NUMBER OF PRIVATE TUBEWELLS IN EACH DISTRICT ACCORDING TO REVENUE DEPARTMENT 1953/54 TO 1963/64

District	1953/54	1954/55	1955/56	1956/57	1957/58	1958/59	1959/60	1960/61	1961/62	1962/63	1963/64
1) D.I. Khan	*n.a.*	*n.a.*	10	10	52	105	124	131	131	149	149
2) Bannu	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*
3) Mardan	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*
4) Hazara	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*
5) Peshawar	*n.a.*	*n.a.*	6	6	6	6	6	6	7	7	8
6) Kohat	*n.a.*	*n.a.*	2	2	2	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*
7) Campbellpur	11	2	1	1	1	1	1	1	1	*nil*	*nil*
8) Rawalpindi	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*
9) Jhelum	5	3	3	3	3	3	5	3	4	7	8
10) Gujrat	8	9	22	69	102	102	112	159	177	198	250
11) Mianwali	17	19	19	19	19	19	20	28	28	37	72
12) Sargodha	57	77	77	77	105	106	106	85	89	157	156
13) Lyallpur	209	210	239	426	389	387	347	474	492	732	599
14) Jhang	105	135	180	178	192	256	403	648	671	738	770
15) Lahore	177	177	177	188	188	201	205	220	301	305	427
16) Gujranwala	96	119	130	143	183	550	1027	1437	1441	2222	2524
17) Sheikhupura	38	38	43	56	56	85	85	174	221	323	455
18) Sialkot	16	49	96	98	129	573	625	853	1215	1413	1422
19) D.G. Khan	13	39	32	37	45	51	58	82	86	93	93
20) Muzaffargarh	7	9	9	10	47	47	48	50	60	60	118
21) Multan	50	50	87	224	221	261	289	1,313	2,159	2,859	3,415
22) Montgomery	181	280	339	339	392	493	700	1,027	2,194	2,494	2,598
23) Bahawalpur	*n.a.*	*n.a.*	*n.a.*	*n.a.*	11	24	28	94	188	198	154
24) Bahawalnagar	*n.a.*	*n.a.*	7	7	7	7	7	16	59	115	126
25) Rahimyar Khan	*n.a.*	*n.a.*	16	18	18	18	18	103	233	279	302
Total:	990	1,216	1,495	1,911	2,168	3,295	4,214	6,904	9,757	12,404	13,646

Sources: i) 1953/54 to 1959/60: From *Season and Crop Reports.*
ii) 1960/61 to 1963/64: Information supplied by the Director, Land Records, Lahore, with his letters of March 15, 1965 and April 9, 1965.

TABLE A-2

NUMBER OF PRIVATE TUBEWELLS INSTALLED BY THE DEPARTMENT OF AGRICULTURE IN EACH DISTRICT 1953/54 TO 1963/64

District	1953/54	1954/55	1955/56	1956/57	1957/58	1958/59	1959/60	1960/61	1961/62	1962/63	1963/64
1) D.I. Khan	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	32	30	34	36
2) Bannu	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	1	4	*nil*	1
3) Mardan	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	3	*nil*	*nil*	*nil*
4) Hazara	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	1	2	*nil*	*nil*	*nil*
5) Peshawar	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	2	7	6	3
6) Kohat	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	1
7) Campbellpur	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	4	*nil*	*nil*	1	*nil*
8) Rawalpindi	*nil*	1	*nil*	*nil*	*nil*	*nil*	1	1	3	*nil*	3
9) Jhelum	*nil*	*nil*	*nil*	*nil*	*nil*	1	3	*nil*	*nil*	*nil*	*nil*
10) Gujrat	7	10	10	11	1	4	31	24	22	24	24
11) Mianwali	2	8	4	7	7	6	7	10	22	46	77
12) Sargodha	6	15	12	8	7	7	23	13	24	26	24
13) Lyallpur	38	30	45	48	59	53	67	82	93	110	112
14) Jhang	33	35	32	15	46	37	32	63	110	95	127
15) Lahore	10	19	5	7	10	8	12	23	37	34	72
16) Gujranwala	16	25	27	56	47	43	52	68	61	62	89
17) Sheikhupura	9	7	10	11	17	15	17	32	24	32	40
18) Sialkot	14	28	40	42	60	36	36	54	58	63	106
19) D.G. Khan	9	11	10	7	7	10	7	33	46	44	51
20) Muzaffargarh	3	4	8	4	5	8	11	28	51	70	47
21) Multan	30	17	40	41	39	45	57	132	194	206	260
22) Montgomery	15	29	47	45	48	70	94	152	177	149	165
23) Bahawalpur }								19	25	22	39
24) Bahawalnagar }	27	19	17	27	18	45	34	7	14	34	71
25) Rahimyar Khan }								36	38	30	62
Total:	219	258	307	329	371	388	489	817	1,040	1,088	1,410

Source: Statement supplied by the Director of Agricultural Engineering, Lyallpur, with his letter dated January 20,1965, and Superintending Engineer, Agricultural Machinery Organization, with his letter dated February 11, 1965.

Appendix B: COST OF INSTALLATION AND OPERATION OF PRIVATE TUBEWELLS

TABLE B-1

COST OF INSTALLATION OF DIESEL AND ELECTRIC TUBEWELLS IN DIFFERENT DISTRICTS OF THE PUNJAB

Item	Unit	Multan and Montgomery districts		Gujranwala and Sialkot districts		Overall average
		Qty.	Cost	Qty.	Cost	Cost
(1)	(2)	(3)	(4)	(5)	(6)	(7)
			(*rupees*)		(*rupees*)	(*rupees*)
Well-digging	Ft.	25	320	—	10	
Boring	Ft.	155	560	105	270	
Lining pipe	Ft.	80	1,180	40	360	
Strainer	Ft.	105	700	70	490	
Pump			740		520	
Belt, pulley, bolts, valve, bearing, angle iron and other parts			630		350	
Bricks	Thousands	18	940	9	470	
Cement	Bags	22	230	12	140	
Labour and other items			950		750	
Subtotal:			**6250**		**3,360**	
Motor	H.P.	18	2,550	14	2,040	
Engine	H.P.	20	5,750	18	5,140	
Total cost of an electric tubewell			8,800		5,400	7,100
Total cost of a diesel tubewell			12,000		8,500	10,300
Overall average			10,400		7,000	8,700

Source: Survey conducted by the PIDE.

TABLE B-2

ANNUAL WORKING EXPENSES AND COST PER ACREFOOT OF WATER PUMPED FROM DIESEL AND ELECTRIC TUBEWELLS IN THE DISTRICTS OF THE PUNJAB

Item	Montgomery and Multan districts			Gujranwala and Sialkot districts			Average of four districts
	Qty.	Rate	Value	Qty.	Rate	Value	Value
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Diesel-Engine Tubewells			(*rupees*)			(*rupees*)	(*rupees*)
Diesel oil (drums)[a]	42	75	3,120	32	77	2,470	
Mobil oil (tins)	135	5	670	103	5	510	
Repair charges			440			320	
Pay of driver and other cost			440			420	
Subtotal:			**4,670**			**3,720**	
Depreciation on tubewell	6,250	10%	630	3,360	10%	340	
Depreciation on diesel engine	5,750	6.7%	380	5,140	6.7%	340	
Interest on average cost	6,000	8%	480	4,250	8%	340	
Total annual cost:			**6,160**			**4,740**	
Cost per acrefoot	256		24.0	245		19.3	21.8
Cost per hour	2,360		2.6	2,430		2.0	2.3
Electric-Motor Tubewells							
Electricity used (kwh)	27,000	.08	2,150	20,500	.08	1,630	
Repair charges			420			310	
Other charges			180			100	
Subtotal:			**2,750**			**2,040**	
Depreciation on tubewell	6,250	10%	630	3,360	10%	340	
Depreciation on electric motor	2,550	6.7%	170	2,040	6.7%	140	
Interest on average cost	4,400	8%	350	2,700	8%	220	
Total annual cost:			**3,900**			**2,740**	
Cost per acrefoot	215		18.1	191		14.3	16.4
Cost per hour	2,350		1.7	2,200		1.2	1.5

[a]Drum contains 45 to 48 gallons.

Source: Survey conducted by the PIDE.

Appendix C

METHOD USED IN CALCULATING THE DISCHARGE OF A PRIVATE TUBEWELL

The discharge of tubewells was calculated by comparing it with the discharge of canal outlet. The discharge of a canal outlet in the former Punjab is directly proportional to the area commanded by the outlet and is one cusec for every 350 acres of land commanded on most canal systems in the former Punjab. The following information was, therefore, obtained from each tubewell farmer and nontubewell farmer for calculating the discharge of the tubewell:

a) total area of land commanded by the canal outlet,

b) the area of the holding and length of water turn (in hours) allotted to the tubewell (or nontubewell) farmer,

c) area irrigated by the canal outlet in twelve hours,

d) area irrigated by the tubewell in twelve hours.

Let us assume that in a particular case:

a) the total area of all holdings on the canal outlet is 525 acres;

b) the tubewell farmer owns 50 acres of land and is allotted 16 hours of canal water every 7 days. Further that the nontubewell farmer has 12½ acres and is allotted 4 hours of water supply after every 7 days;

c) that area irrigated by the canal outlet is 5½ to 6 acres in 12 hours; and

d) that area irrigated by tubewell is 4 acres in 12 hours.

Questions *b*) and *c*) were asked simply to check the area of the canal outlet and the discharge calculated for that area. In the above example, the tubewell farmer should get a water turn equal to $(50/525) \times (7 \times 24)$ hours= 16 hours. This is what he actually got. Therefore, the total area on the canal outlet is 525 acres. The discharge of an outlet commanding 525 acres would be 1.5 cusecs $(525 \div 350 \times 1)$. One cusec of water is equal to 2 acrefeet a day. Therefore, the above outlet will deliver 3 acrefeet in 24 hours or 18 acreinches in 12 hours. One irrigation of a dry but previously irrigated field takes about 3 acreinches of water [21, p. 167]. Therefore, the above outlet should irrigate about 6 acres of land located just near the outlet head in

12 hours. About 10 to 20 per cent of the water supply is lost in transit in the water course. Therefore, the area irrigated by the canal outlet at a distance from the outlet head would be about 5 to 5½ acres depending upon the distance from the outlet head. If this is the answer given by the tubewell and the nontubewell farmers, we know that the discharge of the canal outlet is about 1.5 cusecs.

If the tubewell located on the same canal outlet irrigated about 4 acres in 12 hours against 5½ acres irrigated by the canal outlet, it would be reasonable to assume that discharge of the tubewell was 1.1 cusecs against 1.5 cusecs of the canal outlet.

Development of Irrigated Agriculture in East Pakistan: Some Basic Considerations

Ghulam Mohammad

This chapter originally appeared as an article in the Autumn-1966 issue of *The Pakistan Development Review* and is the result of the research carried out by the author during his association, in the capacity of a Senior Research Economist, with the Pakistan Institute of Development Economics, where he was on deputation from the Planning Commission of Pakistan from March 1963 to July 1967.

Valuable comments were made on earlier draft by Dr. Walter P. Falcon of the Harvard Advisory Group in the Planning Commission of Pakistan, Drs. Gordon C. Winston and Philip S. Thomas, Research Advisers at the Institute, Mr. Majid Hasan Khan, Director of Agricultural Engineering, West Pakistan, and Mr. Kenneth C. Brown, Consultant on Private Tubewells to the Government of West Pakistan. Mr. A. Q. Ziauddin, a Staff Economist at the Institute, collected material from the Pakistan Academy for Rural Development, Comilla, various offices of the East Pakistan Agricultural Development Corporation and the East Pakistan Water Power Development Authority.

Mr. Ghulam Mohammad breathed his last in Rome in September 1967 while on a short-term deputation to the Food and Agriculture Organization of the United Nations.

Development of Irrigated Agriculture in East Pakistan: Some Basic Considerations

Ghulam Mohammad

INTRODUCTION

East Pakistan is characterized by a heavy monsoon rainfall accompanied by inundation of vast areas during the summer season. The inundation is caused by high-flood levels of two of the largest rivers of the world, the Brahmaputra-Jamuna and the Ganges-Padma and by the influx of such major tributaries as the Meghna within the deltaic area. Probably nowhere else in the world is there such a confluence of great rivers as in East Pakistan.

The heavy precipitation and extensive inundation create difficulties for most crops other than rice. Thus, rice is grown on 23 million acres or 112 per cent of the 20.5 million acres of the net area sown[1]. The area of all other crops is 5 million acres, raising the total cropped area[2] to 28 million acres. This gives an intensity of cropping[3] of 137 per cent.

[1] *Net area sown* represents the area actually used for cropping purposes during a year, regardless of number of crops raised on it.

[2] *Total cropped area* represents the aggregate area of all crops raised on the same land during different seasons of the year. East Pakistan has three growing seasons, namely, the summer or *aus* season from March to July; the *bhadoi* or *aman* season from July to November and the *rabi* season from November to March.

If one acre of land is used for growing an *aus* crop as well as an *aman* crop and a *rabi* crop, the net area sown will be one acre, whereas the total cropped area will be three acres.

[3] *Intensity of cropping* represents the ratio between the total cropped area and the net area sown. It is usually shown as a percentage. Thus, the cropping intensity of rice in East Pakistan is $23/20.5 \times 100 = 112$ per cent whereas the total cropping intensity is $28/20.5 \times 100 = 137$ per cent.

From November to March, the rainfall is insufficient for crop production and less than four million acres are grown to winter crops. These crops depend upon the remaining soil moisture, with hoped-for assistance from uncertain showers. The months of October, April and May also frequently have insufficient rainfall for good crop-yields. Some crops also suffer from drought for short period during the monsoon.

In the absence of large funds for investment and advanced engineering and agricultural technology, the cultivators have had to adapt themselves to naturally occurring conditions of land and water rather than modify these conditions so that both land and water could be fully used around the year. The long dry period from October to April, the inundation due to floods and the uncertainty of the monsoon, which determines the pattern of agriculture in East Pakistan, point to the development of irrigation, flood control and drainage as the means for a rapid development of agriculture in East Pakistan.

Master Plan for Water Resources Development

The East Pakistan Government has been working on the problem during the last seven years. A "Master Plan" has been prepared by the International Engineering Company of San Francisco (IECO) for the East Pakistan Water and Power Development Authority (EP-WAPDA) [24 ; 25]. The water development projects included in this Master Plan are estimated to cost Rs. 9,960 million including Rs. 2,882 million in foreign exchange upto 1985 [24, p. 4]. Out of the total cost, about Rs. 4,226 million are proposed to be spent by 1970 and Rs. 7,846 million by 1975 [24, p. 6].

The major emphasis in the IECO Master Plan is on *flood-control* measures. The Master Plan is basically a massive scheme for empoldering[4] large parts of East Pakistan into 50 projects which would provide flood-protection and drainage facilities to about 12.1 million acres and irrigation facilities to about 7.9 million acres by 1985 [24, p. 2].

About Rs. 8,810 million or 88 per cent of the total estimated cost is proposed to be spent on flood-control and multipurpose projects (which include flood-control, drainage and irrigation facilities). Only Rs. 1,150 million or 12 per cent of the total cost is proposed for purely irrigation projects [24, Pp. 120-121].

Under the IECO Master Plan, the *flood-control* works would be provided in the *first stage*. This is because every year large areas (estimated at about

[4]Empoldering means division of area into units called polders which are provided with embankments on all sides to prevent inundation.

ten million acres) are flooded by the three major rivers, the Ganges-Padma, the Brahmaputra-Jamuna, the Meghna and their tributaries. The farmers of East Pakistan have learnt to live with these normal floods over the centuries [24, p. 87]. However, when the floods are abnormal either in their date of arrival, rapidity of rise or mangnitude of duration, the losses of crops, livestock and property are generally severe[5].

Flood protection is to be obtained by building some two thousand miles of embankments along the major rivers and their tributaries. Embankments on both sides of the three main rivers, the Brahmaputra-Jamuna, the Ganges-Padma and the lower Meghna, are proposed to be completed by 1975. The protecting embankments would be designed with regulators for admitting flood waters to the project areas when required and for evacuating excess quantities of water by gravity or by pumping.

The Master Plan envisages the development of *irrigation* at the *second stage.* Within the total protected area of 12.1 million acres, irrigation is to be provided for about 1 million acres by 1975 and to about 3.9 million acres by 1985. In addition, in areas not requiring flood protection, irrigation would be provided to about 1.5 million acres by 1975 and to about 4 million acres by 1985 [24, p. 119; 27, Pp. B-VII-48-49].

In flood-protected areas, surface water would be brought by gravity canals through regulators in the embankments when rivers are full and by pumping from the rivers when they are low. Within the project areas, the fields would be supplied with water by a gravity canal system with distributaries and water courses. Relift pumps would be provided in some areas to supply land not commanded by gravity canals.

Maximum annual diversions from the main rivers would be about 41.7 million acrefeet (MAF) for irrigation of about 6.8 million acres by 1985 [24, p. 112]. This would mean an average annual diversion of about 6.2 acrefeet per acre irrigated.

Groundwater is available in many parts of the province. However, the IECO states that because of the high cost of development and operation of wells, groundwater projects would be limited to a small area in the Rangpur, Dinajpur, Mymensingh and Comilla districts where recharge is assumed to be adequate and which lack an adequate supply of surface water [24, p. 111].

[5]In 1955, an area of 12.6 million acres or 38 per cent of total land area of East Pakistan was inundated. Similarly, there were severe floods in 1954, 1956, 1962 and 1964.

In 1962, the loss of crops alone was estimated at Rs. 1,100 million [24, p.87]. Comparable detailed estimates of loss of crops for other years are not available.

Although low-lift pumps of the Agricultural Development Corporation are mentioned in the Master Plan, there is no reference to smalllow-lift pumps which can be purchased and used by farmers themselves. Similarly, there is no reference to private tubewells which have proved so successful in West Pakistan during the second-plan period.

The IECO states that the flood-control projects of the type recommended by them are seldom able to retire the capital investment directly from benefits in any part of the world. Rather, the investment in such projects is viewed as prudent use of public resources for indirect as well as direct returns. In this connection the IECO refers to flood-protection works on the Mississippi which presumably have not been able to retire the capital cost [24, p. 137].

The IECO further states that if direct cash flow from the completed Master Plan projects is not enough to cover interest on capital costs and operation and maintenance, then new capital must be raised for each step of the total development. The IECO also points out that general and special taxes on the entire province may be the best means of accumulating improvement capital,b ut they consider that it will prove one of the most difficult and complicated aspects of the implementation of the Master Plan [24, p. 137].

The recoveries of charges from the beneficiaries will be less than the interest on capital and the cost of operation and maintenance. The sum outstanding against the Master Plan projects in 1985 for capital cost plus the annual deficit on operation of these projects is estimated to amount to a total of Rs. 12,162 million as against the capital cost of Rs. 9,960 million [24, p. 138].

The IECO Master Plan envisages an increase in the gross crop value at constant prices from Rs. 3,059 million in 1964 to Rs. 6,694 million in 1985 [24, p. 174]. This means an annual rate of increase of 3.8 per cent in agricultural production during the 21-year period.

Rice production is expected to increase from 9.5 million tons in 1964 to 19.6 million tons in 1985. The IECO assumes that an increase of 4.3 million tons can result from the use of fertilizers, improved seeds, plant-protection measures and improved farming practices [27, p. B-VII-II]. This would raise rice production in East Pakistan from 9.5 million tons in 1964 to 13.8 million tons by 1985 without water-development projects. The balance of 5.8 million tons of rice can be obtained, according to the IECO, only by major *flood control* and drainage projects provided in the *first stage* with *irrigation* projects provided in the *second stage.*

Planning Commission Proposals

While the IECO takes the position that *flood control* is the *prerequisite* of agricultural development in East Pakistan, the Planning Commission seems to have taken a stand that covers both positions. Although they state that small-irrigation schemes without flood-control works are more important, they make a smaller allocation for small-irrigation schemes than for flood-control works. Thus, in the *Third Five Year Plan*, the Planning Commission states: "It is apparent, however, that the extent to which the agricultural potential of the province can be realized depends *on* great measure on the additional *water* that can be made available during the winter months. Conditions are ideal during this period for intensive irrigated agriculture and a large segment of the Province can eventually grow two or even three complete crops per year" [38, p. 304]. The Planning Commission further states "that in most years supplemental winter irrigation is possible for about 11 million acres including 4 million acres of *boro* rice and 7 million acres of other crops such as fruits, vegetables, oilseeds and livestock fodder. Thus.... a large and vigorous low-lift pumps and surface irrigation programme during the third-plan period is practicable" [38, p. 305]. However, while making allocations for the third-plan schemes, the Planning Commission provided only Rs. 390 million for "irrigation schemes" out of total allocation of Rs. 2,268 million for "water development schemes". Against this, a sum of Rs. 1,746 million is provided for "flood regulation schemes" and for "multipurpose development schemes" most of which include flood-control and drainage works [39, Pp. 21-22].

Strategy Proposed in this Paper

After an examination of the existing irrigation schemes in East Pakistan, the author considers that the IECO has investigated the possibilities of large gravity canals fed by large pumping plants installed on the rivers and protected by flood-control works in considerable detail. They do not, however, appear to have investigated fully the possibilities of greatly expanded use of low-lift pumps and small tubewells which can be used without a costly gravity canal system and a costly flood-control system. An examination of the current irrigation schemes and cropping patterns in East Pakistan indicates that a very large increase in agricultural production can be realized by concentrating on small low-lift pumps and small tubewells. These can provide supplemental winter irrigation to about eleven million acres including four million acres of *boro* paddy and seven million acres of other *rabi* crops such as fruits, vegetables, potatoes, oilseeds, wheat and maize and other fodder crops as estimated by the Planning Commission [38, p. 305].

At present the *aus*[6] paddy, jute and sugarcane crops suffer from drought during March, April and May. The *aus* paddy also suffers flood damage in June and July. The low-lift pumps and tubewells can enable a large part of the nine million acres under *aus* paddy, jute and sugarcane to be sown early and escape the damage from drought as well as floods.

Similarly, at present the *aman* crop suffers from delayed transplanting due to lack of sufficient rainfall or due to late harvesting of the *aus* crop. Also, droughts in October and November, at the critical flowering and maturing stage, cause considerable reduction in yields. The low-lift pumps and tubewells can enable high yields to be obtained from *aman* paddy by providing supplemental irrigation at the time of transplanting but more particularly at the time of flowering and maturity. The author, therefore, recommends that the strategy proposed by the IECO be modified and most *irrigation* projects be executed in the *first stage* and most *flood-control* and drainage projects be executed in the *second stage*. For this purpose, part of the funds should be diverted from multipurpose and flood-control schemes to winter irrigation schemes during the next five to ten years. With the introduction of high-yielding rice varieties, expanded use of fertilizers, and other improved agricultural practices it should be possible to reach the rice production target of 19.6 million tons with small irrigation schemes during the winter, early summer, and late autumn seasons without executing major flood-control schemes.

Hypotheses Enunciated in this Paper

The above strategy is based on a number of hypotheses which are enunciated in the following paragraphs. These hypotheses will be tested against the working of existing irrigation projects in East Pakistan in Sections II and III of this paper.

[6]There are three rice crops in East Pakistan. These are: *aus* paddy grown on some seven million acres; *aman* paddy grown on about fifteen million acres; and *boro* paddy grown on about one million acres. Out of fifteen million acres under *aman* crop, about six million acres are sown by broadcasting and about nine million acres by transplanting.

The term *aus* is derived from the Bengali word 'ashu' and means early. The origin of the words *aman* and *boro* is not well established.

The *aus* crop is adapted to relatively dry conditions. It is also sown in March to May and harvested in June to August.

The *broadcast aman* is sown in areas where depth of flooding ranges between three to twelve feet. It is sown in March-April and harvested in November-December.

The *transplanted aman* is grown in areas where depth of flooding is zero to three feet. The seed of this *aman* is sown in June-July, the seedlings are transplanted in July-August and the crop is harvested from November to January.

The *boro* crop is grown as a winter crop in areas which are too deeply flooded during the summer to permit growing any other crop. The seed of *boro* is sown in November-December, the transplanting is done in December-January and the crop is harvested in April-May.

Total cultivated area of East Pakistan is 21.6 million acres, including 20.5 million areas as net area sown and 1.1 million acres of current fallow[7]. Out of this, only 2 million acres is above flood level. A major part of the remaining area of 19.6 million acres is subject to flooding of varying depths (Appendix Table A-1). The *first* hypothesis of this paper is that small irrigation schemes, such as low-lift pumps and tubewells, can be executed in a large part of East Pakistan without providing major flood-protection works A system of large gravity canals, fed by diversion or pumping from the rivers, as proposed in the IECO Master Plan, would need complete flood-protection works. Flood-protection works are likely to be exceedingly costly in East Pakistan because of the sheer magnitude of the flood water. The maximum combined discharge of Ganges-Padma-Brahmaputra-Jamuna between 1956 and 1962 was 5.1 million cusecs [24, p. 88]. By comparison, the maximum discharge of the Mississippi River in the United States was only 2.1 million cusecs in 1927 which is considered as the maximum on record [24, p. 92]. The cost of small irrigation schemes based on small low-lift pumps and small tubewells is, therefore, likely to be only a small fraction of the cost of large gravity canals supported by a system of flood-control works.

Our *second* hypothesis is that water requirements of crops for supplementary irrigation are likely to be small. East Pakistan receives about 60 to 120 inches of rainfall in a major part of the province and large areas are inundated by floods every year. The mean annual evaporation is only about 45 to 50 inches [28, plate A-II-6]. Most of the low and intermediate lands (which constitute 72 per cent of the total cultivated area of East Pakistan) have relatively high watertables even during the dry season. The depth of the watertable seldom exceeds 10 to 15 feet, and in many places is within 3 to 4 feet of the soil surface. At the end of the monsoon it comes to within 1 to 2 feet of the surface in most places. Under these conditions, with predominantly silty soils, considerable moisture is supplied to the plant root zone by capillarity. With the advent of irrigation, it is likely that watertables will be even closer to the soil surface and requirements for supplementary irrigation will be small [27, p. B-VII-32].

Our *third* hypothesis is that although *large pumps* are technically more efficient, compared to small pumps, insofar as utilization of fuel and the cost of pumping per unit volume of water is concerned, they are *more costly* insofar as the cost of water delivered to the fields is concerned. This is because they need a costly canal distribution system and a large part of the pumped water is lost by seepage in the distribution system before it reaches the crop-

[7]*Cultivated* area consists of *net area sown* plus *current fallow*. *Current fallow* is that part of the cultivated area which is not cropped during a particular year, but was cropped in the previous year.

ped land to be irrigated. The benefits from large gravity canals are also reduced because of the long gestation period of these projects.

A *fourth* hypothesis, which is an extension of the *third* hypothesis, is that although the cost of installation and operation of *tubewells* for each unit of water pumped is high, the actual cost of delivery of water is less than that in the case of large gravity canals fed from large pumping plants installed on the rivers. The tubewell water can be used where it is pumped without providing for a costly canal distribution system and practically no seepage losses are involved in the distribution system. Another reason for the low cost of water delivered to the fields by tubewells is that practically no gestation period is involved.

The *fifth* hypothesis is that although small *private* low-lift pumps and small *private* tubewells may be *less efficient* in the utilization of fuel and pumping of water, as compared to large *government* low-lift pumps and large *government* tubewells, they are *more economical* because of their very low capital cost, extreme care with which they are worked by the farmers and the great economy in the use of irrigation water brought about by the farmers when they have to pay for the pump, the tubewell, and the fuel.

Our *sixth* hypothesis is that *irrigation* schemes in a country like East Pakistan, where there is practically no rainfall and practically no cropping for about six months of the year, are likely to be *highly productive* and would fully retire the capital cost from the direct benefits. The cash flow from these schemes would not only cover the interest on capital cost and operation and maintenance cost, but would also leave considerable income to pay for the cost of flood-control projects proposed for second stage of development.

The *seventh*, and the last hypothesis, which is an extension of the sixth hypothesis, is that *irrigation* lays a firm ground, technically and economically, for improved farm practices, most particularly for the rapid introduction of *high-yielding varieties* and greatly expanded use of *fertilizer*. As high-yielding varieties and fertilizer spread with expansion of irrigation, a chain reaction is set up; irrigation supporting the expansion of high-yielding varieties and fertilizer use, and high-yielding varieties and fertilizer use supporting the rapid expansion of irrigation. The farmers are, therefore, likely to take up, on a private basis, small low-lift pumps and small tubewells along with the high-yielding varieties and fertilizers.

The above hypotheses are tested against the working of the existing irrigation projects in East Pakistan. Some of the surface-water development projects are discussed in Section II whereas some of the groundwater development projects are discussed in Section III. The benefit-cost estimates of all projects studied in this paper are compared in Section IV and a summary of conclusions is given in Section V.

II. SURFACE-WATER DEVELOPMENT

Two projects dealing with surface-water development in East Pakistan will be considered in this section. One of these deals with the large gravity canal system fed by large pumping plants installed on the rivers, which is the major type of irrigation recommended by the IECO for East Pakistan. The second deals with low-lift pumps which are recommended by the author for large-scale use.

A typical example of the first type is the Ganges-Kobadak Project which is in the most advanced stage of development. A typical example of the second type is the "Mechanical Cultivation and Power-Pump Irrigation" scheme operated by the Agricultural Development Corporation (ADC).

1. GANGES-KOBADAK PROJECT

The Kushtia Unit of the Ganges-Kobadak Project is located south of the Ganges-Padma and the Gorai river and covers most of the Kushtia district. The project provides for a gravity canal system fed by large pumping plants installed on the river Ganges to serve about 3,30,000 acres of land.

Work on Kushtia Unit of the Ganges-Kobadak project was started in 1955 following approval of the project by the government in 1954. A powerhouse to provide electricity for the pumping of water from the Ganges river into large gravity canals to serve the area was completed in 1958. A number of difficulties arose in the construction of the main pumping plant to house three large pumps with a total capacity of 3,000 cusecs. An auxiliary pumping plant with 12 medium-size pumps, having a total capacity of 1,400 cusecs, was completed in 1961. The main pumping plant is still under construction, 12 years after the project was approved [25, Pp. 320-321].

The twelve medium-size pumps installed in the auxiliary pumphouse get frequently out of order, but cannot be repaired until the water level in the river and in the intake channel falls in November [18, p. 4]. Any breakdown of the pumps during the summer thus results in loss of pumping throughout the summer season.

Maintenance of the intake channel has also presented problems due to formation of shoals. The intake channel is excavated by dredgers every winter but is filled up with silt during the next monsoon season [18, p. 4].

The Kushtia Unit is divided into two phases. Irrigation canals have been laid out in 94,000 acres included in phase one of the unit. The canal system includes 46 miles of main canal, 133 miles of secondary canals, 310 miles of tertiary canals and 500 hydraulic structures. From these canals 1,770 outlets were planned for the irrigation of 94,000 acres by constructing field channels which were to be dug by the farmers. The farmers have so far refused to construct the field channels except in small areas. The project authorities have, therefore, increased the number of outlets to 3,055 [18, p. 6]. Even then each outlet will have to irrigate an average of about 31 acres and field channels will have to be constructed if the entire area of 94,000 acres is to be irrigated.

In order to understand the behaviour of the farmers it is pertinent to remember that the project was started in 1955 but that no water was made available upto 1962. On the contrary, the project authorities, in protecting the area from floods by embankments shut off the flood waters which had been used for natural flood irrigation by the farmers for centuries before. The rainfall in this area is low: about fifty to sixty inches a year, compared to the provincial average of over eighty inches a year. The flood water was essential for raising a rice crop and the cutting-off of this flood water turned the farmers against the WAPDA authorities.

Even after 1962, when pumping was started, canals have been run at below the full-supply level. Therefore, irrigation water could not have reached the fields of all the farmers even if they had constructed the field channels. It was, therefore, only natural that the farmers refused to construct the field channels. In August and September 1965, most (though not all) channels were run to full-supply level [18, Annexure 6]. The farmers did use the incoming water for irrigation of 28,600 acres during September 1965 (*see*, Table I) by flooding their fields from plot to plot, a practice which they had used for centuries with natural flood waters before the Ganges-Kobadak Project was started.

The method of flood irrigation from plot to plot is an exceedingly costly and wasteful method for use of the pumped water. Total depth of water pumped for each acre of crop grown in 1965/66 was about 240 acreinches (Column (6) of Table I). It has been assumed by the IECO that about half of the pumped water is lost in the canal system [24, p. 184]. The irrigation water used for each crop grown was, therefore, about 120 acreinches. Water use of 120 acreinches is exceedingly high particularly when compared with the irrigation water used in areas served by low-lift pumps of the ADC (discussed in the next section) where the farmer raised a *boro* crop with only 21 acreinches of pumped water. It appears that either more than half of the pumped water was lost in the canal system *or* that much of the water put

TABLE I

WATER PUMPED, AREA IRRIGATED, AND DEPTH OF WATER USED ON EACH ACRE IRRIGATED ON THE GANGES-KOBADAK PROJECT IN 1965

Month	Fortnight	Water requirement based on area for which indent was placed by the extension staff on the engineering staff	Actual water supplied by the engineering staff	Total area irrigated	Average depth of irrigation per acre irrigated
(1)	(2)	(3)	(4)	(5)	(6)
		(......cusecs......)		(acres)	(inches)
June	Second	65	427	6,800	23
July	First	18	137		
	Second	56	315	3,400	49
August	First	229	471		
	Second	248	740	10,700	42
September	First	293	1,085		
	Second	264	983	28,600	26
October	First	314	1,027		
	Second	220	882	7,000	100
Total, June to October					240

Source: Columns (1) to (4): From [18, p. 51]. Column (5) from [19].
Column (6) : the actual quantity of water given in cusecs converted into acreinches by multiplying cusecs in Column (4) with the number of days in each fortnight and then multiplying The resultant cusec-days with 24 (each cusec-day assumed to be equal to 24 acreinches).

on fields was removed by the farmers onto unsown land and then put into drains.

Capital Cost

In December 1964, the IECO estimated the capital cost of Kushtia Unit at Rs. 232 million out of which Rs. 28.9 million or 12.5 per cent was allocated to the Jessore Unit [25, p. 230]. The Project Director of the Ganges-Kobadak Project estimates the cost of the Kushtia Unit at Rs. 333.9 million (Appendix Table A-2). Out of this, about 12.5 per cent or Rs. 41.6 million may be allocated to the Jessore Unit. The net capital cost of the Kushtia Unit would be about Rs. 292.3 million for a total irrigatable area of 330 thousand acres. The per acre capital cost thus comes to over Rs. 886. The capital cost of canals and hydraulic structures to be provided on these canals accounts for nearly one half of the total cost, *i.e;* about Rs. 153 million or Rs. 460 per acre (Appendix Table A-2).

A sum of Rs. 221.5 million had been spent on the Ganges-Kobadak Project by March 1966 and the remaining sum of Rs. 112.4 million is required for completion of the work during the third-plan period.

Annual Cost

The annual cost of the Kushtia Unit was estimated by the IECO, in December 1964, at Rs. 15.0 million for 330 thousand acres or Rs. 45.4 per acre irrigated. This is based on the following assumptions:

i) The total capital cost of the Kushtia Unit would be Rs. 232 million out of which Rs. 28.9 million (or 12.5 per cent) would be allocated to the Jessore Unit and Rs. 203.1 million to the Kushtia Unit [25, p. 320].

ii) Interest will be charged at the rate of 4 per cent [25, p. 185].

iii) The life of the project will be 50 years, therefore repayment of the capital cost has been based on a sinking-fund contribution and interest payment, both at 4-per-cent interest for 50 years [25, p. 185].

iv) Replacement reserves were established as a sinking-fund contribution at 4-per-cent interest. The life of replaceable items was assumed as varying from 20 years for culverts, 25 years for mechanical equipment, 35 years for electrical equipment and 40 years for substations [25, p. 185].

v) The annual cost of maintenance and operation of irrigation, flood control and drainage features was set at 2 per cent of the capital cost [25, p. 186].

vi) The price of electricity was assumed to be Re. 0.05 per kilowatt hour for pumping purposes [25, p. 186].

The author considers that most of the above assumptions by the IECO are incorrect or unjustified and need modification. For example:

i) The capital cost of the Kushtia Unit is estimated at Rs. 334 million by the Project Director of the Ganges-Kobadak Project as against Rs. 232 million estimated by the IECO (*see*, Table III).

ii) A 4-per-cent rate of interest is very low for Pakistan as a measure of opportunity cost. According to Mahbubul Haq: "It would seem that a

shadow price of capital between 8 to 10 per cent would be . . appropriate. ." [17, p. 47]. The author has used a rate of interest of 8 per cent for *all* projects discussed in this paper.

iii) The life assumed for some of the items appears to be excessive. The mechanical equipment, such as the pumping plants, is not likely to last for twenty-five years in East Pakistan. The twelve medium-size pumps installed in 1961 had to be completely overhauled in 1965. It is unlikely that they will last up to 1986. A ten-year life would be more appropriate for such items.

iv) The average price of electricity in East Pakistan according to the IECO Master Plan works out to be Re. 0.18 per kwh in 1965/66, Re. 0.15 in 1974/75 and Re. 0.125 per kwh in 1984/85 [28, p. D I-7]. While it is perfectly legitimate to subsidize the sale of electricity for use in agriculture in initial years, for the purpose of benefit-cost analysis, the full cost must be taken into consideration. In this paper, the price of electricity has been assumed to be Re. 0.125 per kwh for estimating the benefit-cost ratio.

The author has recalculated the annual operation cost on the basis of the revised assumptions, points *i*), *ii*) and *v*) above, and the results are presented in Table II below.

TABLE II

ANNUAL COST PER ACRE AS ESTIMATED BY IECO AND AS ESTIMATED BY THE AUTHOR FOR THE KUSHTIA UNIT OF GANGES-KOBADAK PROJECT

(*in million rupees*)

Item	Estimated by IECO	Estimated by the author
(1)	(2)	(3)
Interest and amortization	10.8a	23.9b
Operation and maintenance	2.4	3.4c
Replacement reserve	0.1	0.1
Power	1.7	4.3d
Total annual cost	15.0	31.7
Cost per acre (*rupees*)	45.4	96.0

aOn the basis of capital cost of Rs. 203 million and interest rate of 4 per cent.
bOn the basis of capital cost of Rs. 292 million and interest rate of 8 per cent.
cIncrease in proportion to capital cost.
dPrice of electricity assumed to be Re. 0.125 per kwh against Re. 0.05 assumed by the IECO.

Source: Column (2): From [25, p.320]. Column (3): From estimates by the author, *see* text.

The total annual cost increases to Rs. 31.7 million and cost per acre comes to Rs. 96 per acre against Rs. 45.4 per acre as estimated by the IECO.

Benefit-Cost Ratio

The present value of crop production from 330 thousand acres is estimated by the IECO at Rs. 91.8 million or Rs. 278 per acre [25, p. 320]. The value of crop production is expected to rise to Rs. 233.6 million or Rs. 700 per acre at the time of full development. The increase will result from higher yields per acre and from increases in the intensity of cropping from the present 140 per cent to 228 per cent [25, p. 320].

The gross annual benefit would amount to Rs. 141.7 million. The cost of production of crops is estimated at 50 per cent of the gross value. The net benefit would, therefore, be Rs. 70.9 million or Rs. 215 per acre. The benefit-cost ratio was, thus, worked out by the IECO as 215/45 = 4.7. If the full annual cost of Rs. 96 per acre, estimated by the author, is taken into account, the benefit-cost ratio falls to 215/96 = 2.2.

Proposals for Increasing the Efficiency of Water Use on the Ganges-Kobadak Project

It was shown in Table I that the present cropping on the Ganges-Kobadak Project means a water use of 120 acreinches per acre which is an exceedingly high figure particularly when compared to the ADC low-lift pumps where twenty-one acreinches were used to raise a *boro* crop in 1964/65 (*see* Table V) and the cooperative villages of the Pakistan Academy for Rural Development (PARD), Comilla, where only fifteen acreinches were used to raise a *boro* crop in 1965/66 (*see* Table IX).

A considerable loss of water is inevitable in the early stages of development of irrigation on *all* large canal systems when the area cropped is small in relation to the available water supply. This loss can be reduced by extending the area under irrigated crops by constructing field channels. There must, however, be some strong incentive for the farmers to shift from flood irrigation to controlled irrigation which is possible with field channels. The new high-yielding rice varieties evolved at the International Rice Research Institute (IRRI), Manila, and introduced in East Pakistan in 1966 are expected to provide this incentive. The difference that an early sown and transplanted/irrigated IRRI rice, with the proper application of fertilizer, would make to the production of a crop in the *aus* season is likely to be quite spectacular so that once the farmers see the effect of this transplanted/irrigated-fertilized crops, they will begin to construct their channels and may complete them in a few years. For this purpose, it would be necessary to lay out fertilizer

demonstration trials on IRRI rice on each tertiary canal in the project area in the 1966 *aman* season, if the farmers have to grow the IRRI rice in the 1967 *aus* season, when seed would be available for considerable part of the area that can be grown with the IRRI varieties. At present, *aus* rice is grown on about 50 per cent of the total cultivated area in the project [25, p. 320]. A large part of the 47,000 acres can be put under irrigated transplanted *aus* with IRRI seed during the 1967 or 1968 *aus* season, if all the canals are run at full-supply level from February to June 1967. It would be desirable to run all the canals at full-supply level from now onward so that the farmers will develop confidence in the availability of water when they need it.

Summary: Ganges-Kobadak Project

The first unit of the Ganges-Kobadak Project, known as the Kushtia Unit, provides for a gravity canal distribution system fed by large pumping plants installed on the Ganges river to irrigate about 330 thousand acres of land in the Kushtia district. The capital cost of the project is estimated at Rs. 292 million or Rs. 886 per acre. The annual operating cost is estimated at Rs. 96 per acre. The benefits are estimated at Rs. 215 per acre and the benefit-cost ratio works out to be 2.2.

Work on the project was started in 1955 but serious difficulties have been encountered in the construction of the main pumphouse which is to house 3 large pumps of a total capacity of 3,000 cusecs. The pumphouse is still under construction 12 years after the project was approved. An auxiliary pumphouse was constructed to house 12 medium-size pumps with a total capacity of 1,400 cusecs. These pumps were installed in 1961 but have frequently gone out of order during the last two years. These cannot be repaired until the water level in the river and the intake channel falls in November. The intake channel also presents serious problems. It gets silted up during the monsoon and has to be excavated by dredgers every winter.

The canal system has been completed for a total area of 94,000 acres but the farmers have so far refused to construct the field channels. Water is being used by flooding from plot to plot with the result that 240 acreinches of water were pumped for each acre irrigated during 1965/66. About 120 acreinches were actually put on each acre irrigated.

The efficiency of water use on the Ganges-Kobadak Project can be greatly increased by the introduction of high-yielding IRRI rice varieties combined with optimum use of fertilizer. This will provide an incentive to farmers to construct the field channels and to make use of controlled irrigation water required for the IRRI rice varieties.

The following factors regarding the Ganges-Kobadak Project lead us to the conclusion that further work on such large gravity canals fed by large pumping plants installed on the rivers should be delayed till alternative methods of irrigation have been more thoroughly investigated:

i) The high capital cost involved, *ii*) the difficulties encountered in the construction of the main pumphouse to house the large pumps, *iii*) frequent breakdown of the medium-size pumps housed in the auxiliary pumphouse, *iv*) inability to repair the medium-size pumps so long as the water level in the river and in the intake channel remains high, *v*) difficulties involved in the maintenance of the intake channel, *vi*) failure to utilize the irrigation water by the farmers by refusing to construct field channels, and *vii*) comparatively low benefit-cost ratio of the project.

2. LOW-LIFT POWER PUMPS

The IECO has given details of a large number of surface-water development projects involving gravity canals fed by diversions from rivers or by pumping plants installed on the rivers. However, only a passing reference has been made to the low-lift pump programme of the Agricultural Development Corporation (ADC). The low-lift pump programme of the ADC is not included in the IECO Master Plan and is not discussed in detail.

As low-lift pumps are likely to make a greater contribution to agricultural production in East Pakistan during the third-plan period than all the surface-water development projects of the WAPDA, these will be discussed in somewhat greater detail in this paper.

The ADC Programme

In the districts of Sylhet, Mymensingh, Dacca and Comilla there are large areas of very low lands which are deeply flooded during the summer season. No crops can be raised in these areas until the flood waters have receded in October or November. Most of these lands are fertile and have been brought under *boro* paddy which is grown from December to April. As rainfall is very scanty during the winter, supplemental irrigation is required. Supplementary irrigation has been applied over the centuries by lifting water from low-lying places and from small streams and drainage channels on to the fields by crude country methods.

In order to provide irrigation facilities to the *boro* crop on a large scale, a scheme for the "Mechanical Cultivation and Power Pump Irrigation" was introduced in East Pakistan in 1951/52 and expanded in 1955/56. The number of power pumps increased sharply from 40 in 1955/56 to 1,345 in 1959/60

and the area irrigated increased from less than 3,000 acres in 1955/56 to over 47,000 acres in 1959/60 [23]. The scheme was further expanded during the second-plan period (Appendix Table A-3) and the maximum acreage of 1,57,000 acres was irrigated with 2,300 pumps in 1963/64.

The ADC has proposed to expand this scheme by purchasing 16,000 two-cusec pumps during the third-plan period and to reach a target of irrigation of 7,50,000 acres of *boro* paddy by 1969/70 (Appendix Table A-4).

Capital Cost

The capital cost of a two-cusec pump is estimated at about Rs. 7,500 by the ADC [5, p. 5]. The ADC had 1,100 one-cusec pumps which were purchased in 1956/57 and 1957/58 at an average price of about Rs. 5,000 each [8]. No additional one-cusec pumps have been purchased since then.

The capital cost of a two-cusec pump has now increased to Rs. 8,650 [7, p.12]. We have assumed a proportionate increase in the capital cost of a one-cusec pump from Rs. 5,000 to Rs. 5,770.

Annual Operating Cost

The ADC estimates the cost of irrigation of one acre of *boro* paddy at Rs. 57.5 per acre with a two-cusec pump [5, p. 5]. No estimates are presented for a one-cusec pump by the ADC.

We have collected information on hours worked, fuel consumed, and area irrigated by two-cusec pumps and by one-cusec pumps during the last three years. The results are presented in Appendix Table A-3 and are summarized in Table III below.

TABLE III

HOURS WORKED AND AREA IRRIGATED BY TWO-CUSEC AND ONE-CUSEC PUMPS OF ADC: 1962/63 to 1964/65

Year	Hours worked per pump		Area irrigated per pump		Fuel consumed per pump	
	Two-cusec pump	One-cusec pump	Two-cusec pump	One-cusec pump	Two-cusec pump	One-cusec pump
(1)	(2)	(3)	(4)	(5)	(6)	(7)
	(....hours....)		(....acres....)		(....rupees....)	
1962/63	928	687	63	69	700	520
1963/64	707	729	64	60	800	610
1964/65	639	756	60	42	1030	680
Average for three years	733	717	62	59	840	610

Source: [Appendix Table A-5].

During the last three years, 1962/63 to 1964/65, the two-cusec pumps irrigated, on the average, 62 acres of crops and used an average of Rs. 840 worth of fuel. The one-cusec pumps irrigated almost as much area (59 acres) as the two-cusec pumps and used an average of Rs. 610 worth of fuel.

On the basis of the capital cost of Rs. 8,650 and Rs. 5,770 for two-cusec and one-cusec pumps, respectively, average irrigated area of 62 acres and 59 acres, and average fuel consumption as shown in Table III, the author has calculated the annual operating cost of two types of pumps. These are shown in Columns (2) and (3) of Table IV. Other items like cost of operating staff, ADC overhead charges, *etc.*, are taken from the calculations provided by Mr. Hobbs [23].

The annual operating cost comes to Rs. 60 per acre for two-cusec pumps and Rs. 50 per acre for one-cusec pumps. The ADC has been charging Rs. 37 per acre but has not been able to realize the whole of this hire charge. It has so far been able to realize about Rs. 10 million out of Rs. 20 million [10, p. 16]. The total area irrigated to-date is about 700 thousand acres. The recoveries have, therefore, averaged about Rs. 14 per acre. A subsidy of about 71 per cent has, therefore, been involved in the use of one-cusec pumps and 77 per cent in the use of two-cusec pumps.

Benefit-Cost Ratio

The ADC estimates the yield of *boro* paddy raised on low-lift pumps at 25 maunds per acre [10, Pp. 16-17]. Although no crop-cutting experiments have been done by the ADC, the work carried out by the Pakistan Academy of Rural Development (PARD), Comilla, indicates that the estimates obtained by the ADC are reasonable. The price of *boro* paddy in 1964/65 was about Rs. 16 per maund [45, Pp. 48 and 66][8]. The gross income from one acre of *boro* paddy was, thus, Rs. 400 per acre (25 × 16). The cost of production of all crops raised with the aid of irrigation is estimated as 50 per cent of the gross value on IECO-WAPDA projects [25, p. 186]. If the same rate is adopted for the ADC pumps, the net income would be Rs. 200 per acre, against the estimated expenditure of Rs. 60 and Rs. 50 per acre respectively on two-cusec and one-cusec pumps. The benefit-cost ratio is thus 3.3 for two-cusec pumps and 4.0 for one-cusec pumps.

[8]Mahmoodur Rahman, Research Specialist at the Pakistan Academy for Rural Development, Comilla, estimated the yield of irrigated *boro* paddy at 24 maunds per acre in 1964/65 [45, p. 48].

The price of *boro* paddy was Rs. 17 per maund [45, p. 48], whereas price of *shaita* paddy was Rs. 15 per maund [45, p. 66]. An average price of Rs. 16 per maund has been taken for the two varieties combined.

TABLE IV

ESTIMATED ANNUAL OPERATING COST OF TWO-CUSEC AND ONE-CUSEC PUMP UNDER THE EXISTING ADC SYSTEM AND WHEN FARMERS HAVE TO PAY FOR FUEL *PLUS* ANNUAL RENTAL CHARGES

Item	When ADC pays for the fuel and charges flat per acre rate		When farmers pay for fuel *plus* annual rental charges	
	Two-cusec pump	One-cusec pump	Two-cusec pump	One-cusec pump
(1)	(2)	(3)	(4)	(5)
1) Interest and amortization at 8 per cent in 10 years (8650 × .149 and 5770 × .149)	1,289	860	1,289	860
2) Interest and amortization on building and equipment	82[a]	55[b]	82[a]	55[b]
3) Fuel consumption	840[c]	610[c]	1,080[e]	840[f]
4) Spares, travelling, transport and contingencies	270[a]	180[b]	220[g]	147[g]
5) Pay of staff	1,197[a]	1,197[d]	750[h]	750[h]
6) ADC's overhead charges	65[a]	43[b]	65[a]	43[b]
	3,743	2,945	3,486	2,695
Area irrigated (*acres*)	62	59	90	70
Cost per acre irrigated (*rupees*)	60	50	39	39

Source: see text.

a Estimates by Mr. Hobbs [23].

b In proportion to the capital cost of Rs. 8,650 and Rs. 5,770 respectively.

c From Table III.

d Pay of staff for one-cusec pump assumed the same as that for two-cusec pump.

e For 90 acres at Rs. 12 per acre against Rs. 11 per acre incurred in 1962/63. One rupee extra for increased price of diesel oil in 1966/67.

f For 70 acres at Rs. 12 per acre.

g Some reduction due to less staff to be supervised.

h Assistant pump drivers and most of the unit staff engaged in collection of hire charges not required.

Proposal for Raising the Efficiency of ADC Pumps

The question of increasing the efficiency of the ADC pumps has been dealt with at length by Mr. Richard H. Patten of the Harvard Advisory Group, Dacca. In a paper on "Pilot Projects in Irrigation" involving cooperation between the Basic Democracies, the Agricultural Development Corporation, the Agricultural Directorate and the Water and Power Development Authority [40], it has been pointed out that the present system of per acre charge for low-lift pumps has three main disadvantages. *First*, it gives no incentive to the farmers to economise on use of water. *Second*, there is no incentive for the farmers to assist the ADC in an assessment of the acreage irrigated or to assist in the actual collection of the payment. The ADC must, as a consequence, maintain a large staff to make recoveries and even then not more than half of the hire charges are recovered. *Third*, the pump driver and the local people are given an incentive to falsify the records on the amount of fuel used and sell part of the fuel in the market [40, p. 12].

The actual working results of the ADC pumps (Table V) during the last three years confirm these points. Columns (2) and (4) of Table V show that the number of hours taken to irrigate one acre of *boro* paddy by a two-cusec pump was reduced from fifteen in 1962/63 to eleven in 1964/65.

However, the cost of fuel consumed by the pumps increased from eleven rupees per acre in 1962/63 to seventeen rupees per acre in 1964/65. This was inspite of the fact that the cost per gallon of diesel oil for the ADC remained the same[9].

TABLE V

HOURS WORKED, WATER USED AND FUEL CONSUMED PER ACRE IRRIGATED BY A TWO-CUSEC ADC PUMP

Year	Hours worked	Water used	Fuel consumed
(1)	(2)	(3)	(4)
	(hours)	*(acreinches)*	*(rupees)*
1962/63	15	29	11
1963/64	11	22	13
1964/65	11	21	17

Source: Calculated from Appendix Table A-5.

It has been proposed [40] that the Basic Democracies and Local Government Department through the Thana Councils and the Union Councils organize groups of farmers for use of low-lift pumps and use the works programme funds to pay the first year's hire charges of Rs. 1,000 for those organized groups of farmers who agree to pay Rs. 100 in advance. In the second and third years, the charges by Thana Council would be gradually reduced and those by farmers increased while in the fourth year the farmers groups would pay the entire Rs. 1,100 in advance [40, p. 14].

[9]Though an excise duty of Re. 0.20 per gallon was levied on diesel oil in 1964/65 and another Re. 0.20 in 1965/66, this did not affect the ADC, as a rebate equal to the excise duty was allowed for the use of diesel oil in agriculture.

The cost of fuel would be borne by the farmers groups from the very first year.

The ADC has agreed to this system of a fixed hire charge of Rs. 1,100 for a two-cusec pump plus cost of fuel from 1966/67 onward. It is anticipated that this will lead to the following significant changes:

i) considerably increase the area irrigated by the pumps,

ii) considerably reduce the cost of operation of the pumps, and

iii) increase the recoveries of hire charges.

The change in the system of realization of hire charges in the Comilla Kotwali Thana caused an increase of over 50 per cent in the area irrigated by each tubewell in 1965/66 (*see*, Column (5) of Table IX). The change in system of collecting hire charges may be expected to cause a similar increase in the area irrigated by the ADC pumps from 64 and 60 acres in 1963/64 and 1964/65 to about 90 acres or more for a two-cusec pump during 1966/67.

An average area of ninety acres per two-cusec pump is not excessive. An irrigation of sixty-nine and sixty acres was actually achieved with the one-cusec ADC pumps throughout East Pakistan during 1962/63 and 1963/64 (*see*, Table VI). Some of the two-cusec pumps in the Mymensingh and Sylhet districts have irrigated between seventy and ninety acres in recent years under the old system of realization of hire charge (*see*, Table VI). They may, therefore, be expected to reach an average irrigation of ninety acres per pump with the change in the system of hire charges.

The change in the system of collecting hire charges may be further expected to reduce the cost of fuel from seventeen rupees per acre in 1964/65 to the 1962/63 level of about eleven rupees per acre in 1966/67, when the farmers have to pay for the amount of water actually used. Charging for the fuel will mean metering water itself. Under the old system, a flat fee regardless of quantity of water used was levied so that water was used till the marginal product was equal to zero.

Annual Operating Cost when Farmers Pay for Water Used

The annual operating cost for a two-cusec pump irrigating 90 acres of *boro* paddy, when the farmers pay for quantity of water used by buying their own fuel, is shown in Columns (4) and (5) of Table IV. It is assumed that no assistant pump driver will be appointed and that much of the staff, which is used for collection of hire charges, will not be required. It is further assumed that the ADC will continue to maintain workshops and provide repairs and spares for the pumps. It is also assumed that ADC will maintain the fuel depots but will no longer issue any fuel to the pump drivers. The farmers will purchase their own fuel from the ADC depots or from the local market for operation of the ADC pumps. Under the new system, the total annual operating cost of a two-cusec pump is likely to be reduced from Rs. 3,743 for 62 acres at present to about Rs. 3,486 for 90 acres of *boro* irrigation by farmers or Rs. 39 per acre. Out of the total annual cost, the farmers will pay about Rs. 2,180 or Rs. 24 per acre. They will spend Rs. 1,080 on fuel and pay Rs. 1,100 as annual hire charges to the ADC. The balance of Rs. 1,300 (or 37 per cent of the cost) will be borne by the government as a subsidy on the ADC pump operations. The subsidy of 37 per cent compares with the present subsidy of about 75 per cent borne by the government on the ADC operations.

The annual operating cost of a one-cusec pump is likely to be reduced from Rs. 2,945 for 59 acres at present to about Rs. 2,695 for 70 acres when farmers have to buy their own fuel. It may be appropriate to fix the annual rental charges for one-cusec pump at two-thirds of the rental charges of two-cusec pumps, that is, in proportion to the capital cost of the two. This would mean an annual rental charge of about Rs. 700 per pump. The farmers will then pay in all Rs. 1,540 (Rs. 840 for fuel and Rs. 700 as annual rental charges). The balance of Rs. 1,155 or 43 per cent of the annual cost will be borne by the government as a subsidy.

Benefit-Cost Ratio under the Proposed Programme

Under the new system proposed, the gross income and the Rs. net income would be the same as under the old system, that is, Rs. 400 and Rs. 200 per acre respectively.

The annual operating cost would, however, be reduced to only Rs. 39 per acre against Rs. 60 and Rs. 50 per acre under the old system. The benefit-cost ratio would, thus, be 200/39 = 5.1 against 3.3 and 4.0 under the old system.

Introduction of high-yielding IRRI-rice varieties, combined with the optimum use of fertilizer, would greatly increase the yield of *boro* paddy on the ADC pumps. According to Chandler [4, p. 21], these varieties should yield a minimum of about 75 maunds per acre during the *boro* season with good irrigation facilities and with 100 pounds of nitrogen, 40 pounds of phosphates and 40 pounds of potash. All the farmers are not likely to apply the optimum dose of fertilizer. The author has assumed that the farmers will apply an average of about 60 pounds of nitrogen, 30 pounds of phosphate and 20 pounds of potash. With this level of fertilizer application they would probably get about 50 maunds of paddy per acre, giving a gross return of Rs. 800. The cost of production is not likely to increase in the same proportion. The cost of production (excluding cost of fertilizer and irrigation) may go up from Rs. 200 with the old varieties to about Rs. 300 with the new IRRI varieties. The net income would, therefore, rise to Rs. 500 per acre. The cost of fertilizer, at an unsubsidized rate, comes to about Rs. 55 per acre[10]. Water requirements of IRRI rice would also be higher. These may be 50 per cent higher than those of ordinary *boro*. The fuel consumption will, therefore, increase from Rs. 12 to Rs. 18 per acre and total cost of irrigation from Rs. 36 to Rs. 42 per acre.

Total cost of fertilizer and water would then come to Rs. 97 per acre. The benefit-cost ratio would be 500/97 = 5.2. The net income for the farmers would increase from Rs. 164 (=200−36) with *boro* paddy to Rs. 403 (= 500 − 97) per acre by growing IRRI rice.

TABLE VI

AVERAGE AREA COVERED BY TWO-CUSEC AND ONE-CUSEC PUMPS OF ADC IN DIFFERENT ZONES OF EAST PAKISTAN: 1962/63 to 1964/65

Year	Capacity	Average area irrigated per pump in							Average East Pakistan
		Sylhet	Kuliar-char	Chitta-gong	Dacca	Brahman-baria	Nao-gaon	Jessore	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1962/63	Two-cusec	96	77	35	55	52	43	—	63
	One-cusec	53	70	38	40	111	36	—	69
1963/64	Two-cusec	76	71	42	48	81	44	—	64
	One-cusec	68	40	36	33	82	62	—	60
1964/65	Two-cusec	77	62	36	50	71	53	46	60
	One-cusec	35	32	53	53	22	—	124	42
3-year average	Two-cusec	82	68	38	51	70	46	46	62
	One-cusec	54	52	41	46	86	43	124	59

Source: Calculated from statements supplied by the Agricultural Development Corporation with their letter No. ADC/ENG/DEVB/IP-33/65/3225, dated December 7, 1965.

10Urea 1.6 maunds at Rs. 20 per maund (Rs. 32), triple-superphosphate 0.8 maunds at Rs. 20 per maund (Rs. 16) and muriate of potash 0.5 maund at Rs. 14 per maund (Rs. 7).

Acquisition of Pumps during Third-Plan Period: One-cusec Versus Two-cusec

The ADC has proposed the acquisition of 16,000 two-cusec pumps during the third-plan period (Appendix Table A-4). Figures in Table VI indicate that the actual area irrigated by the two-cusec pumps in Chittagong, Dacca, Naogaon and Jessore zones during the second-plan period justified the use of one-cusec pumps instead of two-cusec pumps.

As the number of pumps increases during the third-plan period, the area available at each site would probably become smaller and smaller. It would, therefore, be more economical to purchase 24,000 one-cusec pumps instead of 16,000 two-cusec pumps during the third-plan period. The cost of both would be the same. The one-cusec pumps can be used in Chittagong, Dacca, Naogaon and Jessore zones and in all other parts of East Pakistan. The presently available two-cusec pumps can be concentrated in Sylhet, Kuliarchar and Brahmanbaria zones where larger blocks of land are available.

The ADC does not want any one-cusec pumps even when the size of block available is just enough for a one-cusec pump and not for a two-cusec pump. The ADC states: "In similar conditions, *i.e.*, if a two-cusec set is used in a one-cusec block, there will be saving of approximately Rs. 400 per set" [8, p. 4]. The "saving" of Rs. 400 claimed by ADC results because two pump drivers are supposed to be required for a one-cusec pump and only one pump driver is supposed to be required for a two-cusec pump. An additional pump driver is claimed for one-cusec pump because the pump has to be worked for 1,000 hours in the season whereas the two-cusec pump has to work only 500 hours in the season.

Two questions arise in this connection:

i) does a one-cusec pump need two drivers?

ii) does Pakistan have so much extra capital that it can afford to purchase equipment costing Rs. 8,650 to do the work which can be done by an equipment costing Rs. 5,570?

Regarding *i*) the ADC pumps working for 1,000 hours in 5 months or 200 hours a month would need the services of the pump driver for about 8 hours a day. The tubewells installed in the cooperative villages of the PARD, Comilla, worked for 12 hours a day on an average during the *boro* season in 1965/66 and only one-pump driver was appointed. There is no reason why one ADC pump operator should not be able to work for 8 hours a day.

Regarding the second point, the 16,000 two-cusec pumps proposed for the third-plan period by the ADC would cost Rs. 138 million. If 16,000 one-cusec pumps are purchased, these would cost about Rs. 92 million. Pakistan can use the extra Rs. 46 million in some other development project rather than lock them up in two-cusec pumps which have to do the job of one-cusec pumps. Or, alternatively Pakistan can purchase 24,000 one-cusec pumps and irrigate 50 per cent additional area.

Small Private Low-Lift Pumps

According to a survey by the EP-WAPDA, quoted by the ADC, there are about five million acres of land situated on both sides of perennial streams which can be irrigated by low-lift pumps [6, Appendix XIII].

The 24,000 one-cusec pumps proposed for the ADC in this paper for the third-plan period plus a carryover of pumps from the second-plan period can irrigate about 1.5 million acres of land situated in blocks of 50 acres or more. The remaining area of 3.5 million acres will probably consist of smaller blocks where pumps of less than one-cusec capacity would be more economical. These can best be operated by farmers themselves.

The Agricultural Development Bank of Pakistan (ADBP) is importing 400 small pumps of 0.5 cusec capacity and 400 pumps of 0.25 cusec capacity at a cost of Rs. 4,60,000 in foreign exchange. The C & F cost of these pumps would be less than Rs. 600 each. However the import duty, sales tax, defence surcharge and profit allowed to the importers would raise the sale price of these pumps in East Pakistan to about Rs. 1,100 per pump. These pumps are being imported for the first time in East Pakistan but are in general use on a large scale in the rice-growing areas of South East Asia, particularly in Thailand [13]. Ultimately, most farmers having larger holdings would like to have their own pumps.

There are about 6,50,000 farmers operating 7.2 million acres (38 per cent of the total cultivated area of the province) who have more than 7.5 acres each (Appendix Table A-6). Out of these, about 5,00,000 farmers are located in the districts of Sylhet, Mymensingh, Dacca, Comilla, Rajshahi, Faridpur, Pabna, Rangpur, Jessore, Chittagong, Khulna and Noakhali where water from perennial streams is available for pumping by low-lift pumps. Assuming that 10 to 20 per cent of these larger farmers purchase their own pumps in the near future, about 50,000 to 1,00,000 pumps can be sold in the next two to three years.

To facilitate the purchase of these pumps by the farmers, it is suggested that the government should either abolish the import duty and sales tax on low-lift pumps or allow a subsidy equal to the import duty and sales tax. This would permit the sales of these pumps at C & F cost plus a profit margin for the dealers, that is, at about Rs. 700 per pump. The once-and-for-all subsidy of Rs. 400 on the sale of these pumps would actually be much less than the continuous subsidy now being borne by the government on the working of the ADC pumps.

Only two types of pumps (one type of 0.25 cusec and one type of 0.5 cusec) are being imported by the ADBP. It is suggested that importers of all makes of pumps who are prepared to import and sell their pumps to the farmers should be allowed to import and sell all pumps that they can possibly sell. It is further suggested that small pumps should be placed on the free import list as has been done for tractors. The ADBP should finance the purchase of these pumps by the farmers under the International Development Association (IDA) loan.

With the possibilities of making very high profits by growing IRRI rice with optimum use of fertilizer, which is possible only with irrigation water during the *boro* and *aus* seasons, the sale of these pumps may be even higher than that assumed in this paper. As the ADBP will recover the full foreign-exchange cost from the IDA, repeat licences should be issued for any importer who has sold 50 per cent of his imported pumps and asks for a repeat licence.

Summary: Low-Lift Pumps

During the second-plan period, the low-lift pumps of the ADC provided irrigation facilities to a larger area (1,50,000 acres) than all the irrigation schemes of the WAPDA.

Two types of pumps have mainly been used by the ADC, one-cusec pumps and two-cusec pumps. The capital cost of a one-cusec pump is about Rs. 5,770 and it covered an average of 59 acres a year. The capital cost of a two-cusec pump is about Rs. 8,650 and it covered an average of 62 acres. The capital cost is thus Rs. 98 per acre for one-cusec pumps and Rs. 144 per acre for two-cusec pumps.

The annual operating cost of a one-cusec pump is Rs. 50 per acre irrigated whereas that of a two-cusec pump is Rs. 60 per acre irrigated.

The net benefit per acre was about Rs. 200 per acre in both cases. The benefit-cost ratio was thus 4.0 for a one-cusec pump and 3.3 for a two-cusec pump.

The ADC has now agreed to charge an annual hire charge of Rs. 1,100 plus cost of fuel for a two-cusec pump. It is estimated that the total area irrigated will increase from 62 acres under the old system to about 90 acres under the new system for two-cusec pump. It is further estimated that total annual operating charges will come to about Rs. 3,486 (Rs. 39 per acre), out of which Rs. 1,080 will be spent directly by the farmers on the fuel and Rs. 1,100 will be paid by the farmers to the ADC as hire charges. The balance of Rs. 1,300 (37 per cent of the cost) will be borne by the government as a subsidy on the ADC operations compared to the existing subsidy of about 75 per cent.

In the past, two-cusec pumps covered only as much area as the one-cusec pumps because large blocks of land where two-cusec pumps could be used were not available in most parts of East Pakistan. As the number of pumps greatly expands during the third-plan period, area of blocks available at each site will become smaller and smaller. It would, therefore, be desirable to purchase 24,000 one-cusec pumps rather than 16,000 two-cusec pumps during the third-plan period. They will cost the same amount but will irrigate an area 50 per cent larger. It should be possible to reach an irrigation of about 1.5 million acres against 750 thousand acres proposed by the ADC.

III. GROUNDWATER DEVELOPMENT

Two projects on groundwater development now under execution in East Pakistan will be discussed in this section. One of these relates to large electric-driven tubewells installed by the WAPDA in the north-west portion of the province near Thakurgaon in the Dinajpur district. The second relates to small diesel-driven tubewells installed by the Pakistan Academy for Rural Development (PARD), Comilla. Finally, possibilities of installation of private tubewells in various parts of the province will be discussed at the end of this section.

1. GROUNDWATER DEVELOPMENT AND PUMP IRRIGATION IN THE NORTHERN DISTRICTS OF EAST PAKISTAN

Under this project, 380 large capacity electric tubewells, 60 electric-driven low-lift pumps and 800 diesel-driven low-lift pumps have been installed to irrigate 1,86,800 acres of land in the Dinajpur, Rangpur, Bogra and Rajshahi districts. A powerhouse with seven 1,500-KW diesel-driven generating units has been set up at Thakurgaon to supply electricity to the 380 tubewells and 60 low-lift pumps.

Capital Cost

The capital cost of the tubewells, the electric-driven and the diesel-driven low-lift pumps is given in Table VII. The capital cost of one WAPDA tubewell comes to Rs. 1,20,000 without electric facilities and Rs. 2,30,000 per tubewell inclusive of electric generation, transmission and distribution facilities.

On the basis of 240 acres proposed to be irrigated by each tubewell, the capital cost is equal to Rs. 500 per acre without electric facilities and Rs. 960 per acre inclusive of electric facilities.

Annual Cost

In October 1963, the East Pakistan WAPDA estimated the annual operation cost of 380 tubewells and 60 electric-driven low-lift pumps at Rs. 12.2 million up to 1971/72 (Column (2) of Table VIII). The 380 tubewells are expected to irrigate 91 thousand acres and the 60 electric-driven low-lift pumps are expected to irrigate 19 thousand acres or a total of 110 thousand acres. The annual cost would, thus, be Rs. 110 per irrigated acre upto 1971/72 (Row 12 of Table VIII).

TABLE VII

CAPITAL COST OF WAPDA TUBEWELLS, ELECTRIC-DRIVEN LOW-LIFT PUMPS AND DIESEL-DRIVEN LOW-LIFT PUMPS

Item	Total capital cost	Number	Cost of one tubewell/ electric low-lift pump/diesel low-lift pump
(1)	(2)	(3)	(4)
	(million rupees)	*(number)*	*(rupees)*
Tubewells	45.63	380	120,000
Electric-driven low-lift pumps	6.25	60	104,000
Transmission lines	31.72	440[a]	72,000
Powerhouse	18.08	440[a]	41,000
Subtotal:	101.68	440[a]	231,000
Diesel-driven low-lift pumps	32.95	800	4,000
Total:	134.64		

[a]380 tubewells and 60 electric low-lift pumps.

Source: [11, p. 11].

In the estimates prepared by the EP-WAPDA, a 5-per-cent rate of interest was assumed for local currency and 4-per-cent for the foreign-exchange component. As previously noted, we have used a rate of interest of 8 per cent for all projects discussed in this paper. The annual cost on the basis of an 8-per-cent rate of interest comes to Rs. 15.3 million (Column (4) of Table VIII) against Rs. 12.2 million estimated by the EP-WAPDA on the basis of

TABLE VIII

ANNUAL OPERATING COST OF WAPDA TUBEWELLS, ELECTRIC-DRIVEN LOW-LIFT PUMPS, AND DIESEL-DRIVEN LOW-LIFT PUMPS

Item	Estimates by WAPDA at 4 and 5-per-cent rate of interest		Estimate by the author on the basis of 8 per cent rate of interest
	Cost up to 1971/72	Cost after 1972/73	
(1)	(2)	(3)	(4)
A. *Tubewells and Electric Low-lift Pumps (in thousand rupees)*			
1) Tubewells	4,267	4,267	5,609
2) Electric low-lift pumps	536	536	709
3) Transmission lines	1,789	1,789	2,804
4) Powerhouse	1,292	..	1,857
5) Fuel for power-house	4,630	..	4,630
6) Power from the provincial grid	..	2,074	..
7) Collecting fee	226	226	226
8) Subtotal	**12,740**	**8,892**	**15,835**
9) *Minus* sale of surplus power	578	..	578
10) Total annual cost	**12,162**	8,892	15,257
11) Area irrigated (*in thousand acres*)	110	110	110
12) Cost per acre (*in rupees*)	**110**	**81**	**138**
B. *Diesel Low-lift Pumps (in thousand rupees)*			
13) Annual cost	3,911	3,911	4,821
14) Fuel for diesel pumps	1,230	1,230	1,230
15) Collecting fee	156	156	156
16) Total annual cost	**5,297**	**5,297**	**6,207**
17) Area irrigated (*in thousand acres*)	76	76	76
18) Cost per acre (*in rupees*)	**69**	**69**	**81**
C. *Tubewells, Electric Pumps and Diesel Pumps (A — B)*			
19) Tota l annual cost (*in thousand rupees*) (Row 10 + Row 16)	17,458	14,188	21,463
20) Total area irrigated (*in thousand acres*) (Row 11 + Row 17)	187	187	187
21) Cost per acre (*in rupees*) (Row 19 ÷ row (20)	93	76	115

Source: Columns (2) and (3): Calculated from [11, p. 27].
Column (4): Calculated using 8-per-cent rate of interest.

4 and 5-per-cent rate of interest. The annual cost is equal to Rs. 138 per acre against Rs. 110 per acre estimated by the EP-WAPDA.

After 1971/72 the Thakurgaon powerhouse is proposed to be integrated into the provincial grid. The cost of electricity is then assumed to be reduced from Rs. 0.13 per kwh for electricity supplied from the Thakurgaon powerhouse to Rs. 0.05 per kwh charged for agriculture on the provincial grid throughout East Pakistan. The annual operating cost for tubewells and electric low-lift pumps is then supposed to be reduced from Rs. 12.2 million in 1971/72 to Rs. 8.9 million in 1972/73. Hence, the per acre cost would be reduced from Rs. 110 to Rs. 81 a year (Column (3) of Table VIII).

As has been pointed out by the author in the section dealing with the Ganges-Kobadak Project, the sale of electricity at Rs. 0.05 per kwh for agricultural use can be justified in the initial stage of development and subsidized by the government. However, in the benefit-cost analysis the full cost of electricity must be taken into consideration. The cost of pumping water from the WAPDA tubewells would, therefore, remain Rs. 138 per acre even after 1971/72.

If the diesel-driven pumps are also included, the per acre cost of the scheme is reduced to Rs. 115 per acre (*see*, Row 21 of Table VIII).

In December 1964, the IECO estimated the annual operating cost for the entire scheme at Rs. 11.5 million [25, p. 204] against Rs. 17.5 and 14.2 million estimated by WAPDA in October 1963. The per acre cost was shown to be Rs. 62 by the IECO against Rs. 94 and Rs. 76 estimated by the WAPDA. Apparently, the IECO failed to take into account the estimates prepared by the WAPDA in 1963.

In April 1965, Mr. B. M. Abbas, the then Commissioner for Water Development, EP-WAPDA, stated that the annual operating cost of tubewells would be as high as Rs. 135 per acre if electric power for pump operation, facilities for operators, construction of distributory channels, and other necessary facilities were taken into account [1, p. 3].

It may be pointed out that Mr. B.M. Abbas's estimate of Rs. 135 per acre is quite close to the estimate of Rs. 138 per acre when interest is calculated at 8 per cent and the full cost of electricity produced at the Thakurgaon powerhouse is taken into consideration.

Benefit-Cost Estimates

The gross benefit for the project is estimated by the WAPDA at Rs. 127.9 million for the whole project or Rs. 685 per acre [11, p. 25]. The net benefits are estimated to be 50 per cent of the gross benefits or about Rs. 343 per acre.

The annual operating cost for the tubewells is estimated at Rs. 138 per acre. The benefit-cost ratio comes to 2.5.

The IECO Master Plan estimates the gross benefits on full development at Rs. 102.2 million and net benefit at Rs. 51.1 million [25, p. 204]. The net benefits are equal to Rs. 274 per acre. The IECO estimated the annual cost to be at Rs. 62 per acre and the benefit-cost ratio at 4.4. However, taking the rate of interest at 8 per cent and the full cost of electricity, the annual operating cost comes to Rs. 138 per acre and the benefit-cost ratio falls to 2.0.

Utilization of Tubewell Water: Some Recommendations

The powerhouse and most of the tubewells were installed during 1962/63 and 1963/64. Actual irrigation started in May 1965 and about 4,000 acres were irrigated from 116 tubewells during summer 1965 and about 400 acres during winter 1965/66. The average commanded area per tubewell is 240 acres. But the irrigated area averaged only 35 acres per tubewell during summer 1965 and 3 acres per tubewell during winter 1965/66, even though no water charges were collected from the farmers. An examination of working records of tubewells indicates that basic causes for this failure to utilize tubewell water are the following:

i) Electricity connections have not so far been given to 50 tubewells.

ii) The main channels have not been constructed by the WAPDA on 180 tubewells.

iii) The main channels have been constructed only in part of the area served by the remaining 184 tubewells.

iv) The powerhouse runs for only 6 hours a day; 5 days a week. Electricity is supplied to some tubewells 3 days a week and to others 2 days a week.

v) During the period when electricity is supplied, the pump operator may be absent or on leave. If the pump operator is present, the agricultural overseer, responsible for giving names of farmers who need water, may be absent or on leave. In either case the pump remains unutilized.

If the WAPDA wishes the farmers to use water it is essential to create confidence among the farmers regarding the regular availability of water. For this purpose it is suggested that:

i) Electricity connections should be given to the 50 tubewells where these have not yet been given.

ii) The main channels should be constructed on all the 180 tubewells where these do not exist at present. These channels should cover the entire length and breadth of the commanded area.

iii) The main channels should also be completed in the entire length and breadth of commanded area on the 184 tubewells where these have so far been constructed in only a part of the commanded area.

iv) At Comilla, the tubewells run from 10 to 19 hours a day with an average of about 12 hours a day. It is suggested that as a start the Thakurgaon powerhouse should run 12 hours a day, 7 days a week. All tubewells should get electricity for 7 days of the week and for 12 hours a day.

v) There is no need for the pump driver to obtain the list of farmers from the agricultural overseer. He should run the tubewells every day. Pumping should stop only on days when rainfall exceeds one-half inch or on days when farmers specifically request that the tubewell be stopped.

The author considers that the income from the tubewells can be greatly increased by the introduction of the high-yielding IRRI-rice varieties, potatoes and tobacco. The IRRI-rice varieties would give high yields only with irrigation water and optimum use of fertilizer. These are likely to increase the crop production on the lands served by tubewells so that the farmers would construct the field channels and utilise the tubewell water within a period of a few years. It is, therefore, suggested that fertilizer demonstration trial on IRRI rice be laid out during the *aman*-1966 season on each of the 116 tubewells which are now in working condition. The remaining tubewells should also be brought into use and fertilizer demonstration trials on IRRI rice laid on them. The whole of the area, which can be irrigated by the beginning of 1967, should be planted with *irrigated transplanted aus* in February 1967. It is this crop which is likely to make the greatest increase in yield compared to the *unirrigated broadcast aus*, and which, therefore, will make it attractive for farmers to construct the field channels and utilize the tubewell water.

Summary: WAPDA Tubewells

In the northern most part of East Pakistan, 380 tubewells have been installed to irrigate an area of about 91 thousand acres near Thakurgaon in the

Dinajpur district. Each tubewell has an average discharge of about 3.0 cusecs and is expected to irrigate about 240 acres. The capital cost of the tubewells is Rs. 1,20,000 without electricity facilities and Rs. 2,30,000 with electricity generation, transmission and distribution facilities. The capital cost, thus, comes to Rs. 500 per acre for tubewell alone and Rs. 960 per acre for tubewell and electric facilities.

The annual operating cost of the tubewells comes to Rs. 138 per acre when the entire area is irrigated. The gross annual benefits are estimated at Rs. 547 to Rs. 685 per acre and the net annual benefits at Rs. 274 to Rs. 343 per acre by the IECO and the WAPDA. The benefit-cost ratio on full development will be between 2.0 and 2.5 when the whole area is irrigated.

Some of the tubewells were installed 4 years ago. More than 2 years have passed since all the tubewells were installed but only 4,000 acres have so far been irrigated. The major cause appears to be that the main channels have not been constructed on more than half of the tubewells and that the powerhouse is run for only few hours a day. Where main channels have been constructed, electricity is supplied for only 2 or 3 days a week and 6 hours a day. The farmers have not, therefore, constructed field channels and have not used the irrigation water. Construction of main channels on all tubewells and regular operation of tubewells is likely to create confidence among the farmers regarding the availability of water. Introduction of high-yielding IRRI-rice varieties may provide a strong incentive for the farmers to construct the field channels for utilizing the irrigation water which is required to get high yields from the IRRI varieties.

2. THE COMILLA TUBEWELLS

This project is located in an area a major part of which is normally flooded every year. The project is under execution by the Pakistan Academy for Rural Development (PARD), Comilla. The PARD has demonstrated its capability in organizing rural cooperatives and in installing tubewells in the Comilla Kotwali Thana during 1963/64 and 1964/65 and in 7 other thanas of the Comilla district during 1965/66. By June 1966, 40 tubewells had been installed in 8 thanas of the Comilla district at an average cost of about Rs. 20,000 each [2 ; 35].

The progress of tubewell irrigation in the Comilla Kotwali Thana is shown in Appendix Table B-1. In 1964/65, 34 tubewells irrigated a total of 1,006 acres for an average of about 30 acres each. In 1965/66, some of the tubewells, where the farmers had not paid their dues, were closed and the remaining 25 tubewells irrigated a total of 1,142 acres, or 46 acres each (Table IX).

This increase in area irrigated in 1965/66 took place primarily as a result of change in the collection of hire charges from a basis of Rs. 45 per acre in 1963/64 and 1964/65 to a fixed annual charge of Rs. 1,000 per tubewell plus cost of fuel and oil in 1965/66. Under this system most of the farmers increased the efficiency of water use and reduced the cost of pumping as is shown in Table IX which gives the results of all tubewells which worked in 1963/64, 1964/65 and 1965/66[11].

TABLE IX

RESULTS OF THE OPERATION OF THE COMILLA TUBEWELLS 1963/64 to 1965/66

Year	Per tubewell				Per acre		
	Hours worked	Water pumped	Cost of fuel consumed	Area irrigated	Hours run	Water used	Fuel consumed
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	(number)	*(acrefeet)*	*(rupees)*	*(acres)*	*(number)*	*(acreinches)*	*(rupees)*
1963/64	794	73	653	36	22	24	18
1964/65	1,158	106	1,158	27	43	47	44
1965/66	640	59	638	46	14	15	14

Source: Compiled from records of the PARD (Comilla) by Mr. A. Q. Ziauddin, Staff Economist at the Institute.

A comparison of the working results of 1964/65 and 1965/66 clearly shows that:

i) The farmers reduced the number of hours of tubewell operation from 1,158 in 1964/65 to 640 in 1965/66 because they had to pay for the quantity of water used, whereas in the previous years they paid the charges on a per acre basis and, therefore, did not economize in the use of water.

ii) Inspite of a reduction in the number of hours of tubewell operation, there was an increase in the irrigated area of more than 50 per cent, from 27 acres[12] per tubewell in 1964/65 to 46 acres per tubewell in the *boro* season, 1965/66.

[11]It might be argued that the cost of nine tubewells which were closed in 1965/66 should be charged to the twenty-five tubewells which actually worked. However, the closure was a temporary disciplinary measure and all of the defaulting cooperatives have agreed to pay their arrears and work the tubewells in 1966/67.

[12]There is a slight difference in the number of acres irrigated per tubewell given in Appendix Table B-1 (30 acres) and in Table IX (27 acres). Figures in Appendix Table B-1 refer to *all* tubewells used in 1964/65, whereas those in Table IX refer only to 25 tubewells used both in 1964/65 and 1965/66.

iii) The number of hours for each acre of irrigated crop was reduced from 43 in 1964/65 to 14 in 1965/66.

iv) Water was used more sparingly in 1965/66 and the farmers applied only 15 acreinches of water to raise a *shaita*[13] and *boro* crop as compared to 47 acreinches in 1964/65.

v) The net result was that farmers spent only Rs. 14.00 per acre on fuel in 1965/66 as compared to Rs. 44.00 per acre in 1964/65.

If the results of operation in 1963/64 are compared with those of 1965/66, it is seen that the farmers worked the tubewell for 22 hours and used 24 acreinches of water to raise one acre of irrigated crop in 1963/64 compared to 15 acreinches in 1965/66. Waste of water to this extent may be expected on operations where farmers do not pay for the cost of fuel. But in 1964/65, the waste of water appears to have been excessive.

The reason why farmers were able to raise a successful *boro* and *shaita* crop with 15 acreinches of water is as follows. At the end of the monsoon season, the watertable comes quite close to the ground surface and the soil profile is completely saturated with moisture [27, p. B-VII-32]. There is some reduction of moisture in the soil in November and December but considerable moisture is still present in the soil profile below the ground surface. A relatively small quantity of irrigation provided to the crop, thus, enables the root system to make use of part of the water already stored in the soil.

The results of an experiment conducted on the yield of *boro* paddy at Hathazari Government Agriculture Farm, Chittagong, with different depths and intervals of irrigation are presented in Appendix Table B-2. These results show that with the interval of irrigation at ten to fifteen days and a total depth of irrigation of forty-one acreinches, the average yield of *boro* paddy from four replicated plots was thirty-eight maunds per acre. With the interval of irrigation at thirty to forty days and total depth of irrigation of thirteen acreinches, the average yield of *boro* paddy was thirty-four maunds per acre (Appendix Table B-2). There was, thus, a reduction of about four maunds per acre in the yield of *boro* when irrigation water was reduced from forty-one acreinches to thirteen acreinches. With a given quantity of water the farmers would, however, be better off by growing three acres of *boro* rice with thirteen acreinches irrigation than by growing one acre of rice with forty-one acreinches. This is what the farmers of the Comilla villages

[13]*Shaita* is a short-growing seasonal variety of *boro* rice. Literally *shaita* means sixty, indicating that this rice will mature in sixty days. Actually, it takes about eighty days to mature.

who had access to tubewell water appear to have done when they had to pay for the quantity of water used in 1965/66 rather than pay a flat per acre rate as in 1963/64 and 1964/65.

It should be pointed out, however, that when high-yielding IRRI varieties of rice are introduced in 1966/67 and adequate fertilizer is applied, much larger quantities of irrigation water will have to be made available to get the higher yields possible with the new varieties.

Annual Operating Cost of Tubewells

In August 1964, the annual operating cost of a diesel-driven tubewell was estimated by the PARD at Rs. 4,290 (Table X) [35, p.57]. In this calculation the period of amortization was assumed to be 50 years (to bring it in line with the IECO-WAPDA practice). The life of diesel engine was assumed to be 15 years and that of the tubewell 30 years. The rate of interest was assumed to be 5 per cent.

The PARD itself charges a 15-per-cent rate of interest from the cooperative societies which run the tubewells. While a rate of interest of 15 per cent probably represents the scarcity value of capital for the farmers correctly, it probably overstates the overall scarcity of capital in Pakistan. As previously explained, we have used an 8-per-cent rate of interest for all projects considered in this paper.

With regard to the life of tubewells, experience in West Pakistan indicates that their life is likely to be closer to 10 years than 30 years. On the basis of a 10-year life for tubewell, 15 years for diesel engine, an 8-per-cent rate of interest and other expenses as actually incurred by the PARD in 1965/66, the annual operating cost of a tubewell comes to Rs. 6,085 (Column (3) of Table X) against Rs. 4,290 estimated by the PARD. For an average of 60 acres irrigated per tubewell, the cost would be equal to Rs. 101 per acre.

Annual Income and Benefit-Cost Estimates for a Tubewell Commanding 60 Acres

The gross annual income is estimated by the PARD at Rs. 59,500 per tubewell with a cultivated area of 60 acres. The present value of crop production is estimated at Rs. 27,700 (Rs. 462 per acre). The increase in the gross value of crop production is, therefore, Rs. 31,900 for each tubewell covering 60 acres [35, p. 50][14].

[14]The PARD has given the present gross income, projected gross income, and increase in gross income due to irrigation for 18,960 acres to be irrigated by tubewells, low-lift pumps and by surface-canal irrigation. Proportionate figures for 60 acres for one tubewell have been assumed in this paper.

TABLE X

ANNUAL OPERATING COST OF A DIESEL-DRIVEN TUBEWELL IN COMILLA

Item	As estimated by PARD for 60 acres	As estimated by the author for 60 acres and hire charges on a flat per acre basis	Estimates by the author for 80 acres with hire charges of 1,000 rupees a year plus cost of fuel	Estimates by the author for tubewell costing Rs. 13,000
(1)	(2)	(3)	(4)	(5)
1) Interest and amortization	1,174[a]			
2) a) Replacement reserve engine and pump	370[b]	2,685[f]	2,685	1,728[j]
b) tubewell	203[c]			
3) Operation and maintenance				
a) Diesel fuel	2,115[d]	2,640[g]	2,400[i]	2,400[i]
b) Maintenance	428[e]	660[h]	760[h]	760[h]
Total:	**4,290**	**6,085**	**5,845**	**4,888**
Water pumped (acrefeet)	150	150	200	200
Cost per acrefoot of water pumped (*rupees*)	29	35	29	24
Area irrigated (land-acres)	60	60	80	80
Cost per land-acre irrigated (*rupees*)	72	101	73	61
Crops irrigated (crop-acres)	135	135	180	180
Cost per crop-acre irrigated (*rupees*)	32	45	32	27

Source: Column (2): From [35, p. 57].
Columns (3) to (5): Estimates by the author. *See* text.

a At 5-per-cent interest, repayment in 50 years.
b Replacement in 15 years at 5-per-cent interest.
c Replacement in 30 years at 5-per-cent interest.
d For 1,410 hours at Rs. 1.50 per hour.
e At 2 per cent of the total capital cost.
f At 8-per-cent interest and repayment in 10 years for tubewell and 15 years for diesel engine on total capital cost Rs. 20,200 of which half is for tubewell and half for engine.
g For 60 acres at Rs. 44 per acre.
h Actual expenses during 1965/66 consisting of cost of spares (Rs. 64), repairs (Rs. 136), pay of driver (Rs. 360) and cost of supervision (Rs. 200).
i For 2,400 hours at one rupee per hour.
j At 8 per cent interest and repayment in 10 years for tubewell and 15 years for diesel engine ona total capital cost of Rs. 13,000.

Assuming the cost of production at 50 per cent of the gross value, the net increase in the value of crop production due to irrigation comes to Rs. 15,950 for 60 acres or Rs. 266 per acre[15].

The annual operating cost is about Rs. 101 per acre. The benefit-cost ratio is, therefore, 2.6.

Area Commanded by a Tubewell

For the WAPDA tubewells near Thakurgaon, it was assumed that each tubewell, with a discharge of about 3 cusecs, will cover about 240 acres. This is about 80 acres per cusec.

It now appears that the Comilla tubewells will also be able to command an area of about 80 acres per well instead of the 60 acres originally proposed by the PARD. An average area of about 46 acres per tubewell has already been irrigated during the *boro* season, 1965/66. The *boro* area is expected to increase by about 10 acres on each tubewell during the next few years and reach about 56 acres per well.

With the introduction of high-yielding IRRI-rice varieties, an area of about 40 acres (50 per cent of the cultivated area) may be expected to be irrigated during the *aus* season against the present *aus* acreage of about 42 per cent.

Aman rice is now grown on about 80 per cent of the cultivated area. This may be expected to remain at the present level. With the change in the system of hire charges, *aman* rice will, however, get irrigation water at the critical maturing stage as the farmers have to pay for fuel only for this supplementary irrigation. The farmers regard the rental charges of Rs. 1,000 a year mainly for the *boro* paddy which cannot be grown without irrigation.

Total area under rice will probably reach 160 acres or about 200 per cent of the cultivated area (*boro* 56 acres, *aus* 40 acres, and *aman* 64 acres). The present rice area is about 100 acres (125 per cent of the cultivated area) on each tubewell commanding 80 acres. Thus, there will be an increase of 60 acres in the rice area and improvement of yield on about 100 acres.

Area under other irrigated crops may reach about 20 acres (25 per cent of the cultivated area) as estimated by the PARD [35, p. 46].

[15]The PARD has given the cost of production for each crop and the net increase in income is estimated by the PARD at 49.3 per cent of the gross increase in income. In this paper, however, the net increase is assumed at 50 per cent of the gross increase as has been done for all other projects discussed in the paper.

Benefit-Cost Estimates for a Tubewell Commanding 80 Acres

Irrigation-water requirements of crops were estimated at 30 acreinches per acre or 1,800 acreinches per tubewell (60 acres) by the PARD [35, p.55]. Water requirements for individual crops were assumed to be as follows: *boro* 27 acreinches; *aman* 10 acreinches; *aus* 8 acreinches; other crops 10 to 15 acreinches. Experience during the 1965/66 *boro* season indicates that with the present varieties of rice, the farmers will use much less water. However, with the introduction of high-yielding IRRI-rice varieties, water use may reach the level estimated by the PARD. About 200 acrefeet of water for each 80 acres would then be required.

The discharge of tubewells was assumed at 1.5 cusecs by the PARD. It is now estimated as 1.1 cusecs [31]. Tubewells will, therefore, have to run for about 2,400 hours to deliver 200 acrefeet of water to the fields.

The annual operating cost of tubewell working for 2,400 hours and irrigating 80 acres is shown in Column (4) of Table X. The total annual cost comes to Rs. 5,845 or Rs. 73 per acre. The net annual income will be about Rs. 21,280 = (266$\times$80) per tubewell. The benefit-cost ratio would be 266/73 = 3.6 ignoring any increase in the value of crop production due to high-yielding IRR-Irice varieties.

If the farmers install their own tubewells, their net annual income after deducting the annual operating cost would be Rs. 15,435 (Rs. 21,280 *minus* Rs. 5,845). The farmers would, thus, recover the capital cost of Rs. 20,000 in less than 2 years.

Benefit-Cost Estimates for a Low-Cost Tubewell

It will be shown in a later section of this paper that the capital cost of a tubewell can be reduced from Rs. 20,000 to about Rs. 13,000 with the use of locally manufactured diesel engine, ADBP-imported lining pipe and use of coir-string strainer. The annual operating cost will then come to Rs. 4,888 (Column (5) of Table X) or Rs. 61 per acre.

The benefit-cost ratio will become 266/61=4.4.

Benefit-Cost Estimates with IRRI-Rice Varieties

Five acres of IRRI rice were grown at Comilla during the *aus* season, 1966. These gave an average yield of 50 maunds per acre. This is exactly what had been forecast by Chandler who estimated the yield of IRRI-rice varieties at 50 maunds per acre during the *aus* and *aman* season and 75 maunds per acre during the *boro* season [4, p. 21].

Under large-scale operations by farmers, yields are likely to be lower. Assuming an average yield under farmers condition of 35 maunds per acre for *irrigated aus* and *irrigated aman* and 45 maunds per acre for *irrigated boro* and the income from other crops as estimated by the PARD, the total income from 80 acres on one tubewell comes to Rs. 93,000 as shown in Table XI.

TABLE XI

ESTIMATED INCOME FROM CROP PRODUCTION ON TUBEWELL WITH IRRI RICE

Crop	Area	Yield per acre	Total production	Rate per maund	Total value
(1)	(2)	(3)	(4)	(5)	(6)
	(acres)	*(maunds)*	*(maunds)*	*(rupees)*	*(rupees)*
Aus	40	35	1,400	13	18,200
Aman	64	35	2,240	14	31,360
Boro	56	45	2,520	14	35,280
Other crops	20				8,000
Total:	**180**				**92,840**

Source: See text.

From the gross value we should deduct the present value of crop production of Rs. 36,960 (Rs. 462×80). The increase in gross value comes to Rs. 55,880. If half of this is taken as the cost of production, the net increase in income due to tubewell and IRRI varieties comes to Rs. 27,440. This is equal to Rs. 349 per acre. The benefit-cost ratio, thus, comes to 4.8 or 5.7, depending upon whether the annual operating cost of Rs. 73 or Rs. 61 per acre is used.

Farmers installing their own tubewells and growing IRRI-rice will have a net income of Rs. 21,595 after deducting the annual operating cost (Rs. 27,440 *minus* Rs. 5,845). They will, thus, recover the capital cost of Rs. 20,000 or Rs. 13,000 in one year.

Subsidy on Comilla Tubewell Operations

Although the annual operating cost of a tubewell comes to Rs. 5,845 for 80 acres, the PARD is charging only Rs. 1,000 as rental charges plus cost of fuel which comes to about Rs. 2,400 for 80 acres of cultivated land growing 135 acres of irrigated crops.

Total charges to be paid by the farmers come to Rs. 3,400. The balance of Rs. 2,445 is borne as a subsidy and is met out of Rural Works Programme funds. The subsidy is 42 per cent of the annual operating cost.

The tubewell programme has just started in East Pakistan. It is one of the key elements in increasing agricultural production in areas where low-lift pumps cannot be used due to lack of surface water. It is, therefore, desirable to continue this subsidy till tubewells have covered a major part of the area suitable for tubewell installation.

Summary: Comilla Tubewells

Forty tubewells have been installed by the PARD, during the last three years, in the cooperative villages of the Academy near Comilla. The average capital cost of these is about Rs. 20,000. These tubewells have an average discharge of about 1.1 cusecs and are expected to cover an area of about 80 acres each. The capital cost, thus, comes to Rs. 250 per acre.

The working of these tubewells was under the complete control of the PARD in 1964/65 and the farmers were charged Rs. 45 per acre irrigated. The total annual cost was estimated at Rs. 101 per acre out of which about Rs. 44 were spent on fuel.

During 1965/66, the farmers were required to pay Rs. 1,000 per tubewell as rental charges plus cost of fuel. With this change, the cost of fuel was reduced from Rs. 44 to Rs. 14 per acre and the total annual cost is estimated to have decreased to about Rs. 73 per acre. The farmers are expected to pay a total of Rs. 3,400 (Rs. 1,000 rental charge *plus* Rs. 2,400 on fuel) or Rs. 42.5 per acre. This would imply a subsidy of about 42 per cent.

The net benefits on full development of 80 acres are estimated at Rs. 21,280 per tubewell or Rs. 266 per acre, giving a benefit-cost ratio of 3.6. The farmers installing their own tubewells are expected to recover the capital cost in less than 2 years.

It is possible to reduce the capital cost of installation of a tubewell from Rs. 20,000 to about Rs. 13,000 by the use of locally manufactured diesel engine and coir-string strainers. This will reduce the annual operating cost to about Rs. 61 per acre and raise the benefit-cost ratio to about 4.4. The subsidy to be borne by the government will then be reduced to about 30 per cent.

Introduction of high-yielding IRRI-rice varieties is expected to increase significantly the net income accruing from the installation of tubewells and is expected to cause a rapid demand for tubewell installations.

3. PRIVATE TUBEWELL DEVELOPMENT IN EAST PAKISTAN

One of the major causes of increase in agricultural production in West Pakistan during the second-plan period has been the private investment in tubewell installation. It is estimated that about 27,000 private tubewells were installed during the last five years, raising the total number from about 4,600 at the end of 1959/60 to about 31,600 at the end of 1964/65[16]. Early in 1964, the author proposed a similar installation of private tubewells in East Pakistan for the third-plan period [15, p. 250]. Serious doubts have, however, been expressed about the availability of groundwater for pumping and the extent to which it could be annually recharged without mining, by the publication of the reports by Professor Thijsse [47 ; 48]. Evidence available on the subject indicates that these doubts are perhaps not fully justified.

Groundwater

A considerable body of information is available on the existence and recharge of groundwater in East Pakistan as well as in other alluvial deltaic areas of the world. One of the best studies which compiles most of the information available on the subject in East Pakistan is that by Mr. H. V. Peterson, Groundwater Hydrologist of International Engineering Company. This report on *Groundwater in East Pakistan* describes the aquifer material of tubewells in different parts of East Pakistan [41]. From a study of these logs he concludes that over much of the area of East Pakistan silt and clay predominate in the top 50 to 80 feet, with sands forming the major part of the deposits from 80 to 300 feet and below.

Peterson concludes that where a well penetrates 150 or more of clean medium to coarse sand, a good yield is assured; for fine and very fine sands a greater thickness is required. He further considers that these minimum thicknesses of sand should be present within 300 feet of drilling depth [41, p. 6].

Somewhat similar conclusions can be drawn from a study of the wells in the Dacca municipal area carried out by Mr. Welsh of Parsons Corporation. This report on *Dacca Groundwater Supply* states that in a depth of 180 to 400 feet the average well encounters 120 to 200 feet of aquifer material generally labelled as fine to medium sand [50, p. 9]. It is capable of giving a discharge of 2.8 cusecs with a thickness of 115 feet of fine to medium sand and an 8-inch diameter tubewell [50, p. 11].

[16] For tubewells installed up to 1963/64, *see* [16, p. 7]. Number of tubewells installed during 1964/65 is taken from unpublished results of a survey by the author in collaboration with Directors of Agriculture, Lahore, Peshawar, and Hyderabad.

A number of good results have been obtained in other parts of East Pakistan. Successful tubewells have been installed at Thakurgaon (Dinajpur district), Comilla, Gauripur (Mymensingh district), Gaibanda (Rangpur district), Natore (Rajshahi district) and a number of other places. The depth of these tubewells ranges from 125 to 300 feet and they give a discharge of 1.0 to 4.0 cusec each [11; 35; 41; 42; 43; 44].

Recharge

Professor Thijsse is particularly doubtful regarding the recharge of groundwater. Here again his doubts do not seem to be fully justified. Although no specific studies have been carried out on the extent of recharge, the fact that watertable rises every year by 5 to 10 feet during the monsoon season over major part of East Pakistan indicates that there is a large recharge of groundwater in East Pakistan. An order of magnitude of how much water can actually be pumped from tubewells without unduly mining the aquifer can be had from the working of municipal tubewells in the Dacca area. There are 24 tubewells located in an area of 1,900 acres in Old Dacca City [50]. These tubewells pump about 8.6 million gallons a day or about 8,900 acrefeet of water in a year. This is equal to 4.7 acrefeet per acre for the Old Dacca City area, and is considered to be in excess of the annual recharge. The watertable is, therefore, going down in the Old Dacca City area. In the remaining municipal area of Dacca, 9.4 million gallons of water a day, or 9,700 acrefeet a year, is being pumped from 8,100 acres. This means an annual extraction of 1.2 acrefeet per acre. Parsons Company consider that more water can be pumped in this area [50]. They consider that the total yield of water in the entire Dacca Municipal area can be increased from 18 million gallons a day at present to about 33 million gallons a day during the next 10 years. This would mean a total pumping of about 34,000 acrefeet from 10,000 acres, giving an extraction rate of about 3.4 acrefeet per acre. Although it is not explicitly stated, some of these tubewells would probably be located outside the present municipal area of 10,000 acres. The extraction rate would probably be somewhat less than 3.4 acrefeet per acre.

The Parsons Corporation recommend installation of large tubewells of 60,000-gallon-per-hour (2.8 cusecs) capacity but suggest that these wells should not be located at less than 2,000 feet apart to prevent excessive mutual interference [50, p. 14]. In other words, a tubewell of 2.8-cusec capacity should not have an area of less than 92 acres. Here again the Parsons Corporation does not refer to the lowering of watertable which was specifically pointed out for the Old Dacca City area. The Parsons Corporation appear to imply that there would be no undue mining of water if tubewells of less than 2.8-cusec capacity are located to serve areas of more than 92 acres each.

Tubewells installed in West Pakistan, and those proposed for East Pakistan in this paper, would have less than half the capacity of tubewells in the Dacca Municipal area, that is about 1.0 to 1.4 cusecs each, and would serve 100 to 200 acres each. These are, therefore, not likely to cause any mining of groundwater.

Both Professor Thijsse [47, p. 20] and Mr. Peterson [41, p. 21] stressed the undesirable effects of pumping water from tubewells on the reduction of discharge in the rivers during the dry season when the rivers have low discharges. In stressing these undesirable effects, it appears that the assumption has been made that all pumping from tubewells will take place during the winter season. This is not necessarily correct. The major part of pumping on the 116 tubewells which worked in the 1965/66 season in the Thakurgaon area took place in the summer season when 4,000 acres were irrigated. Only a small part of the pumping took place during the winter season when less than 400 acres were irrigated. The same is true of the Ganges-Kobadak Project area where 75 per cent of the water pumped during the year was used in the summer season (May to October) and only about 25 per cent of the pumped water was used in the winter season [19].

It was only in Comilla that tubewells were used mostly during the winter season in the last two years. With the change in the system of realization of charges for irrigation, tubewells are now also being used in the summer season at Comilla.

It should, however, be pointed out that in the Thakurgaon area as well as in the Ganges-Kobadak Project area, more and more pumped water will be used during the winter season when irrigation develops. Considerable part of the pumping will, however, continue to be done during the summer season and this should have no undesirable effects on the depletion of groundwater.

Professor Thijsse seems to have used a very high figure for water requirement of crops and hence for pumping of water during the *rabi* season. He uses a figure of 5.3 acrefeet per acre for a *boro* crop grown from December to April [47, p. 38, Tables II, I and III]. Farmers in the Comilla area applied only 1.3 acrefeet per acre to the *boro* crop in 1965/66. For the whole area of the village where the tubewells were located (200 acres) the pumping was about 0.3 acrefeet per acre. This is insignificant compared to the likely recharge from the monsoon rainfall and other sources. It is true that water requirements of crops will increase as *shaita* rice is replaced by *boro* and the *boro* is replaced by high-yielding IRRI-rice varieties. But even then much less water will be used by the farmers than that assumed by Professor Thijsse, and less pumping of water will therefore take place. It appears from the above analysis that there is no need to be concerned in the immediate future with a likely permanent lowering of the ground watertable until the number of tubewells has increased very considerably.

Size of Holdings and Tubewells in East Pakistan

It is argued by the East Pakistan government officials that private tubewells can be installed in West Pakistan but not in East Pakistan because of very small size of holdings in the latter province. To test the validity of this hypothesis, we have collected data on the size of holdings of 33,000 farmers who have installed 20,100 tubewells in four major districts of West Pakistan. The results of this survey are summarized in Appendix Table C-1. At the end of 1965, there were 14,200 farmers who had installed their own individual tubewells; 18,800 additional farmers had jointly installed 5,900 more tubewells. About 6,500 farmers (or 20 per cent of all farmers installing tubewells) had less than 12.5 acres each. In most cases they combined to install jointly owned tubewells.

We have applied the results of the survey on the West Pakistan size of holding to East Pakistan and calculated the number of tubewells that could be installed in East Pakistan, singly and jointly owned, if size of holdings was the sole criterion. The results of this exercise are given in Appendix Table C-2. There should be about 11,000 single tubewells and about 15,000 joint tubewells or a total of 26,000 tubewells in East Pakistan under this assumption. There are, however, other points to be considered. Of the total cultivated area of 21.6 million acres, low-lift pumps can be used in 5 million acres. Tubewells can be used in greater part of the remaining 16.6 million acres. However, in some areas out of these 16.6 million acres, the aquifer material is not so suitable for tubewells. These areas will have to be left out. There are still some other areas in the south near the seas where tubewells cannot be installed on account of saline groundwater. If all these areas are excluded, it may be possible to install tubewells over 5 to 10 million acres.

Organization for Tubewell Installation

In West Pakistan, the Department of Agriculture has so far been responsible for installation of tubewells for the farmers. The Department of Agriculture undertakes the drilling of holes and installation of pipes and strainers. The remaining work, *i.e.*, supply and installation of pump and engine and construction of pumphouse, is done by the farmers themselves. Pipes and strainers can be purchased from the Department of Agriculture or from the local market. Private drillers have also been drilling wells for the farmers for the last twenty years or so but have entered this field in a big way only during the last seven years [16, Pp. 2-3].

For the purposes of tubewell installation, West Pakistan is divided into three regions. The Central Region is the most important and has over 90 per cent of all tubewells. East Pakistan corresponds in area and possibilities of tubewell installation to the Central Region of West Pakistan.

The tubewell organization in the Central Region of West Pakistan consists of a Director of Agricultural Engineering, 2 Agricultural Engineers, 21 Assistant Agricultural Engineers[17], 18 Drilling Supervisors and about 190 Drillers, one for each hand-operated drilling rig. It is suggested that the Government of East Pakistan should set up a similar tubewell drilling organization in the Department of Agriculture or in the Agricultural Development Corporation.

It is further suggested that Government of East Pakistan should place immediate orders for the import of 200 hand-operated drilling rigs of the type used in West Pakistan and at Comilla. These would cost about Rs. 4 million [32, p. 45]. Out of these, about 100 should reach Dacca within the next 6 months and the remaining in 12 months.

Assuming that each rig installs 8 to 9 tubewells in a year[18], these rigs would install about 5,000 tubewells in the last three years of the third-plan period. For the installation of the remaining 5,000 tubewells, it is suggested that some of the private tubewell drillers from West Pakistan should be invited to start their drilling operations in East Pakistan.

Cost of a Six-inch Tubewell

In West Pakistan, the average cost of a 6-inch diesel-driven tubewell comes to about Rs. 10,000 [16, p. 51]. The average cost of a 6-inch diesel-operated tubewell at the PARD, at Gauripur (Mymensingh) and at Gaibanda (Rangpur) comes to about Rs. 20,000 each. The major items where cost can be reduced in East Pakistan are in *i*) the cost of the diesel engine, *ii*) the cost of the lining pipe, and *iii*) the cost of the strainer.

i) *Diesel Engine*

West Pakistan farmers are using locally manufactured low-speed diesel engines of 18 to 22 HP costing about Rs. 4,500 to Rs. 5,000 each. Inclusive

[17]These include Assistant Engineers, incharge of mechanized cultivation (bulldozers), and drilling operations as well as workshop superintendents and training and research engineers.
For tubewell operations alone, Mr. Majid Hasan Khan, Director of Agricultural Engineering, considers that one Assistant Engineer should be adequate for 25 hand-operated drilling plants [33].

[18]In West Pakistan, one drilling rig installs one tubewell in one month. In East Pakistan, it is assumed to take longer time.

of the pump, the cost comes to about Rs. 6,000. Against this, the PARD is using imported German-made high-speed diesel engines costing about Rs. 10,000 each. The German-made high-speed diesel engines are more efficient in the utilization of fuel oil but these are highly sophisticated and difficult to maintain under Pakistani conditions. Even under the excellent supervision and repair services provided by the PARD, most of the German-made engines had to be overhauled within a period of three years [31]. On the other hand, the West Pakistan's locally manufactured low-speed diesel engines are somewhat less efficient in the consumption of diesel oil[19], but they are very sturdy and extremely durable. The West Pakistan manufacturers guarantee to replace *free* any part which goes out of order during a period of three years. Even after three years there is no difficulty on spares and repairs as all parts are manufactured locally. This would reduce cost of Comilla tubewells by Rs. 4,000.

ii) *Lining Pipe*

Lining pipe of 6-inch diameter costs about Rs. 20per foot at Comilla whereas the West Pakistan Directorate of Agricultural Engineering has been selling the same at Rs. 10 per foot. The Agricultural Development Bank is importing lining pipe worth two million rupees in foreign exchange for installation of tubewell under the IDA Loan in West Pakistan. This pipe is expected to sell at about Rs. 7 per foot at the village level. It is suggested that the ADBP should be requested to import lining pipe worth about one million rupees in foreign exchange for sale of the same to the farmers in East Pakistan as well as to the PARD. This would reduce the cost of Comilla tubewells by about Rs. 1,000.

iii) *Strainer*

West Pakistan farmers use coir-string strainer manufactured from iron strips and coconut-fibre rope imported from East Pakistan. This sells for about Rs. 6 to 7 per foot in the rural area. The PARD (Comilla) uses brass strainer which costs about Rs. 30 to 40 per foot.

The coir-string strainers are quite durable. According to a survey conducted by the author in November-December 1965, more than 99 per cent of the private tubewells installed by the farmers in Multan, Montgomery,

[19]The 15-HP German-made high-speed diesel engines consumed 253 gallons of diesel oil in 640 hours at Comilla in 1965/66, giving a rate of consumption of 0.4 gallon per hour. In a comparable area in the Gujranwala-Sialkot districts in West Pakistan, locally manufactured low-speed diesel engines of 18 HP consumed an average of 32 drums (1,440 gallons) in 2,430 hours [16, p. 52]. This gives a rate of consumption of 0.6 gallon per hour.

Gujranwala and Lahore districts were in satisfactory working condition at the time of the survey. These tubewells had mostly been installed within the last 10 years but 692 tubewells or 3.4 per cent of the total were older and were still in satisfactory working condition. There is no reason to believe that coir-string strainers will not do as well in East Pakistan as they are doing in West Pakistan. In order to reduce the initial capital cost, coir-string strainers should be used in East Pakistan just as they are being used in West Pakistan. This would reduce the cost of Comilla tubewells by another Rs. 3,000.

It is possible to reduce the cost of a 6-inch tubewell from Rs. 20,000 at Comilla to about Rs. 12,000 with the use of locally manufactured low-speed diesel engines, coir-string strainers, and the ADBP-imported lining pipes. The depth of tubewells will, however, be somewhat more in East Pakistan than in West Pakistan. About 50 feet extra lining pipe and 50 feet extra coir-string strainer would cost Rs. 700. It would also cost about Rs. 500 extra in drilling charges. Total cost of the tubewell should, therefore, be about Rs. 13,000 in East Pakistan against Rs. 10,000 in West Pakistan.

Summary: Private Tubewells

A large programme of private investment in tubewell installation on the lines now under way in West Pakistan is considered feasible for a major part of those areas of East Pakistan where low-lift pumps cannot be used.

There is reason to believe that groundwater is available in pumpable quantities in various parts of East Pakistan as shown by irrigation tubewells installed at Thakurgaon (Dinajpur), Rangpur, Comilla, Gauripur (Mymensingh), Gaibanda (Rangpur), Natore (Rajshahi) and other places. There is also reason to believe that the recharge in East Pakistan is large, as shown by the rise of watertable by five to ten feet every year after the monsoon over major parts of East Pakistan.

Evidence collected on the size of holdings of tubewell farmers in West Pakistan indicates that about 11,000 single tubewells and 15,000 joint tubewells or a total of 26,000 private tubewells could have been installed by the farmers of East Pakistan if size of holding were the sole criterion. These tubewells can be installed now by providing an aggressive drilling organization and strong incentives for the farmers to install private tubewells. A tubewell drilling directorate in the EP-ADC on the lines of the Directorate of Agricultural Engineering in West Pakistan and some incentives to the private drillers in West Pakistan to start their drilling operations in East Pakistan can do the job.

TABLE XII

COMPARATIVE COSTS AND BENEFITS OF SOME IRRIGATION PROJECTS IN EAST PAKISTAN

Item	Surface-water development					Groundwater development			
	Ganges-Kobadak Project	Low-lift pumps				WAPDA tubewells in North Bengal	Comilla tubewells		
		Worked by ADC		Worked by farmers			Worked by the Academy (60 acres)	Worked by the farmers (80 acres)	Assuming local diesel engine and coir-string strainers (80 acres)
		Two-cusec pumps	One-cusec pumps	Two-cusec pumps	One-cusec pumps				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Capital cost	886[a]	144[b]	98[c]	98[d]	82[e]	500[f] 960[g]	333[h]	250[i]	163[j]
Annual operating cost	96	60	50	39	39	138	101	73	61
Annual benefits	215	200	200	200	200	274 to 343	266	266	266
Benefit-cost ratio	2.2	3.3	4.0	5.1	5.1	2.0 to 2.5	2.6	3.6	4.4

[a]Rs. 292 million for 330 thousand acres of irrigated areas.
[b]Rs. 8,650 for 62 acres actually irrigated.
[c]Rs. 5,770 for 59 acres actually irrigated.
[d]Rs. 8,650 for 90 acres likely to be irrigated.
[e]Rs. 5,770 for 70 acres likely to be irrigated.
[f]Rs. 45.8 million for 380 tubewells for 91 thousand acres of irrigated land excluding electrification facilities.
[g]Inclusive of electric generation, transmission and distribution facilities.
[h]Rs. 20,000 for 60 acres.
[i]Rs. 20,000 for 80 acres.
[j]Rs. 13,000 for 80 acres.

Source: See text.

The cost of a private tubewell of about one-cusec capacity with the locally manufactured diesel engine and coir-string strainer is estimated at about Rs. 13,000 in East Pakistan compared to about Rs. 10,000 in West Pakistan. With the introduction of high-yielding IRRI-rice varieties which can be grown during the *boro* and *aus* season only with irrigation, the farmers will recover capital cost in less than 2 years.

IV. COMPARISON OF DIFFERENT IRRIGATION PROJECTS STUDIED

Table XII summarizes the capital cost, the annual operating cost, the annual benefit and benefit-cost ratio for the four different projects discussed in this paper.

The capital cost of the Ganges-Kobadak Project as well as the WAPDA tubewells is exceedingly high, about Rs. 900 per acre, whereas the capital cost of low-lift pumps is only about Rs. 100 per acre. The capital cost of Comilla tubewells is about Rs. 250 per acre but can be reduced to about Rs. 160 per acre. With the same amount of funds, it is possible to cover nine times the area with low-lift pumps as compared with Ganges-Kobadak Project or the WAPDA tubewells. The tubewells of the type installed in Comilla would cover nearly four times the area with the same funds as the WAPDA tubewell or the Ganges-Kobadak Project.

The annual operating cost of the WAPDA tubewells is the highest of all (Rs. 138 per acre), whereas that of Ganges-Kobadak Project is slightly less than Rs. 100 per acre. The low-lift pumps have the lowest annual operating cost of about Rs. 50-to-60 per acre even when worked under the old ADC system. When the working of these pumps is organized in such a way that farmers have to pay for the amount of water used by paying for the fuel instead of paying a flat per acre rate, the cost is expected to be reduced to about Rs. 39 per acre.

The annual cost of Comilla tubewells is less than that of the WAPDA tubewells but is still quite high. It has been reduced from Rs. 100 per acre to Rs. 73 per acre by making the farmers pay for the quantity of water used. It can be further reduced to about Rs. 60 per acre if locally manufactured diesel engine, the ADBP-imported lining pipe and coir-string strainers are used. These would reduce the capital cost to about Rs. 13,000 per well and the annual cost to about Rs. 60 per acre.

The benefit-cost ratio is the lowest in the case of Ganges-Kobadak Project (2.2) and about the same in the case of the WAPDA tubewells (2.0 to 2.5). It is the highest in the case of one-cusec low-lift pumps (4.0) with that of a two-cusec pump somewhat less (3.3). It is expected to become even higher

(5.1) when the farmers have to pay for the volume of water used by purchasing their own fuel and when one-cusec pumps are used in most areas of East Pakistan and two-cusec pumps are limited to areas where larger blocks of land are available for irrigation.

The benefit-cost ratio of the Comilla tubewells (2.6 to 3.6) is midway between the Ganges-Kobadak Project and the WAPDA tubewells on the one hand and low-lift pumps on the other. It can, however, be increased to 4.4 by reducing the capital cost to about Rs. 13,000 per well by using locally manufactured diesel engines and coir-string strainers.

V. CONCLUSIONS

Evidence presented in this paper leads to six important inferences which support the hypotheses enunciated in the beginning of this paper.

1) The capital cost of a low-lift pump is about Rs. 80 to 140 per acre, whereas that of a small 6-inch tubewell is about Rs. 160 to 330 per acre irrigated. Against this the capital cost of a gravity canal system fed by large pumps installed on large rivers is about Rs. 900 per acre. The capital cost of large government tubewells is also high, about Rs. 500 per acre without electrification network and about Rs. 960 per acre inclusive of electricity generation, transmission and distribution facilities. A large programme to cover major part of East Pakistan by low-lift pumps and small tubewells in preference to that of large gravity canals fed by large pumping plants and government tubewells would, therefore, be more appropriate for East Pakistan.

The small low-lift pumps can be provided in an area of about 5 million acres out of the total cultivated area of 21.6 million acres. At Rs. 100 an acre, these would cost about Rs. 500 million.

The remaining area of 16.6 million acres cannot be served entirely by tubewells due to an unfavourable aquifer condition in some parts and salinity hazard in other parts. Excluding these unfavourable areas, it may be possible to develop about 5 million acres by tubewells during the third-plan period. These would require about 60,000 tubewells, each covering about 80 acres and costing about Rs. 13,000 each. The total cost of this programme for 5 million acres would be about Rs. 800 million. The total cost of the low-lift and the tubewells programme for 10 million acres would, thus, be about Rs. 1,300 million.

2) The annual operation cost of an ADC pump is estimated at Rs. 50 and Rs. 60 per acre for a one-cusec and a two-cusec pump respectively. When

hire charges are fixed on annual rental basis plus cost of fuel, the per acre cost is likely to be reduced to about Rs. 39 for the *boro* crop. It is likely to be reduced still further when farmers begin to use the pumps for the *aus* and the *aman* crops. Similarly, the cost of fuel used on Comilla tubewells has been reduced from Rs. 44 to Rs. 14 an acre by shifting from a per acre hire charge to an annual rental charge plus cost of fuel. The total cost of working of Comilla tubewells now comes to about Rs. 73 per acre, but can be reduced to about Rs. 60 an acre by reducing the capital cost of installation from Rs. 20,000 to about Rs. 13,000 by the use of locally manufactured diesel engines, the ADBP-imported lining pipe and coir-string strainers.

The annual operation cost of large gravity canals fed by large pumping plants comes to about Rs. 96 per acre. The cost of large government tubewells comes to Rs. 138 per acre irrigated.

The capital cost and annual operating cost of large gravity canal and large government tubewells are higher than those of small low-lift pumps and small tubewells. They also have much longer gestation period. On the other hand, small low-lift pumps and small tubewells begin to yield benefits from the first year. A much larger programme for small low-lift pumps and small tubewells and a much smaller programme for large gravity canals and large government tubewells is, therefore, desirable.

3) The small low-lift pumps as well as small tubewells have been used in areas which are normally inundated by floods to varying depths. No flood-protection works have to be provided for these low-lift pumps and the tubewells. This means that costly flood-protection works proposed by the IECO, the WAPDA and the Planning Commission can be postponed till a large part of East Pakistan is provided with irrigation facilities by means of low-lift pumps and tubewells.

It is important that there is no misunderstanding on this point. In the long run, flood-protection works will be required; they are essential if the summer crop yields are to be materially improved. What is proposed here is that the area under crops can be increased by some ten million acres during the winter season. Furthermore, the yield of early summer crops (*aus* paddy, jute, sugarcane, *etc.*) can be materially increased in a large part of ten million acres and that of *aman* paddy on a large part of ten million acres with the low-lift pumps and the small tubewells. The additional production from additional ten million acres of winter crops and improved yield of *aus* and *aman* season crops will enable East Pakistan to launch a flood-protection programme to protect the sixteen million acres of monsoon season crops.

4) The irrigation water used by farmers for crop production on small tubewells and low-lift pumps is only 15 to 21 acreinches for winter crops. Another 10 to 15 acreinches would probably be required for the *aus* and the *aman* crops at the beginning of the *aus* season and end of the *aman* season. Thus, only 30 acreinches of water (about 2.5 acrefeet) would be required during the year against 6.2 acrefeet proposed to be pumped by the WAPDA with a system of gravity canals which lose half of the water by seepage in the distribution system. Much less pumping of water would therefore be required.

5) The capital cost of a one-cusec pump per acre irrigated is much lower (Rs. 98) than the capital cost of a two-cusec pump (Rs. 144). The annual operating cost of a one-cusec pump (Rs. 50 per acre) is also lower than the annual operating cost of a two-cusec pump (Rs. 60 per acre). The benefit-cost ratio of a one-cusec pump (4.0) is, therefore, higher than that of a two-cusec pump (3.3). The one-cusec pumps have done better than two-cusec pumps because larger blocks of land where two-cusec pumps can be fully used are not available in most places in East Pakistan. As the number of pumps greatly expands during the third-plan period, area available at each site will become smaller and smaller. It would, therefore, be desirable to purchase 24,000 one-cusec pumps instead of 16,000 two-cusec pumps proposed by the ADC. They will cost the same but irrigate 50 per cent additional area.

6) Low-lift pumps and small tubewells are highly productive and would repay their cost in a period of about 2 years. These would, therefore, be taken up by the farmers and a large part of the Rs. 1,300 million required for 10 million acres would be provided by the farmers if a system of incentives for private investment in tubewells and low-lift pumps is provided. A programme for the sale of low-lift pumps at a subsidized price and of private investment in tubewell installation with a small subsidy should, therefore, be prepared. The government may not have to spend more than Rs. 500 million out of the total capital cost of Rs. 1,300 million required for irrigation facilities for 10 million acres if appropriate incentives are provided to the farmers.

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of Private Tubewells

tute of Development Economics carried out a small
bewells in a few villages in the former Punjab in March
f this survey were published in *The Pakistan Development*
243]. While carrying out the survey, the author found
er of cases the tubewell farmers were paying the usual
ater and were not getting any rebate for irrigation by
he obvious implication of this was that these tubewells
the Irrigation and Revenue Departments. The author,
the desirability of carrying out a survey or a complete
ls in the former Punjab with the help of the Department
e question was discussed with the Director of Agri-
readily agreed to the proposal and directed his staff to
e proposed survey.

onducted in the summer of 1964 in each village of six-
Northern Zone of West Pakistan. These districts were
had large areas underlain with nonsaline groundwater
ere installing tubewells for irrigation. The survey was
he District Agricultural Officers. The actual count of
y the Field Assistants in each village in their Unions and
rvised by Agricultural Assistants, most of whom were
re. The author made extensive tours of the villages of
he survey was being done.

survey are summarized in Table II and shown graphi-
re the number of tubewells in each Union is represented
. The Union Council boundaries are not shown on the
congestion. A rough estimate of the number of tube-
has also been prepared and included in Table II. There
ddle of 1964, 24,000 private tubewells in the Northern
oo tubewells in the whole of West Pakistan. Out of
tubewells were installed by the farmers in the year
he Northern Zone and 200 in the Southern Zone.

n areas of concentration of tubewells. One of these
Montgomery districts where electricity was supplied
wo districts had 9,200 tubewells by the middle of 1964.
Gujranwala and Sialkot districts where electricity

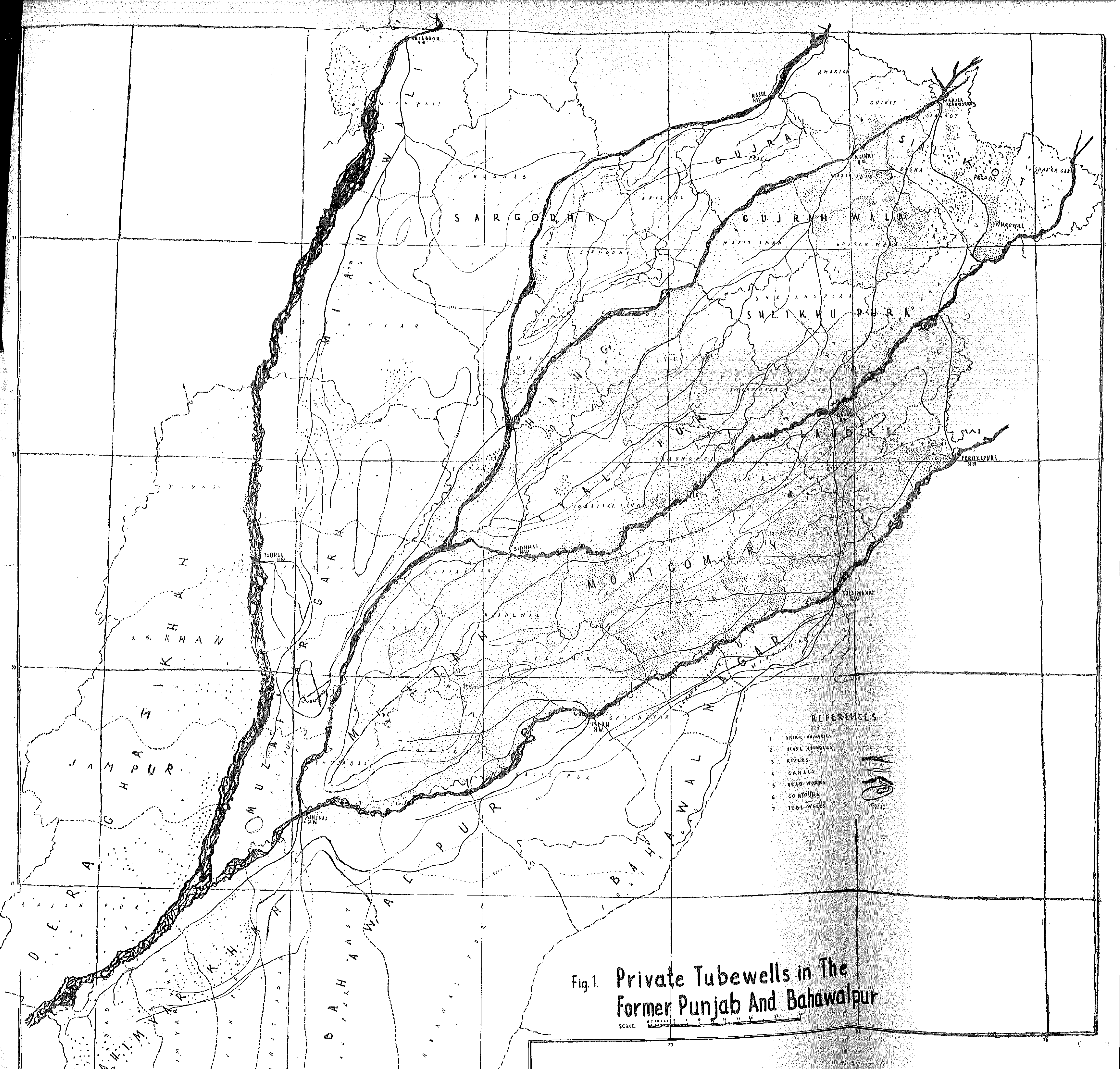

Fig. 1. Private Tubewells in The Former Punjab And Bahawalpur

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Appendix A

TABLE A-1

CLASSIFICATION OF CULTIVATED AREA OF EAST PAKISTAN WITH RESPECT TO DEPTH OF FLOODING

Type of land	Area		Depth of flooding
	Per cent	Million acres	
(1)	(2)	(3)	(4)
High	7.8	1.69	Above flood level
Intermediate	44.8	9.70	Less than 2 feet
Low	27.3	5.91	3 to 10 feet
Very low	4.6	0.99	More than 10 feet
Saline-tidal	14.6	3.16	Subject to saline-tidal action
Hilly	0.9	0.20	
Total:	100.0	21.64	

Source: [27, p. B-IV-9].

TABLE A-2

TOTAL CAPITAL COST OF THE GANGES-KOBADAK PROJECT, KUSHTIA UNIT, PHASES I AND II

Item	Capital cost
	(million rupees)
Powerhouse	13.7
Pumping stations	44.7
Irrigation canals	84.0
Intake channel	12.2
Drainage canals	21.8
Structures	68.8
Tools and plants	14.7
Establishment	9.6
Other items	64.4
Total:	333.9

Source: Information supplied by Project Director, Ganges-Kobadak Project, in May 1966.

TABLE A-3

LOW-LIFT POWER PUMPS USED AND AREA IRRIGATED DURING THE SECOND-PLAN PERIOD

Year	Total number of pumps used	Total cusec capacity utilized	Total area irrigated
(1)	(2)	(3)	(4)
			(in acres)
1960/61	1,367	1,743	62,100
1961/62	1,555	2,267	73,900
1962/63	2,024	3,461	133,000
1963/64	2,277	4,604	156,800
1964/65	2,239	4,381	131,400

Source: [10, p. 16].

TABLE A-4

LOW-LIFT PUMP PROGRAMME OF THE ADC FOR THE THIRD-PLAN PERIOD

Year	Number of pumps to be procured	Number of pumps proposed to be utilized	Total cusec capacity to be utilized	Area proposed to be irrigated
(1)	(2)	(3)	(4)	(5)
				(in acres)
1965/66	1,000	3,600	7,840	235,000
1966/67	2,000	4,480	9,740	292,000
1967/68	3,000	6,400	12,830	385,000
1968/69	5,000	8,390	17,520	521,000
1969/70	5,000	12,400	25,460	764,000

Source: [10, p. 17].

TABLE A-5

NUMBER OF PUMPS, HOURS WORKED AND AREA IRRIGATED BY LOW-LIFT PUMPS OF THE AGRICULTURAL DEVELOPMENT CORPORATION IN EAST PAKISTAN, 1962/63 TO 1964/65

Year	Number of pumps used			Hours worked by			Area irrigated by			Total fuel consumed by		
	All pumps	2-cusec pumps	1-cusec pumps	All pumps	2-cusec pumps	1-cusec pumps	All pumps	2-cusec pumps	1-cusec pumps	All pumps	2-cusec pumps	1-cusec pumps
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
	(....number....)			(....thousand hours....)			(....thousand acres....)			(....thousand rupees....)		
1962/63	2019	1096	643	1721	1018	442	133	69	44	1295	770	336
1963/64	2477	1649	343	1748	1166	343	157	105	28	1973	1322	287
1964/65	2239	1822	349	1532	1164	264	131	109	15	2156	1881	239

Source: Compiled from a statement supplied by the Agricultural Development Corporation with their letter No. ADC/ENG/DEN-B/IP/33/65/3225, dated December 7, 1965.

TABLE A-6

NUMBER OF LARGE OPERATIONAL HOLDINGS, TOTAL CULTIVATED AREA, WHICH CAN BE IRRIGATED BY LOW-LIFT PUMPS AND AREA WHICH CANNOT BE SERVED BY LOW-LIFT PUMPS IN DIFFERENT DISTRICTS OF EAST PAKISTAN

District	Number of farmers having operational holdings above				Area of the district		
	40 acres	25 acres	12.5 acres	7.5 acres	Total cultivated area	Area which can be served by low-lift pumps	Area which cannot be served by low-lift pumps
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	(......*number in thousands*......)				(......*thousand acres*......)		
Mymensingh	5	27	269	908	3069	1,041	2,028
Sylhet	4	28	208	529	1,724	759	965
Dacca	2	10	91	318	1,285	539	746
	11	65	568	1,755	6,078	2,339	3,739
Comilla	—	1	27	143	1,337	425	912
Rajshahi	5	33	263	727	1,714	309	1,405
Faridpur	2	10	94	329	1,382	369	1,013
Pabna	2	14	103	297	984	276	708
Rangpur	5	26	187	594	1,590	271	1,319
Jessore	1	9	116	455	1,220	271	949
Chittagong	2	7	49	144	714	69	645
Khulna	2	15	138	408	1,070	50	1,020
Noakhali	2	6	45	131	831	86	745
	21	121	1,022	3,228	10,842	2,126	8,716
Barisal	8	33	209	584	1,884	?	1,884
Dinajpur	3	21	170	475	1,151	122	1,029
Bogra	1	7	59	211	831	106	725
Kushtia	2	10	94	253	669	52	617
Chittagong Hill Tracts	—	2	16	52	187	264	(—)77
	14	73	548	1,580	4,722	544	4,178
Total:	46	459	2,138	6,563	21,642	5,009	16,633

Sources: Column (1) to (5): From [37, Pp. 29-34].
Column (6): From [27, p. B-IV-9].
Column (7): From [6, Appendix XIII].
Column (8): Column (6) *minus* Column (7).

Appendix B

TABLE B-1

PROGRESS OF IRRIGATION ON TUBEWELLS IN COMILLA KOTWALI THANA

Year	Number of tubewells worked	Total area irrigated	Area irrigated per tubewell
		(........*acres*........)	
1962/63	2	36	18
1963/64	12	437	36
1964/65	34	1,006	30
1965/66	25	1,142	46

Source: Compiled from the records of the PARD, Comilla, by Mr. A. Q. Ziauddin, Staff Economist at the Institute.

TABLE B-2

YIELD OF *BORO* PADDY WITH DIFFERENT IRRIGATIONS HATHAZARI, CHITTAGONG, 1964/65

Interval of irrigation	Total irrigation water applied during *boro* season	Average yield of *boro* paddy (4 replications)
(1)	(2)	(3)
(*days*)	(*acreinches*)	(*maunds per acre*)
10	50.7 } 41.2	38.8 } 38.0
15	31.8	37.3
20	21.6	36.3
25	18.9	32.6
30	14.0	33.3
35	14.7 } 13.4	32.9 } 33.7
40	11.5	34.9
Control	nil	12.8

Source: Figures collected from the Agricultural Assistant, Hathazari, Government Agricultural Farm, Chittagong, on April 8, 1966.

Appendix C

TABLE C-1

SIZE OF HOLDING AND NUMBER OF SINGLE AND JOINT TUBEWELLS IN THE LAHORE, GUJRANWALA, MONTGOMERY AND MULTAN DISTRICTS AT THE END OF 1965

Size of holdings	Total number of farmers	Number of farmers who installed tubewells			Number of tubewells installed jointly by farmers	Percentage of farmers who installed tubewells		
		Indivi-dually	Jointly	Total		Indivi-dually	Jointly	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(acres)								
0	—	119	200	319		—	—	
0.0 - 5.0	337,415	65	730	795		.019	.216	
5.0 - 7.5	94,669	141	1,599	1,740		.149	1.686	
7.5 - 12.5	138,356	535	3,398	3,933		.387	2.913	
12.5 - 25.0	131,865	1,592	5,670	7,162		1.192	4.300	
25.0 - 50.0	44,981	4,206	5,233	9,439		9.359	11.634	
50.0 - 150.0	9,196	6,117	1,887	8,004		66.518	20.520	
above 150.0	712	1,489	83	1,572		206.129	11.657	
	757,194	14,244	18,798	33,042	5,904	1.883	2.483	

Source: Survey by the PIDE.

TABLE C-2

POSSIBLE NUMBER OF TUBEWELLS IN EAST PAKISTAN ON THE BASIS OF SIZE OF HOLDING IN FOUR DISTRICTS OF WEST PAKISTAN

Size of holding	Total number of farmers	Percentage of farmers likely to install tubewells		Number of farmers likely to install tubewells			Number of tubewells likely to be installed		
		Indivi-dually	Jointly	Indivi-dually	Jointly	Total	Indivi-dually	Jointly	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(acres)									
0.0—5.0	4784,900	.019	.019	909	10,335	11,244			
5.0—7.5	698,450	.149	.149	1,040	11,775	12,815			
7.5-12.5	442,360	.387	.387	1,712	12,886	14,589			
12.5-25.0	187,790	1.192	1.192	2,238	8,075	10,313			
25.0-40.0	21,370	9.359	9.359	2,486	2,475	4,961			
above 40.0	4,610	66.518	20.520	3,066	946	4,012			
	6139,480			11,451	46,492	57,943	11,543	14,600	26,053

Source: Column (2): From [37, Pp. 29-34].
Other columns have been calculated from Appendix Table C-1.

Rainfall, Acreage and Wheat Production in West Pakistan: A Statistical Analysis

Sarfraz Khan Qureshi

This chapter originally appeared as an article in the Winter-1969 issue of *The Pakistan Development Review* and is the result of research carried out in 1963 when the author was a Staff Economist at the Pakistan Institute of Development Economics.

The study was done under the supervision and guidance of Dr. Christoph Beringer, a former Research Adviser at the Institute. Drs. Stephen R. Lewis Jr. and Ronald Soligo, former Research Advisers at the Institute made helpful comments on an earlier draft.

Mr. Qureshi is at present a Research Economist at the Pakistan Institute of Development Economics.

Rainfall, Acreage and Wheat Production in West Pakistan: A Statistical Analysis

Sarfraz Khan Qureshi

INTRODUCTION

Reliable knowledge about the factors causing variability in agricultural production is indispensible in the process of planning for economic development in Pakistan. This holds particularly for the major foodgrains, wheat and rice, which account for at least 40 per cent of gross national product. If we can determine the extent to which factors beyond our control (*e.g.*, weather) cause year-to-year fluctuations in output, we should be able to estimate more accurately the increases in output attributable to our own development efforts (*e.g.*, increased use of fertilizers, pest-control measures, *etc.*).

In the case of wheat production in West Pakistan, our immediate concern is to study factors that determine acreage and production in any cropping season. With reliable indicators of the probable wheat production earlier than the month of September when official estimates are made available, government policy-measures with respect to foodgrain import and storage could be taken to ensure a more stable domestic supply and price level.

There is a general feeling — perhaps justified — that a "good rainfall year" means a good wheat-crop. Statistically, however, this relationship is by no means obvious on such an aggregative level. In fact, the simple correlation coefficient between total rainfall in a year and wheat production in West Pakistan is close to zero.

The purpose of this paper is to make a somewhat more refined analysis of this problem so as to work out concepts of rainfall and production that can be useful for predicting total output. In particular, we shall try to estimate production on the basis of not only the quantity but also the distribution of rainfall during the presowing, sowing and growing periods of wheat. We shall limit overselves in this paper to three districts in the northern Punjab, namely, Rawalpindi, Jhelum, and Campbellpur where more than 97 per cent of wheat acreage is dependent on rainfall. These districts account for 8 per cent of total wheat grown in West Pakistan and 34 per cent of total wheat grown on unirrigated land.

The data underlying our analysis are for a 30-year period, 1931/32 to 1960/61, for which both rainfall and production statistics were available.

II. DESCRIPTION AND USE OF DATA

Rainfall

The meteorological department of undivided India published monthly rainfall figures by districts. These are simple averages of the actual rainfall measured in one or more meteorological stations in each district[1]. After Partition, this work was continued by the meteorological department of Pakistan. The data are complete for all years from 1931 to 1961 and are highly reliable.

The recorded average rainfall cannot be used directly for analytical purposes as a portion of it is lost through run-off, drainage and evaporation. Sometimes, the rainfall in a month exceeds the waterholding capacity of the rootzones of crops, and to the extent that it does, it is of no use to crops. An allowance for these factors must, therefore, be made to get a rainfall series that represents its useful contribution for crop production. This adjustment is particularly important since the relationship between rainfall and wheat production is of a technical nature: additional rainfall results in increased production without requiring any extra effort on the part of farmers.

[1]District Campbellpur has stations at Campbellpur, Talagang, Fatehjang, Hasan Abdal, Pindigheb, Lawa, and Taman. District Rawalpindi has stations at Rawalpindi, Gujar Khan, Kahuta, and Murree. District Jhelum has stations at Jhelum, Chakwal, and Pind Dadan Khan.

The method adopted for this adjustment follows that used by the U.S. Bureau of Reclamation[2]. It consists essentially of applying a declining percentage for each additional inch of rain each month. Of the first inch, 95 per cent is taken as effective rainfall; for the rainfall exceeding six inches, only 5 per cent is considered as useful. The schedule of the maximum-effective rainfall is given in Appendix Table A-1. The rainfall data thus adjusted are called "maximum-effective rainfall".

The relationship between total recorded rainfall and the maximum-effective rainfall during the period under consideration in three districts is shown in Appendix Tables A-2, A-3 and A-4 and is summarized in Table I.

TABLE I

VARIABILITY IN RAINFALL DURING JULY TO MARCH

(1931/32 to 1960/61)

	Rawalpindi	Jhelum	Campbellpur
Total Rainfall			
Mean rainfall (*inches*)	34.34	18.88	18.34
Standard deviation (*inches*)	6.96	5.27	4.37
Coefficient of variation (*per cent*)	20.27	26.50	23.88
Maximum-effective Rainfall			
Mean rainfall (*inches*)	20.24	14.60	13.94
Standard deviation (*inches*)	2.66	2.57	2.43
Coefficient of variation (*per cent*)	13.14	17.43	17.60
Mean effective Rainfall as Per Cent of Mean Total Rainfall	58.94	73.44	76.01

Source: Appendix Tables A-2, A-3 and A-4.

[2][6, p. 12; 4, p. 8]. Mann uses daily rainfall figures and has different rules to exclude the portion of rainfall which is not of any use to the crop. We could not use this method as no detailed data were available.

It is clear from Table I that there are considerable interdistrict differences in the rainfall pattern. Compared with Jhelum and Campbellpur, Rawalpindi has a less erratic rainy season and receives a larger quantity of rainfall. Jhelum and Campbellpur are similar in that both districts have relatively more variable and lower average rainfall. The table also shows considerable interdistrict differences between actual and effective rainfall which makes it essential to adjust crude rainfall before analysis of production. As one would expect, the ratios of mean-effective rainfall to mean total rainfall show striking differences between districts. This ratio is highest for Campbellpur which has the lowest mean rainfall, and lowest for Rawalpindi which has the highest mean rainfall.

Acreage and Production

The sources of acreage and production data are the *Season and Crop Reports for Punjab*, published since the turn of the century by the Director of Land Records, Punjab, and since 1955 by the Director of Land Records, West Pakistan, Northern Zone, Lahore. These data have been compiled in a statistical publication of the Pakistan Institute of Development Economics [5].

While the data for rainfall are accurate and the only problem is estimating the portion which is of use to the crop, the same cannot be said for the crop data. Walter Falcon [3, p. 3] has shown that official acreage estimates in West Pakistan are reasonably accurate so that they can be used without too much reservation. Production figures, on the other hand, are subject to large errors. A recent comparison of official estimates with estimates based on crop-cutting experiments for wheat in West Pakistan has shown that the official figures differ significantly from those derived from the crop-cutting surveys. These comparisons indicate that the official production estimates have underestimated total wheat output on the average by about 21 per cent and that there has been a tendency for official estimates to overestimate the actual output in poor seasons and to underestimate it in good seasons [1]. The deficiencies in crop-production data result from the procedures being used for estimating crop production. Production is the multiplicand of sown area, normal yield and a seasonal condition factor. Normal yield is, in fact, a five-year moving average of results obtained from crop-cutting surveys. This tends to dampen the amplitude of the deviations from the true average. The seasonal condition factor is subjectively estimated by the local revenue officer and is, therefore, statistically unreliable.

From the point of view of our analysis, the tendency for official figures to reduce the amplitude of the variability is a more serious problem than the error in the absolute level of output. Unfortunately, there is no basis on which the official figures can be corrected for the errors present in them; and the estimates of wheat output from crop-cutting surveys are too few to be used in a time-series model.

III. IRRIGATION AND VARIABILITY IN WHEAT PRODUCTION

Wheat is the staple food in West Pakistan. More than 95 per cent of the country's wheat production is being produced in West Pakistan. About 30 per cent of the cultivated area of West Pakistan and 60 per cent of the major food-crop area is under wheat. About 23 per cent of the wheat production in West Pakistan is in areas where rain is the only source of moisture for the plants.

Irrigation gives the farmer some degree of control over his crops since his dependence on rainfall is considerably reduced. Statistically, this is reflected in Table II and Figure I which show the variability in wheat production in the former Punjab area on irrigated and nonirrigated lands[3].

TABLE II

VARIABILITY IN WHEAT PRODUCTION IN PUNJAB: IRRIGATED AND NONIRRIGATED AREAS

(1947/48 to 1958/59)

	Mean production	Standard deviation	Coefficient of variation
	(........000 *tons*........)		(*per cent*)
Irrigated wheat	1,942.8	236.9	12.2
Nonirrigated wheat	597.4	143.9	24.1
Total wheat	2,540.2	306.5	16.0

It is apparent that the variability of nonirrigated wheat is twice as high as that of irrigated wheat. Although unirrigated wheat accounts for only 25 per cent of the total production, a substantial part of the variability in total

[3]We have restricted our observations to the former Punjab area as no breakdown into irrigated and nonirrigated wheat production was available for the rest of West Pakistan.

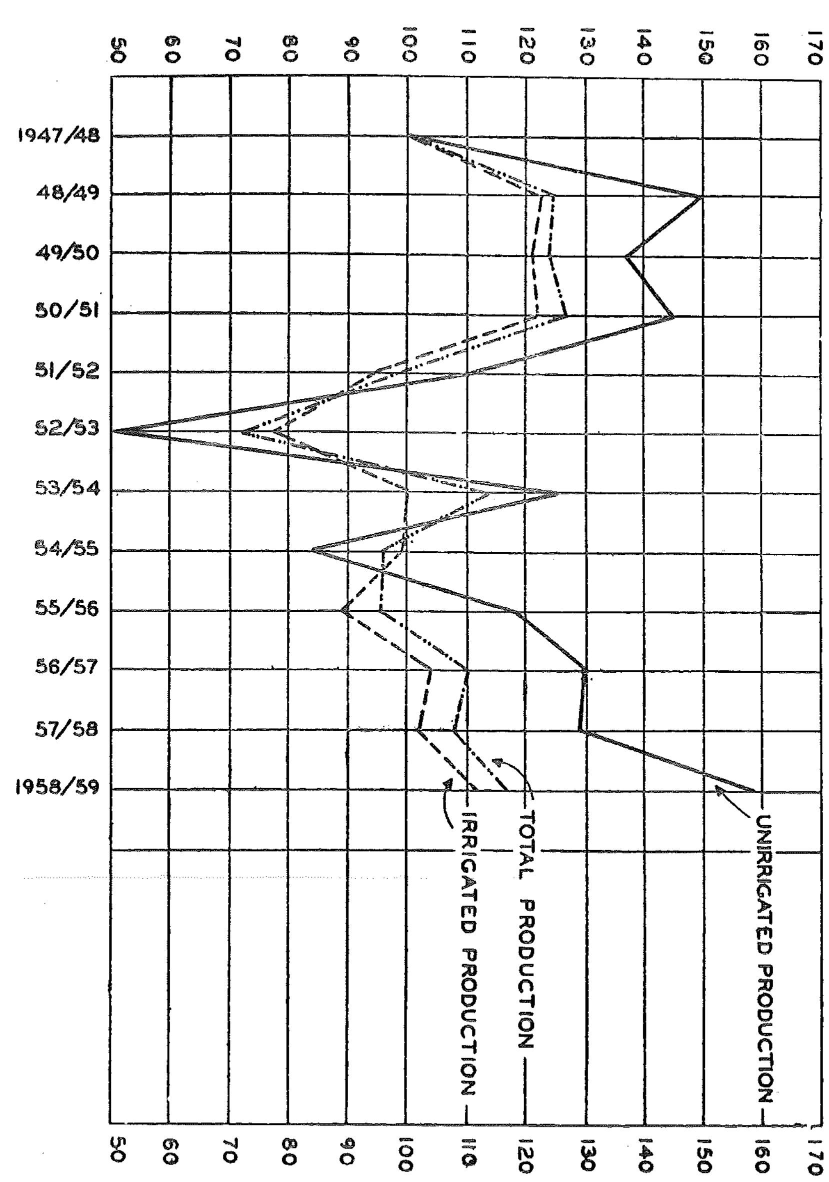

FIGURE I
VARIATION IN INDICES OF WHEAT PRODUCTION (PUNJAB, WEST PAK.)
IRRIGATED AND NONIRRIGATED LANDS
(1947/48 = 100)

wheat output is accounted for by the variation in *barani*[4] wheat production. Knowledge of factors affecting variation in production on *barani* land is, therefore, likely to be useful in planning.

IV. VARIABILITY IN ACREAGE AND PRODUCTION BY DISTRICTS

Although the districts chosen for analysis account only for 34 per cent of the wheat production on unirrigated land in West Pakistan, their behaviour can be taken as an indicator for other areas growing *barani* wheat.

During the period from 1931/32 to 1960/61, Rawalpindi, Jhelum, and Campbellpur districts showed wide fluctuations in wheat production. The variation in acreage is considerable but variation in production is even more marked. The annual data for acreage and production are shown in Appendix Tables A-5 and A-6. Table III and Figures II and III show the variability in acreage and production.

TABLE III

VARIABILITY IN ACREAGE AND PRODUCTION IN THREE DISTRICTS (1931/32 to 1960/61)

District	Acreage		Production	
	Mean	Coefficient of variation	Mean	Coefficient of variation
	(thousand acres)	*(per cent)*	*(thousand tons)*	*(per cent)*
Rawalpindi	251.32	5.47	57.4	18.20
Jhelum	337.30	6.37	82.3	22.60
Campbellpur	588.10	9.17	112.8	24.90

Source: Appendix Tables A-5 and A-6.

Rawalpindi has relatively smaller variation in wheat production than the districts of Jhelum and Campbellpur, but even so it is much larger than the variability in irrigated wheat production. This interdistrict difference in the

[4]*Barani* is derived from the Persian word *baran* which means 'rain'. In the agricultural statistics of West Pakistan, *barani* refers to the unirrigated areas that depend on rainfall for cultivation.

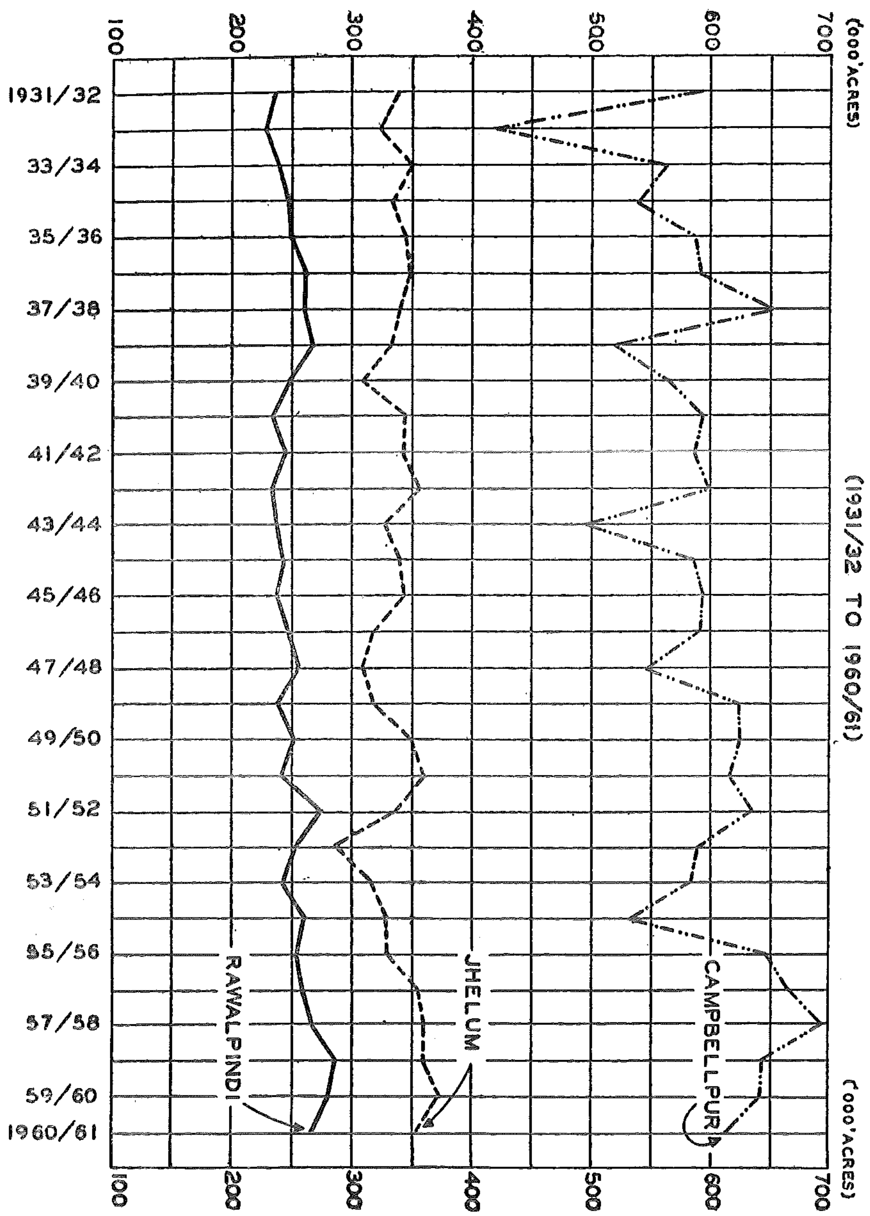

FIGURE II
WHEAT ACREAGE IN RAWALPINDI, JHELUM AND CAMPBELLPUR DISTRICTS
(1931/32 TO 1960/61)

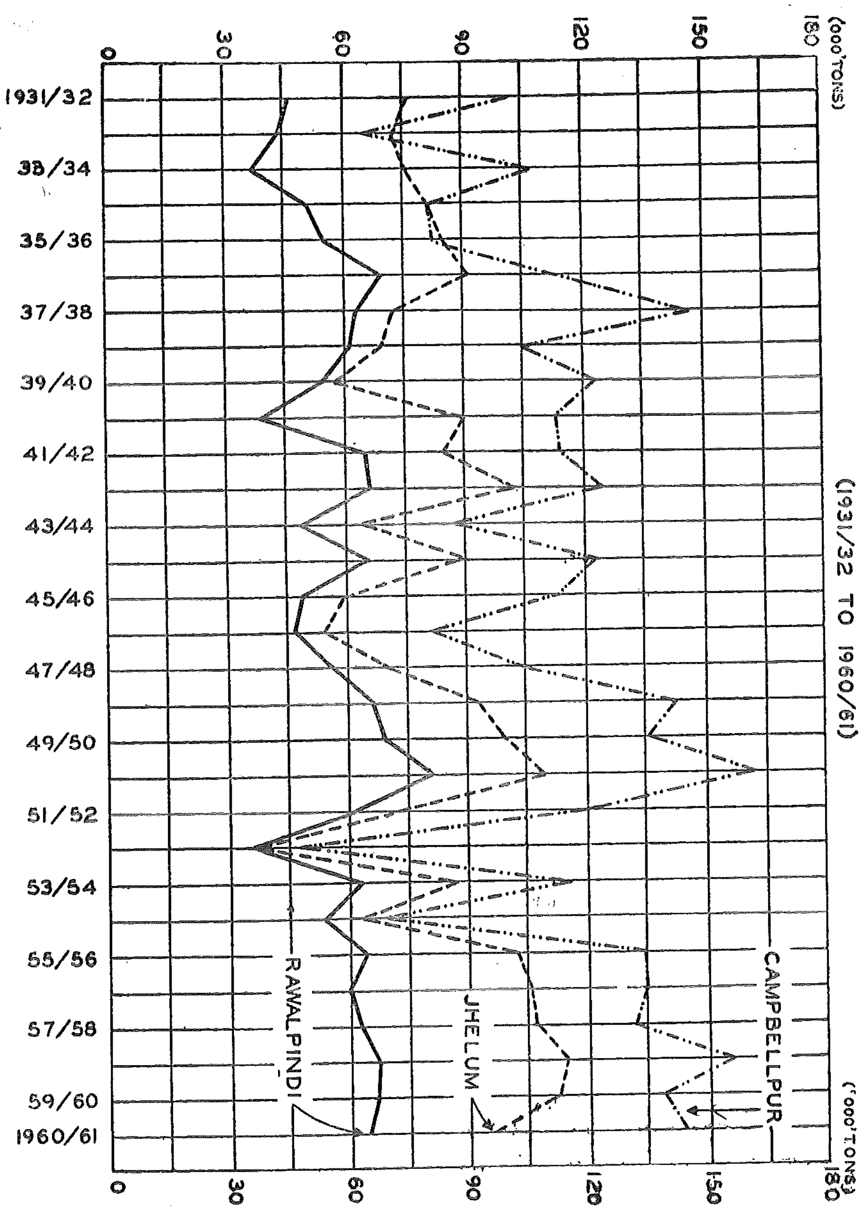

FIGURE III
WHEAT PRODUCTION IN RAWALPINDI, JHELUM AND CAMPBELLPUR DISTRICTS
(1931/32 TO 1960/61)

variability in acreage and production corresponds to the variation in the rainfall in the three districts. Jhelum and Campbellpur are characterized by high variability in rainfall, acreage and production while Rawalpindi exhibits relatively less variation in these three magnitudes. The relationship suggested above is, however, based on a high level of aggregation and needs a careful analysis for its substantiation.

V. FACTORS CAUSING VARIATION IN WHEAT ACREAGE

It is customary to use the relative prices of competing crops as an explanatory variable in supply models of agricultural commodities. A positive price response is considered to be consistent with economic rationality on the part of farmers. Consequently, the relative prices of different farm products can be relied upon to explain the process of allocation of crop land among the competing crops. Recently, however, there has been a growing awareness of factors that may limit the price responsiveness of the farmers in a developing country [2]. The two major factors cited are the desire to grow a sufficient quantity of foodgrains for home consumption and the limited choice between alternative crops due to climatic conditions in a particular region.

These same considerations may justify our neglect, in the present analysis, of price as a determining variable in the explanation of variations in wheat acreage in the *barani* areas of West Pakistan. Because of limitations on water availability, there are very few substitute crops available to the farmers of the region. None of the cash crops that are important in irrigated areas can be grown on *barani* land[5]. Gram and barley are the only alternative crops to wheat. However, these crops have less food value per acre than wheat and are, therefore, not considered important by farmers who aim to be self-sufficient in food production.

[5] Oilseeds are the only cash crop in the districts under study. The percentage distribution of *rabi* crops is shown below:

PRODUCTION OF *RABI* CROPS BY DISTRICT
(1955/56 to 1958/59 AVERAGE)

Crops	*Rawalpindi*	*Jhelum*	*Campbellpur*
Wheat	89.3	84.7	82.0
Barley	1.9	0.8	2.5
Gram	4.3	8.9	9.5
Oilseeds	4.5	5.6	6.0
Total *rabi* :	100.0	100.0	100.0

Source: [7].

Soil moisture is an important requisite for preparing any piece of land for sowing and for proper germination of any seed. The only source of such moisture in these districts is the rainfall. It is, therefore, presumed that acreage of wheat is a positive function of rainfall during the presowing (July to September) and sowing (October to December) periods. The concept of rainfall implied in the hypotheses is the actual rainfall and not the maximum-effective rainfall that we shall use in relating rainfall to production in subsequent section. The reason for using the actual rainfall in the acreage function is that a farmer's decision on how much acreage he should sow in any season is not based on the exact calculation of the usable portion of the rain received in any season but somehow on the basis of how good the rainy season has been in the immediate past and how good the season will be when the wheat seed has to germinate. Rainfall during the presowing period is used in the acreage function for two reasons. *First*, it is required for the preparation of land for ultimate sowing. *Second*, the soil moisture from the presowing period can be preserved to supplement the soil moisture available from the sowing-period rain.

To provide some information on the relationship between wheat acreage and rainfall over the period from 1931/32 to 1960/61, three regression equations have been fitted to the available data of the three districts under study. The results are presented in Table IV below.

TABLE IV

ESTIMATED RELATIONSHIPS BETWEEN ACREAGE AND RAINFALL IN THE THREE DISTRICTS: 1931/32 to 1960/61

District	Estimated equation	Degree of freedom	Coefficient of determination (R^2)
Rawalpindi	$Y = 247.587 - \underset{(.0547)}{0.251X_1} + \underset{(.1433)}{3.374X_2}$	27	.4507
Jhelum	$Y = 314.207 + \underset{(.0711)}{1.241X_1} + \underset{(.4212)}{5.003X_2}$	27	.2355
Campbellpur	$Y = 551.380 + \underset{(.3850)}{0.871X_1} + \underset{(.9764)}{18.916X_2}$	27	.3144

Y = Wheat acreage in thousand acres
X_1 = Actual rainfall in inches during the presowing period
X_2 = Actual rainfall in inches during the sowing period

Note: Figures in parentheses show the standard errors of regression coefficients.

The relationship between wheat acreage and rainfall during presowing and sowing periods can be easily seen from the regression equations. An increase in rainfall by one inch during the sowing period leads to an increase in wheat acreage by 3774, 5003 and 18,916 acres respectively in Rawalpindi, Jhelum, and Campbellpur districts. One additional inch of rain during the presowing period increases wheat acreage by 1241 and 871 acres respectively in Jhelum and Campbellpur, but it reduces the wheat acreage in Rawalpindi by 251 acres. The different behaviour in Rawalpindi may be explained by the fact that the presowing period for wheat is also the sowing and growing period for the summer crops which generally require heavy rainfall for proper growth and maturity. The average rainfall in Jhelum and Campbellpur districts during July to September is low compared with Rawalpindi. In the low-rainfall districts, summer crops are not grown on a large scale and the land is earmarked for wheat. However, in Rawalpindi, the rainfall conditions permit the growing of larger summer crops. The ratios of average area under summer crops to the average total cropped area for the period 1955/56 to 1958/59 were 20 per cent, 26 per cent and 46 per cent respectively in Campbellpur, Jhelum, and Rawalpindi. In good rainfall years, the land is diverted more towards the summer crops, thereby reducing the land available for the wheat crop.

The higher value of R^2 in Rawalpindi requires some comment. Rawalpindi has relatively less erratic rainfall than Jhelum or Campbellpur, which means that actual rainfall in the sowing period approximates more closely the farmers' expectation in Rawalpindi than in Jhelum and Campbellpur. Total variance in acreage is also less in Rawalpindi campared with Jhelum and Campbellpur.

The coefficients of determination (R^2) are not very high. About 45 per cent of the variation in acreage is explained by variations in rainfall in Rawalpindi, while the variation in acreage explained in the other two districts is even lower. Factors other than rainfall are extremely important in the determination of wheat acreage. However, the regression coefficients are significant at the 99-per-cent confidence level in all districts.

Having discussed the relationship between rainfall and acreage in absolute terms, we pass on to the estimation and interpretation of the acreage elasticities with respect to rainfall in different periods. The use of elasticities eliminates the problem of differences in absolute size of districts and allows us to isolate the relative effects of rainfall on acreage in each district. Since the elasticity changes with the size of the independent variable because of the particular form chosen for the regression equation, we shall measure acreage elasticity in each district at the respective mean levels of rainfall in both periods. These elasticities are shown in Table V.

TABLE V

ACREAGE ELASTICITIES WITH RESPECT TO RAINFALL AT MEAN LEVELS OF RAINFALL IN EACH PERIOD

District	Presowing period		Sowing period	
	Mean rainfall $\overline{X}_1$	Acreage elasticity	Mean rainfall $\overline{X}_2$	Acreage elasticity
	(inches)		*(inches)*	
Rawalpindi	23.29	—.02	2.54	.04
Jhelum	14.06	.05	1.13	.02
Campbellpur	12.20	.02	1.38	.04

For Rawalpindi, an elasticity of — 0.02 would mean that holding rainfall during the sowing period constant at its mean level of 2.54 inches, a 1-per-cent increase in rain during the presowing period will decrease the acreage by 0.02 per cent of the average acreage. Similarly, holding rainfall constant at 23.29 inches during the presowing period, a 1-per-cent increase in rainfall during the sowing period will lead to an increase in acreage by 0.04 per cent of the average acreage. Other elasticities can be read in a similar way. Since the intercept in the three regression equations is positive for all observed values of X_1 and X_2, the acreage elasticity with respect to rainfall in each period will be an increasing function of amount of rainfall in each period. However, we should not expect much from this property of the acreage elasticities.

The interdistrict differences in the acreage elasticities are quite revealing. In Rawalpindi and Campbellpur, acreage is relatively more elastic to the sowing-period rain and less elastic to the presowing-period rain while in Jhelum the acreage is relatively more elastic to the presowing-period rain and less elastic to the sowing-period rain. The different districtwise behaviour may be explained by a simple hypothesis. Assuming that soil-moisture requirements for the germination of wheat plant are the same in the three districts, districts which receive low average rainfall during the sowing period have to depend much more on rains in the presowing period than those districts that receive relatively larger amounts of rain during the sowing season. In our case, the average rainfall in Jhelum is 18 per cent less than the rainfall in Campbellpur and 56 per cent less than the rainfall in Rawalpindi. It is, therefore, understandable that farmers in Jhelum have to be more concerned with the effective utilization of rain received during the presowing period than their counterparts in Campbellpur or Rawalpindi who, in turn, respond more (in acreage) to increases or decreases in the sowing-period rain.

VI. FACTORS AFFECTING VARIATION IN PRODUCTION

Two hypotheses are advanced to explain the variation in the levels of wheat production in any cropping season. *First*, we presume that wheat production is a positive function of rainfall in the presowing, sowing and growing periods. For explaining the interrelationship between rainfall in any period and wheat production, it is convenient to think of production as the multiplicand of the area under the crop and the yield per acre. Presowing- and sowing-period rains affect production through changes in acreage and the yield while growing-season rain influences production only through its effect on the yield per acre. *Secondly*, production is influenced by the pattern of rainfall in different periods. Low rainfall in each of the three periods is likely to give a poor crop while good rainfall in all periods will give a bumper crop. Good early rains and low follow-up rains may give high acreage and low yield resulting in average production. Poor early rains combined with good follow-up rains may give low acreage but good yields again resulting in average production. These are the hypotheses that we test in this section.

The results of fitting linear-regression equations to the production and rainfall data for the three districts for the period 1931/32 to 1960/61 are given in Table VI. However, it should be remembered that the production figures may deviate from their true levels by as much as plus or minus 30 per cent[6]. All the regression coefficients are significantly different from zero at 99-percent confidence level. All the signs of the regression coefficients are consistent with the hypothesis of a positive relationship between rainfall and production. This is true even in the case of presowing-period rainfall in Rawalpindi where an increase of one inch of rain increases wheat production by 244 tons. The explanation for the difference in the effect of presowing rainfall on acreage and production is that although one inch of additional rainfall during July to September decreases wheat acreage by 251 acres, its beneficial effect on the yield is apparently so strong that wheat production is increased by 224 tons despite reduced acreage.

[6]*See*, p. 569.

TABLE VI

ESTIMATED RELATIONSHIPS BETWEEN PRODUCTION AND RAINFALL IN THE THREE DISTRICTS: 1931/32 to 1960/61

District	Estimated equation	Degree of freedom	Coefficient of determination (R^2)
Rawalpindi	$Y = 29.042 + .224X_1 + .757X_2 + 2.648X_3$ (.0156) (.0408) (.1640)	26	.3261
Jhelum	$Y = 34.005 + 1.835X_1 + 6.526X_2 + 3.483X_3$ (.319) (.391) (.299)	26	.4664
Campbellpur	$Y = 66.581 + 2.110X_1 + 6.810X_2 + 2.692X_3$ (.215) (.545) (.507)	26	.2512

Y = Wheat production in thousand tons

X_1 = Actual rainfall in inches during July to September

X_2 = Actual rainfall in inches during October to December

X_3 = Maximum-effective rainfall during January to March

Note: Figures in parentheses show standard errors of regression coefficients.

The production elasticities with respect to rainfall in different periods are presented in Table VII. These are computed from the regression equations listed in Table VI above.

The production elasticities with respect to rainfall during the sowing period are of the same magnitude in all the three districts. However, there are marked interdistrict differences regarding the elasticities with respect to the presowing- and growing-period rainfall. Production is relatively more elastic with respect to X_3 in Rawalpindi than in Jhelum or Campbellpur, whereas it is more elastic with respect to X_1 in Campbellpur and Jhelum than in Rawalpindi. The difference among districts can be explained in terms of the relative importance of different periods' rainfall as a source for the soil moisture required by the wheat plant. In Rawalpindi, the average rainfall during January to March is higher than the other two districts; and, consequently the need to preserve soil moisture from the early two periods is less

TABLE VII

PRODUCTION ELASTICITIES WITH RESPECT TO RAINFALL AT MEAN LEVELS OF RAINFALL

District	Presowing period		Sowing period		Growing period	
	Mean rainfall $\overline{X}_1$	Production elasticity	Mean rainfall $\overline{X}_2$	Production elasticity	Mean rainfall $\overline{X}_3$	Production elasticity
	(inches)		*(inches)*		*(inches)*	
Rawalpindi	23.29	0.09	2.54	0.08	7.03	0.32
Jhelum	14.06	0.31	1.13	0.09	4.33	0.18
Campbellpur	12.20	0.23	1.38	0.08	4.12	0.10

pressing in Rawalpindi than Jhelum and Campbellpur. Since production will tend to be more sensitive to rainfall in that period whose rainfall is more crucial for the determination of production levels, it is understandable that the production elasticity with respect to growing-period rainfall is relatively higher in Rawalpindi and the elasticity with respect to presowing period relatively higher in Jhelum and Campbellpur.

Distribution of Rainfall and Wheat Production

So far we have been concerned with the effect on production of changes in the quantity of rainfall in any one period holding rainfall levels constant in the other two periods. Now we turn to our second hypothesis concerning the relationship between different patterns of rainfall distribution in any season and the wheat production. The cropping season, July to March, is divided into two periods: July to December (Period 1) and January to March (Period 2). The years from 1931/32 to 1960/61 are grouped into four categories according to different annual patterns of rainfall. Pattern I is characterized by those years when rainfall was below average in each of the two periods; Pattern II, by those years when rainfall was below average in Period 1 but above average in Period 2; Pattern III, by those years when rainfall was above average in Period 1 but below average in Period 2; and Pattern IV, by those years when rainfall was above average in both periods. The average production per year in each group is computed. The results appear in Table VIII[7].

TABLE VIII

SEASONAL DISTRIBUTION OF RAINFALL AND WHEAT PRODUCTION (1931/32 to 1960/61)

Rainfall pattern			Rawalpindi	Jhelum	Campbellpur
	July to December	*January to March*	(.........000 *tons*.........)		
I.	below average	above average	50.27	69.06	94.75
II.	below average	above average	57.71	78.17	108.72
III.	above average	below average	53.85	89.82	119.14
IV.	above average	below average	64.00	95.86	148.63

It is clear from Table VIII that the distribution of rainfall in the two periods has a clear-cut relationship to the level of production. In all districts the figures support our hypothesis: Patterns I and IV are the extreme cases

[7]The number of years in each rainfall pattern in the three districts is shown below:

DISTRIBUTION OF YEARS ACCORDING TO DIFFERENT RAINFALL PATTERNS

Rainfall pattern	*Rawalpindi*	*Jhelum*	*Campbellpur*
I.	8	8	7
II.	11	11	10
III.	6	6	7
IV.	5	5	6
Total No. of years	30	30	30

Source: Appendix Tables A-2, A-3 and A-4.

of poor and bumper crops while the other two patterns are the intermediate, average cases of wheat production. The fact that presowing- and sowing-period rains are more crucial for wheat production in Jhelum and Campbellpur and that the growing-period rains are more important in Rawalpindi is also borne out from the above table. Poor early rains followed by good growing-period rains (Pattern II) result in more production in Rawalpindi than does a pattern of good early rains and poor follow-up rains (Pattern III). On the other hand, Pattern III gives higher production in Jhelum and Campbellpur than does Pattern II, showing that wheat production is hit harder when the rains are low in Period 1 than when the rains are low in Period 2 in Jhelum and Campbellpur.

Production as Explained by Acreage and Rainfall

The regression equations of the preceding sections have established significant relationships between acreage, rainfall and wheat production in the *barani* districts. One of the purposes of this study, however, is to see if these relationships can be used as the basis for improved estimates of wheat production prior to September when official crop estimates become available. Since acreage figures are known in January of each year, short-run forecast can be based on the estimated relationship between production, acreage and rainfall during January to March. In Table IX, regression equations linking these three variables are presented for the three districts under consideration.

TABLE IX

ESTIMATED RELATIONSHIPS BETWEEN PRODUCTION, ACREAGE AND RAINFALL: 1931/32 to 1960/61

District	Estimated equation	Degree of freedom	Coefficient of determination
Rawalpindi	$Y = -30.731 + \underset{(.0286)}{.293X_1} + \underset{(.1591)}{2.064X_2}$	27	.3958
Jhelum	$Y = -188.820 + \underset{(.0232)}{.784X_1} + \underset{(.2440)}{1.565X_2}$	27	.5945
Campbellpur	$Y = -139.525 + \underset{(.0132)}{.405X_1} + \underset{(.3633)}{3.427X_2}$	27	.5913

Y = Wheat production in thousand tons
X_1 = Wheat acreage in thousand acres
X_2 = Maximum-effective rainfall during January to March in inches

Note: Figures in parentheses show standard error of regression coefficients.

The regression coefficients are all significantly different from zero at 99-per-cent confidence level. The coefficients of determination are higher in each district than in the case when production was explained on the basis of rainfall in different periods. The variation explained in production is 59 per cent in Jhelum and Campbellpur districts and about 40 per cent in Rawalpindi whereas the variation explained in production by rainfall in three periods was only 32 per cent, 25 per cent and 46 per cent respectively in Rawalpindi, Jhelum and Campbellpur. It is not difficult to explain these results, particularly in Jhelum and Campbellpur. The earlier analysis showed that both production and acreage arer elated significantly to the rainfall of the presowing and sowing periods and that rainfall affects production partly through acreage changes. The substitution of acreage for early-period rainfall in the production function reduces the error in the independent variable and so explains a larger amount of variation in the dependent variable, *i.e.*, production. Since early rains are more crucial for wheat production in Jhelum and Campbellpur, the R^2s in their case improve to a much larger extent than in Rawalpindi where early rains are not that crucial. To eliminate the effect of absolute differences in the geographic size of the districts, the production elasticities with respect to acreage and rainfall have been computed and are shown in Table X.

TABLE X

PRODUCTION ELASTICITIES WITH RESPECT TO ACREAGE AND RAINFALL AT MEAN LEVELS OF ACREAGE AND RAINFALL (1931/32 to 1960/61)

District	Acreage		Growing-period rainfall	
	Mean acreage $\bar{X}_1$	Production elasticity	Mean rainfall $\bar{X}_2$	Production elasticity
	(*thousand acres*)		(*inches*)	
Rawalpindi	251.321	1.28	7.03	0.25
Jhelum	337.300	3.21	4.33	0.08
Campbellpur	582.106	2.11	4.12	0.12

The production elasticity with respect to growing-period rainfall is higher in Rawalpindi than in Jhelum or Campbellpur. This is presumably because of the relative importance of January-to-March rainfall in Rawalpindi versus the other two districts where sowing and presowing rainfall is more crucial to wheat production. The production elasticity with respect to acreage has the reverse pattern in the three districts, being higher in Jhelum and Campbellpur than in Rawalpindi. One reason for this different interdistrict behaviour has already been mentioned that presowing and sowing rainfall is relatively more crucial for wheat production in Jhelum and Campbellpur. However, another factor appears to be that the high average rainfall in Rawalpindi has helped farmers to bring the marginal land under cultivation and any increase in rainfall now extends cultivation to less fertile land. In the other two districts where the general deficiency in rainfall has not permitted cultivation to extend to lands that are really marginal, an increase in rainfall extends cultivation to relatively more fertile lands. Hence, there is a relatively greater change in wheat production. The data on the extent of land utilization in the three districts support this explanation. For example, the current fallow was 2.5 per cent of the total area in Rawalpindi while this percentage was 4.33 and 5.27 respectively in Jhelum and Campbellpur suggesting that cultivation is nearer the margin in Rawalpindi than in the other two districts.

We have so far studied the relationship between production and two determinants, acreage and rainfall. An alternative way of looking at this relationship would be the regression of rainfall during January to March on

TABLE XI

ESTIMATED RELATIONSHIPS BETWEEN YIELD PER ACRE AND RAINFALL DURING JANUARY TO MARCH FOR THREE DISTRICTS: 1931/32 to 1960/61

District	Estimated equation	Degree of freedom	Coefficients of determination (R^2)
Rawalpindi	$Y = .168 + 0.0085X$ (.0003)	28	0.13
Jhelum	$Y = .220 + 0.0052X$ (.0005)	28	0.33
Campbellpur	$Y = .172 + 0.0044X$ (.0001)	28	0.12

Y = Yield per acre in thousand tons
X = Maximum-effective rainfall in inches during January to March

Note: Figures in parentheses show the standard error of the regression coefficients.

the *yield per acre*. For this purpose, regression equations for each district were fitted between the yield and rainfall data for the period from 1931/32 to 1960/61. The estimated relationships are shown in Table XI. The regression coefficients are all significant at 99-per-cent confidence level but the coefficients of determination are very low.

Our study covered the period from 1931/32 to 1960/61. The results, however, should be useful for predicting wheat output in any other year provided the acreage and rainfall lie within the range of the observed values in the fitted relationships. There are three alternative methods for predicting wheat output in any year. *First*, the set of equations relating production to acreage and rainfall during January to March could be used since acreage and rainfall are known by April every year[8]. We shall denote this as 'Method 1'. *Second*, the yield per acre could be predicted every year with the help of the set of equations relating the yield to rainfall during January to March. By multiplying the yield thus predicted with wheat acreage we get an estimate of wheat production. This method is denoted as 'Method 2'. *Third*, the simple model of multiplying wheat acreage in any year with the long-run average yield in each district would give us another estimate of total wheat production[9]. We call this simple model as 'Method 3'. The results are presented in Table XII.

The actual production in the two years for the three districts lies less than 2 standard error of estimate from the estimated production by Methods 1 and

[8]The acreage and the maximum-effective rainfall during January to March for 1961/62 and 1962/63 for the three districts is shown below:

WHEAT ACREAGE AND MAXIMUM-EFFECTIVE RAINFALL IN THREE DISTRICTS: 1961/62 and 1962/63

District	1961/1962		1962/1963	
	Acreage	Rainfall	Acreage	Rainfall
	(thousand acres)	*(inches)*	*(thousand acres)*	*(inches)*
Rawalpindi	339.2	5.68	290.1	5.22
Jhelum	363.1	3.56	355.6	2.74
Campbellpur	637.7	3.00	582.9	2.99

[9]The long-run yield per acre of wheat is taken to be the average yield realized during the period from 1931/32 to 1960/61. The yields for Rawalpindi, Jhelum and Campbellpur districts were 0.228, 0.242 and 0.180 tons per acre respectively.

2. However, the percentage difference between any of the three estimates and the actual production is quite high. Method 1 is relatively better for predictions than the other two methods. In five out of six predictions, the difference between the actual and estimated production is less than 7 per cent while for the other two methods only 3 out of 6 predictions lie less than 7 per cent away from the actual production.

The prediction of wheat output on the basis of the studied relationship between production, acreage and rainfall, though not a correct estimate of production in any year, is useful as it approximates the actual production more closely than other simple methods of estimation. However, further research work is needed to take account of other determinants of wheat production, as the rainfall and acreage could explain only 60 per cent of the variance in wheat production. Such broad models would presumably be more accurate in prediction.

VII. SUMMARY AND CONCLUSIONS

The main conclusions of the study have been listed at each stage of the analysis. It is, however, useful to restate the broad conclusions and point out some of the policy suggestions emerging from the analysis.

Rainfall during the presowing and sowing periods is an important determinant of wheat acreage in any cropping season. Sowing-period rainfall is relatively more important in districts where the average rainfall during October to December is generally adequate for proper seed germination. The presowing-period rainfall becomes crucial for districts where the average rainfall during the sowing season is so low that soil moisture from early rains has to be preserved for the proper germination of wheat plant.

The wheat production in any cropping season is heavily influenced by the quantity and distribution of rainfall in the presowing, sowing and the growing periods. Presowing- and sowing-period rains are relatively more crucial for wheat production in Jhelum and Campbellpur while the growing-period rains are more important for production in Rawalpindi.

There are some important implications of our results for the agricultural sector in the economy. *First*, the estimated relationships between acreage, rainfall and wheat production give us a fairly reliable estimate of wheat production every year by mid-April whereas the official estimates are available by the first week of September. The three districts account for 8 per cent of the total wheat production in West Pakistan but their behaviour can be reasonably good indicator of wheat production in the remaining *barani* areas. This way we get an estimate for about 24 per cent of the total wheat

TABLE XII

ACTUAL AND ESTIMATED WHEAT PRODUCTION: 1961/1962 and 1962/63

Wheat production / District	1961/1962			1962/1963		
	Rawalpindi	Jhelum	Campbellpur	Rawalpindi	Jhelum	Campbellpur
Actual production (*thousand tons*)	85.400	84.900	139.200	46.700	80.100	111.700
Estimated production as per cent of actual production: Method 1	−5.88	+6.87	−7.31	−0.53	+17.68	−4.39
Method 2	−14.21	−8.94	−15.25	−4.94	+3.88	−3.46
Method 3	−9.44	−7.41	−17.70	−2.23	+7.43	−6.07

production in West Pakistan. Since the *barani* wheat production accounts for a substantial portion of the variability in wheat production in West Pakistan, our results are useful in improving government policies regarding foodgrain imports, storage, prices, *etc.*

Secondly, the fact that the performance in the agricultural sector is significantly and measurably influenced by weather conditions is important and should be taken note of in assessing the impact of investment in agricultural sector in any development plan. The estimated relationship between production and rainfall in different periods gives us the estimated production levels in different plan years. If the actual production is away by more than 2 standard errors of estimate from the estimated production for the plan years in a row, it would be reasonable to presume that the investment in agriculture is bearing fruit. Since for the first two years of Second Five Year Plan, the wheat production in three districts was not significantly different from the predicted production, it can be said that the development expenditure in the agricultural sector in the three districts was not effective. *Thirdly*, the estimated relationships between rainfall, acreage and production have at best explained only 60 per cent of the variance in production and still lower in acreage. A follow-up study of using prices as the explanatory variable may yield some interesting results. *Finally*, the fact that the influence of weather is measurable and relatively stable indicates that the sort of analysis followed here could be profitably applied to other important crops and the results used for planning process and for the evaluation of plan.

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Appendix A

TABLE A-1

SCHEDULE OF MAXIMUM-EFFECTIVE RAINFALL

Monthly rainfall increment	Estimated effective rainfall	
	Per cent	Accumulated
	(inches)	(inches)
1	95	0.95
2	90	1.85
3	82.5	2.68
4	65	3.32
5	45	3.78
6	25	4.02
over 6	5	

Note: This schedule has been worked out on the basis of the procedure developed by the United States Bureau of Reclamation.

TABLE A-2

RAWALPINDI: MAXIMUM-EFFECTIVE RAINFALL AS PERCENTAGE OF ACTUAL RAINFALL

Year[a]	Actual rainfall	Maximum-effective rainfall	Col. (2) as per cent of Col. (1)
	(1)	(2)	(3)
	(.........inches.........)		
1931/32	38.34	20.49	53.44
1932/33	28.08	17.70	63.03
1933/34	32.33	16.55	51.19
1934/35	34.18	19.35	56.61
1935/36	36.19	21.49	59.38
1936/37	33.46	21.71	64.88
1937/38	25.32	17.73	70.02
1938/39	34.28	20.47	59.71
1939/40	19.32	16.46	85.20
1940/41	28.67	16.76	58.46
1941/42	33.08	22.19	67.08
1942/43	31.74	19.34	60.93
1943/44	31.71	22.28	71.90
1944/45	36.59	21.31	58.24
1945/46	33.85	19.03	56.22
1946/47	29.70	17.61	59.29
1947/48	38.85	22.61	58.20
1948/49	47.49	23.25	48.96
1949/50	32.83	20.57	62.66
1950/51	41.71	20.40	48.91
1951/52	23.79	16.90	71.04
1952/53	28.72	15.45	53.80
1953/54	38.91	22.23	57.13
1954/55	27.56	17.82	64.66
1955/56	38.34	21.08	54.98
1956/57	44.35	21.01	47.37
1957/58	29.88	22.11	74.00
1958/59	45.62	26.49	48.07
1959/60	51.50	26.32	51.11
1960/61	33.94	20.55	60.55

[a]The year is defined from July to March corresponding to the wheat season.

Sources: *i)* For the period 1931/32 to 1946/47:[8]. *ii)* Since 1947/48: [9].

TABLE A-3

JHELUM: MAXIMUM-EFFECTIVE RAINFALL AS PERCENTAGE OF ACTUAL RAINFALL

Year[a]	Actual rainfall (1)	Maximum-effective rainfall (2)	Col. (2) as per cent of Col. (1) (3)
	(...........	inches.........	)
1931/32	15.37	12.07	78.53
1932/33	17.08	12.24	71.66
1933/34	24.19	12.25	50.64
1934/35	17.75	13.44	75.72
1935/36	20.76	15.28	73.60
1936/37	16.18	13.35	82.51
1937/38	14.43	9.98	69.71
1938/39	15.21	12.58	82.71
1939/40	12.41	10.94	88.15
1940/41	18.44	12.68	68.76
1941/42	20.91	17.33	82.88
1942/43	21.61	13.88	64.17
1943/44	22.54	16.46	73.02
1944/45	24.96	14.87	59.58
1945/46	16.05	11.56	72.02
1946/47	12.26	10.40	84.83
1947/48	18.87	15.45	81.88
1948/49	21.48	15.90	50.51
1949/50	20.56	16.44	79.96
1950/51	20.99	13.77	65.60
1951/52	19.44	12.75	65.59
1952/53	13.40	10.29	76.79
1953/54	19.53	16.24	83.15
1954/55	15.39	12.50	81.22
1955/56	22.57	15.24	67.52
1956/57	25.64	15.15	59.08
1957/58	15.30	12.84	88.92
1958/59	22.25	17.80	80.00
1959/60	35.93	20.87	58.08
1960/61	24.82	13.46	54.23

Sources: *i*) For the period 1931/32 to 1946/47: [8].
ii) Since 1947/48: [9].

[a]The year is defined from July to March corresponding to the wheat season.

TABLE A-4

CAMPBELLPUR: MAXIMUM-EFFECTIVE RAINFALL AS PERCENTAGE OF ACTUAL RAINFALL

Year[a]	Actual rainfall (1)	Maximum-effective rainfall (2)	Col. (2) as per cent of Col. (1) (3)
	(...........	inches.........	)
1931/32	14.81	13.02	87.91
1932/33	16.66	10.89	67.81
1933/34	23.65	13.58	57.42
1934/35	19.64	13.51	68.77
1935/36	19.11	14.87	77.81
1936/37	14.31	12.35	86.30
1937/38	17.33	12.72	73.40
1938/39	19.47	13.52	74.58
1939/40	14.53	13.35	91.88
1940/41	15.92	12.45	78.20
1941/42	18.18	16.06	88.34
1942/43	22.34	15.50	69.38
1943/44	20.18	15.19	75.28
1944/45	21.84	14.64	67.03
1945/46	17.11	13.33	77.91
1946/47	15.05	11.73	77.94
1947/48	15.48	13.57	87.60
1948/49	23.59	16.61	70.41
1949/50	15.73	12.56	79.85
1950/51	20.91	13.48	64.47
1951/52	15.59	12.46	79.92
1952/53	11.81	9.41	79.68
1953/54	18.36	15.36	83.66
1954/55	10.88	9.75	89.52
1955/56	15.15	12.64	83.43
1956/57	26.31	17.21	65.15
1957/58	14.14	12.70	89.82
1958/59	26.75	21.06	78.73
1959/60	29.52	19.32	65.11
1960/61	16.73	14.43	86.25

Sources: *i*) For the period 1931/32 to 1946/47: [8].
ii) Since 1947/48: [9].

[a]The year is defined from July to March corresponding to the wheat season.

TABLE A-5

ACREAGE FOR THREE DISTRICTS

Year	Rawalpindi	Jhelum	Campbellpur
	(..........000 *acres*..........)		
1931/32	238.37	337.33	591.50
1932/33	227.51	322.65	421.28
1933/34	238.69	349.62	560.59
1934/35	246.34	331.91	538.59
1935/36	246.94	345.04	585.73
1936/37	260.02	348.32	590.01
1937/38	259.44	339.77	650.51
1938/39	263.52	332.58	517.11
1939/40	248.89	310.16	562.55
1940/41	235.42	344.53	592.54
1941/42	244.17	343.49	585.31
1942/43	236.00	354.00	598.30
1943/44	237.26	327.14	496.44
1944/45	243.05	340.38	584.10
1945/46	238.84	341.60	592.40
1946/47	247.43	316.74	590.75
1947/48	253.35	309.52	547.53
1948/49	240.01	316.96	621.34
1949/50	251.32	350.01	621.34
1950/51	242.48	359.39	614.96
1951/52	273.32	337.00	635.38
1952/53	253.39	289.35	539.25
1953/54	243.91	315.30	581.55
1954/55	259.57	329.24	643.76
1955/56	253.34	329.24	533.40
1956/57	257.75	353.17	660.90
1957/58	267.30	359.80	691.00
1958/59	285.00	360.00	642.00
1959/60	280.00	371.00	641.00
1960/61	267.00	353.00	612.00

Sources: *i*) For 1931/32 to 1958/59, [5].
ii) For 1959/60 and 1960/61, final estimates of Agriculture Department, West Pakistan.

TABLE A-6

PRODUCTION OF WHEAT IN RAWALPINDI, JHELUM, AND CAMPBELLPUR DISTRICTS

Year	Rawalpindi	Jhelum	Campbellpur
	(........000 *acres*........)		
1931/32	46.3	76.2	101.4
1932/33	44.4	73.2	65.4
1933/34	37.6	75.2	106.8
1934/35	50.01	80.7	80.7
1935/36	54.6	83.4	83.4
1936/37	69.4	91.3	111.8
1937/38	62.1	71.5	146.7
1938/39	60.6	69.1	103.5
1939/40	55.1	57.2	121.5
1940/41	39.3	90.2	111.8
1941/42	63.0	84.1	112.3
1942/43	65.2	102.3	124.4
1943/44	48.4	62.8	86.6
1944/45	62.7	88.9	121.7
1945/46	48.5	58.6	112.1
1946/47	45.8	54.4	81.3
1947/48	56.3	70.0	103.9
1948/49	66.4	93.0	141.6
1949/50	69.4	98.5	134.5
1950/51	80.5	107.8	162.3
1951/52	60.6	70.5	120.5
1952/53	35.0	35.9	47.2
1953/54	63.06	86.6	115.6
1954/55	53.7	62.0	53.5
1955/56	64.3	102.0	134.2
1956/57	60.2	104.7	134.2
1957/58	62.4	106.7	131.3
1958/59	66.6	109.1	155.9
1959/60	66.2	107.1	133.2
1960/61	64.4	94.9	144.9

Source: Same as for Table A-5.

Part 2

Economic Behaviour of the Farmers

The pagination here seem discontinuous; this is only due to an oversight. Nothing is missing in between.

Editors

A Note on Farmer Response to Price in East Pakistan

Sayed Mushtaq Hussain

This chapter originally appeared as an article in the Spring-1964 issue of *The Pakistan Development Review* and is the result of research carried out by the author at the Pakistan Institute of Development Economics.

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A Note on Farmer Response to Price in East Pakistan

Sayed Mushtaq Hussain

INTRODUCTION

During the past decade, increasing attention has been given to the role of agriculture in the process of economic development. One aspect of the discussion has concerned the significance of relative prices for farmer in decision-making. Recent studies have yielded estimates of supply elasticities for jute in East Pakistan, and for cotton, wheat, and several other crops in West Pakistan, so that a basic body of information is beginning to emerge. The main purpose of this note is to supplement these studies by presenting estimates of the price elasticity of supply for rice in East Pakistan. However, since rice and jute are the main alternate crops in East Pakistan, supply elasticities for jute will also be presented.

Because of fluctuations in agricultural yields due to variations in weather conditions, the *acreage* response to price has generally been estimated rather than the output response. Significant changes in the size and timing of the monsoon rains in East Pakistan make it particularly important in this case to use acreage as a measure of farmer response to price. Inputs other than land, such as fertilizers, better seeds, and plant-protection measures are not widely used in East Pakistan; and apparently, these measures are not very responsive to price changes. At least, no statistically significant relationship exists between the relative price of rice (to jute) in one year and rice yields in the next year[1]. An

[1]Similarly, Walter P. Falcon found no relationship between cotton yields in West Pakistan and the relative price of cotton in the preceding year [4, Pp. 76-81].

increased price for rice results in an extension of rice acreage, but it does not result in significantly more intensive cultivation. Under these conditions, the price elasticity of acreage closely approximates the elasticity of planned output[2].

II. RICE IN THE EAST PAKISTAN ECONOMY

Rice is the main subsistence crop in East Pakistan; and is, virtually, the only foodgrain produced. During the three-year period, 1959/60 to 1961/62, it accounted for 86 per cent of the area under all crops and 99 per cent of the area under foodgrains. Rice cultivation is so important in this province that it makes Pakistan, in acreage, the third largest rice-growing country in the world.

There are basically three distinct growing and harvesting seasons during the year, and rice is grown in all the three. The main rice crops, in order of increasing importance, are *boro* (spring), *aus* (summer), and *aman* (winter)[3]. (*See*, Table I.)

Boro rice is sown in seed-bed during October-November, transplanted in December-January, and harvested in March-April. Since there is very little rain in this season, *boro* rice is generally grown on river beds and areas with irrigation water. If there is some rainfall in March, it usually results in a bumper crop.

Aus rice is sown mostly broadcast in high and medium lands from March to May and harvested from July to September. This paddy has a comparatively short maturing-period (three to four months) and low yields. However, it makes use of the premonsoon rains and makes an important contribution to the food supply in the province.

Aman rice is usually sown in seed-bed in May-June, transplanted in July-August in puddled fields and harvested in November to January. An early *aus* crop can be followed by a late *aman* crop, so there is a substantial amount of double-cropping. For water, the *aman* crop depends almost entirely on monsoon rains.

The present study concentrates on the *aus* and *aman* crops, which constitute over 95 per cent of the total rice acreage, as shown in Table I.

[2]For a more detailed explanation of the relationship between acreage elasticity and the planned output elasticity, *see*, [9, Pp. 67-68].

[3]The crops are designated by their time of harvest. The information in this and the following three paragraphs is based on [1].

TABLE I

DISTRIBUTION OF RICE ACREAGE BY CROP

Crop	1959/60	1960/61	1961/62	1962/63
	(..........	*in per cent*	....	)
Boro	4.4	4.6	4.8	5.0
Aus	28.1	28.8	28.0	28.8
Aman	67.5	66.6	67.2	66.2

Source: Same as Appendix Table A-I.

Because of their growing seasons noted above, these two crops compete with jute, which is planted from February to April and harvested from July to September. This competitive relationship has long been recognized and, from the standpoint of jute, has been subjected to analysis by serveral economists [2, Pp. 1-10 ; 11 ; 12 ; 13]. One of these, Ralph Clark, concluded:

> "An increase in rice prices, of course, discourages the planting of jute: an increase of 50 per cent in rice prices was, on the average, associated with a decline of 180,000 hectares in the jute area in the following season .... With a change between two successive seasons of jute prices upto 50 per cent and rice prices down 50 per cent, the effect would be an increase in the jute area of about 340,000 hectares, on the average" [2, Pp. 4-5][4].

He found the relative price (jute to rice) elasticity of supply for jute to be 0.6.

Clearly, the price of rice in relation to the price of jute plays a decisive role in determining the acreage under jute and rice in the next season. This relationship, for the past 14 years, is shown graphically in Figure I, in which the ratio of price of rice to the price of jute is plotted on the right vertical axis and the rice acreage under both the *aman* crop and *aus* crop is plotted on the left vertical axis. A comparison of the changes in the relative price of rice in any year, with the changes in the rice acreage in the following year, shows a direct correlation between the two variables with the exception of two years, 1951/52 and 1960/61.

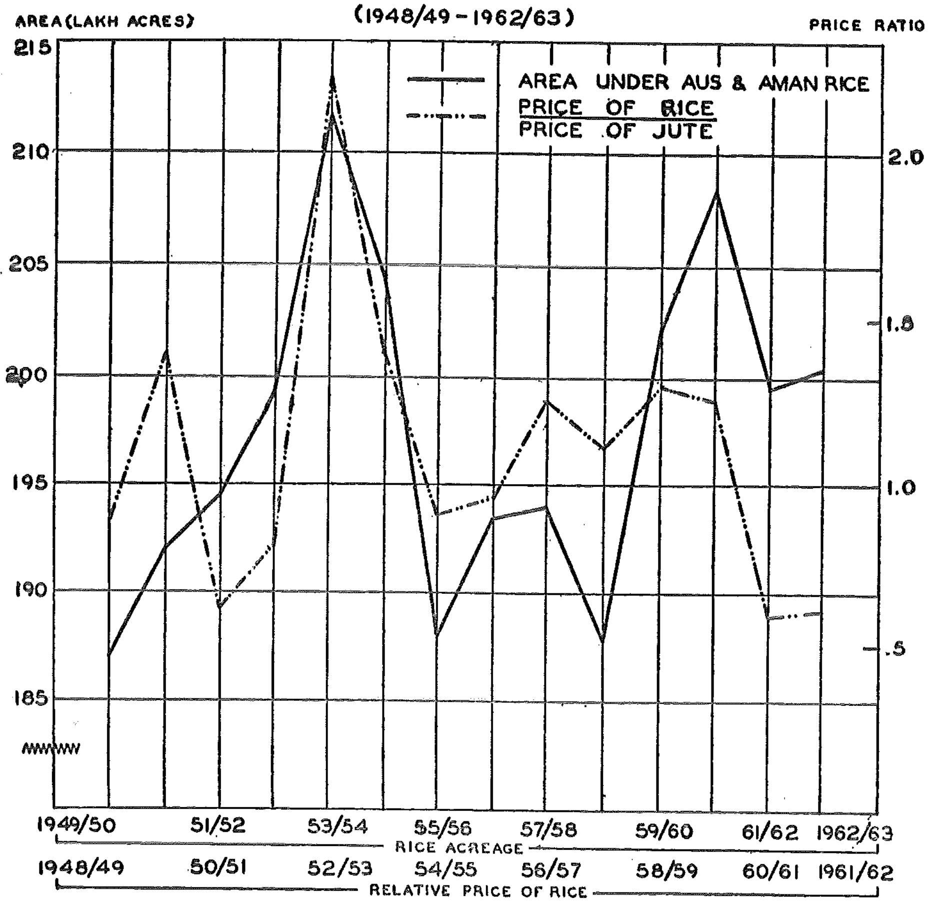
III: THE PRICE ELASTICITY OF RICE AND JUTE ACREAGE

The price elasticity of acreage is, in theory, a measure of the response of farmers to *expected* prices. Although many possible models exist for estimating this

[4](1 hectare = 2.47105 acres).

FIGURE I

RELATION BETWEEN AREA AND PRICE OF RICE AND JUTE IN EAST PAKISTAN (1948/49 - 1962/63)



SOURCE : TABLE A-II

elasticity [9], the common one of correlating, by means of a linear regression, each year's acreage with the relative price in the preceding season was employed.

The specific relationships that could be tested were limited by the data available. Acreage statistics for both rice and jute are available for all 17 districts for the period 1948/49 to 1962/63. In the case of prices, however, only the following series were complete for this entire period: *i*) the average harvest price of jute in rural areas (July-September); *ii*) the average harvest price of *aus* (July-September), for both Dacca and Mymensingh; and *iii*) the average harvest price of *aman* (December-February) for both Dacca and Mymensingh. (Acreage and price data are given in the Appendix Tables A-II and A-III.)

The rice acreage response to three different relative prices was tested (all three with the harvest price of jute in the denominator): *i*) the *aman* price; *ii*) an average of the *aman* and the *aus* prices; and *iii*) the *aus* price. The *aus* and *aman* acreage in any given year, such as 1962/63, refers to the acreage planted during 1962, but harvested after Ist July, which is the beginning of the 1962/63 fiscal year. Each year's acreage was correlated with the price of rice prevailing in the preceding fiscal year. The 1962/63 acreage, for example, was correlated with the 1961/62 prices (the average *aus* price during July-September 1961, and the average *aman* price during December 1961—February 1962).

Because the *aman* harvest is nearer in time to the planting of the *aus* and the following *aman* crop, it might be expected that the acreage response to changes in the relative *aman* price would be the greatest and statistically the most significant of the three. Similarly, the average of the *aus* and *aman* prices might be expected to be closely correlated with acreage in the following year. However, in the former case no significant correlation could be found; and in the case of the *aus-aman* average price, the correlation is less significant than when the relative *aus* price alone is used. Therefore, in the following analysis of the price elasticity of rice acreage, the relative price of rice is the average *aus* harvest price divided by the average jute harvest price (both relating to the same three-month period)[5]. In all cases, this price variable is significant at 1-per-cent level.

The first relationship tested was:

$$R_t = a + b X_{t-1}$$

where R_t is the rice acreage under both *aus* and *aman* in all of East Pakistan, and X_{t-1} is the relative price of rice in the preceding year. The results are shown

[5]The Dacca and Mymensingh *aus* prices moved together so the Dacca price series alone has been used.

in Row 1 of Table II. The elasticity of this function at the average price and acreage is 0.043. However, it should be noted that the variance explained is low ($R^2 = 0.18$), due primarily to the fact that the acreage under rice, and other crops as well, changed from year to year as a result of varying-weather conditions (principally rainfall).

To eliminate the effects of weather and other factors on the total area planted to rice (*aus* plus *aman*) and jute, we fitted a linear equation of the proportion of rice in the total area $\left(\frac{R}{R+J}\right)_t$ as a function of the relative price of rice (X_{t-1}). The results are shown in Row 2 of Table II. This linear equation explains a higher proportion of the variance ($R^2 = 0.64$) than the previous one. The price elasticity of rice acreage was calculated to be 0.030 on the average[6]. This means that a 50-per-cent increase in the relative price of rice was associated, on the average, with an increase of approximately 300,000 acres under rice (and a decrease of 300,000 acres under jute).

In certain areas of East Pakistan, rice and jute do not compete for the same land due to climatic and physical limitations. Over 90 per cent of the total area under jute is in 9 districts: Dacca, Mymensingh, Faridpur, Comilla, Rajshahi, Rangpur, Bogra, Pabna, and Jessore[7]. It is of interest to estimate the acreage response to price changes in these districts in which the substitution between rice and jute is technically more feasible.

A linear regression of the proportion of rice acreage (*aus* plus *aman*) in the total area under rice and jute $\left(\frac{R}{R+J}\right)_t$ as a function of the relative price of rice X_{t-1} was fitted for the nine districts. The results are shown in Row 3 of Table II. The proportion of variance explained is 65 per cent, essentially the same as in the previous case. The price elasticity is 0.047, which is substantially higher than that for East Pakistan as a whole. A 50-per-cent increase in the relative price of rice was associated, on the average, with about a 280,000-acre shift from jute to rice. As was expected, almost all (28/30) of the *aus* and *aman* response to changes in the relative price of rice was in these nine jute-growing districts.

[6]It should be noted that this elasticity is actually the price elasticity of the *ratio* of rice acreage to total acreage. However, the variation in total area is sufficiently small that the price elasticity of this ratio may be taken as a good approximation of the price elasticity of rice acreage.

[7] The proportion of jute acreage in these 9 districts to the total jute acreage in the province was:

1959/60	1960/61	1961/62	1962/63
94.6%	92.4%	89.9%	98.4%

TABLE II

A: ACREAGE RESPONSE FUNCTIONS FOR RICE (EAST PAKISTAN)

Row No.	Area	Regression equation[a]	Number of observations	R2
(1)	Province[b]	$R_t = 1890.570 + \underset{(1.378)^{*}}{79.490} X_{t-1}$	14	0.18
(2)	Province[b]	$\left(\frac{R}{R+J}\right)_t = 0.900 + \underset{(0.008)^{*}}{0.024} X_{t-1}$	14	0.64
(3)	9 Districts[c]	$\left(\frac{R}{R+J}\right)_t = 0.855 + \underset{(.011)^{*}}{0.039} X_{t-1}$	14	0.65
(4)	Dacca Division[d]	$\left(\frac{R}{R+J}\right)_t = 0.835 + \underset{(.013)^{*}}{0.036} X_{t-1}$	14	0.54
(5)	Province[b]	$\left(\frac{A}{A+J}\right)_t = 0.716 + \underset{(.017)^{*}}{0.065} X_{t-1}$	14	0.54
(6)	9 Districts[c]	$\left(\frac{A}{A+J}\right)_t = 0.655 + \underset{(.017)^{*}}{0.083} X_{t-1}$	14	0.60
(7)	Dacca Division[d]	$\left(\frac{A}{A+J}\right)_t = 0.602 + \underset{(.020)^{*}}{0.083} X_{t-1}$	14	0.51

B: ESTIMATED PRICE ELASTICITY OF RICE ACREAGE (EAST PAKISTAN)

Row No.	Area	Average acreage	Price elasticity of acreage
		(000 *acres*)	
(1)	Province[b]	19,770	0.043
(2)	Province[b]	19,770	0.030
(3)	9 Districts[c]	12,070	0.047
(4)	Dacca Division[d]	5,032	0.045
(5)	Province[b]	5,382	0.09
(6)	9 Districts[c]	4,032	0.12
(7)	Dacca Division[d]	1,611	0.13

Notes: *Source:* Table A-II.

X_{t-1} = Price of rice relative to jute in year t−1.

R_t = Area under *aus* and *aman* rice crops (lakh acres) in year t.

$\left(\frac{R}{R+J}\right)_t$ = Rice acreage (*aus* and *aman*) as a proportion of the total rice and jute acreage in year t.

$\left(\frac{A}{A+J}\right)_t$ = *Aus* rice acreage as a proportion of the total acreage under *aus* and jute in year t.

*Significant at 1-per-cent level

[a]The figures in parentheses are the standard errors of the regression coefficients.

[b]Acreage used is the provincial total.

[c]Acreage used is the total for the nine important jute-growing districts: Dacca, Mymensingh, Faridpur, Comilla, Rajshahi, Rangpur, Bogra, Pabna, and Jessore.

[d]Acreage used is the total for the three largest jute-growing districts: Dacca, Mymensingh, and Faridpur.

The final price elasticity of *aus* and *aman* rice acreage that we estimated was for the three largest jute-growing districts: Dacca, Mymensingh, and Faridpur. These make up Dacca Division, and include about 50 per cent of the total jute acreage. Since the available series of rice prices all related to this division, it was expected that the acreage response would be greatest in this case.

The results of the regression analysis are shown in Row 4 of Table II; they do not support our initial expectation. The proportion of variance explained and the price elasticity of rice acreage (0.045) are not significantly different from that for the nine districts. The probable reason for this result is that, just as certain areas are not suitable for jute growing due to lack of water, certain other areas in the heart of the jute-growing region are not suitable for rice cultivation[8]. In such areas, the acreage response to price changes would not be high.

Although the *aus*-plus-*aman* acreage response to the relative price of rice to jute is significant, the *aus* crop competes with jute more directly (since its planting and harvesting seasons more closely approximate those of jute), and thus the price elasticity of *aus* acreage would be expected to be higher than the elasticity for *aus* and *aman* together. This expectation was confirmed by our study, the results of which are shown in Rows 5-7 of Table II. For East Pakistan as a whole, the price elasticity of *aus* acreage was 0.09; for the nine jute-growing districts and for the three largest jute districts, the elasticities were higher and essentially the same, 0.12 and 0.13. In the nine districts alone, a 50-per-cent increase in the relative price of rice was associated with approximately a 240,000-acre shift from jute to *aus*. Thus, not only is the rice acreage response to the relative price of rice to jute largely confined to the nine districts, but, within these, the major part of the response is in the *aus* crop.

Jute elasticities, paralleling the rice elasticities, are presented in Table III. In these cases, the reciprocal of the relative *aus* price was used (*i.e.*, the jute harvest price divided by the *aus* harvest price), and in all cases but one this price variable is significant at 1-per-cent level. (The exception is regression equation 4 in Table III in which the price variable is significant at 5-per-cent level.) As would be expected, the jute elasticities are higher than for rice, and with the exception of Dacca Division, they all approximate 0.4. In the three districts of this Division, the elasticity is lower (0.29) because these districts contain areas where rice cannot be substituted for jute (for reasons noted above).

IV. CONCLUSION

The price elasticities of rice and jute acreage presented above can be compared with the elasticities estimated in recent studies of other Pakistani crops which

8 "In char and bil areas, jute is generally sown instead of paddy as the latter would be washed away or blown away" [10, p. 38].

TABLE III

A: ACREAGE RESPONSE FUNCTIONS FOR JUTE (EAST PAKISTAN)

Row No.	Area	Regression equation[a]	Number of observations	R^2
(1)	Province[b]	$J_t = 966.900 + \underset{(1.475)^{*}}{56.070Z_{t-1}}$	14	0.59
(2)	Province[b]	$\left(\frac{J}{R+J}\right)_t = 0.047 + \underset{(.011)^{*}}{0.042Z_{t-1}}$	14	0.54
(3)	9 Districts[c]	$\left(\frac{J}{R+J}\right)_t = 0.060 + \underset{(.011)^{*}}{0.042Z_{t-1}}$	14	0.65
(4)	Dacca Division[d]	$\left(\frac{J}{R+J}\right)_t = 0.087 + \underset{(.016)^{**}}{0.036Z_{t-1}}$	14	0.43
(5)	9 Districts[c]	$\left(\frac{J}{A+J}\right)_t = 0.1630 + \underset{(.020)^{*}}{0.087Z_{t-1}}$	14	0.54

B: ESTIMATED PRICE ELASTICITY OF JUTE ACREAGE (EAST PAKISTAN)

Row No.	Area	Average acreage	Price elasticity of acreage
		(000 *acres*)	
(1)	Province[b]	1,556	0.38
(2)	Province[b]	1,556	0.36
(3)	9 Districts[c]	1,373	0.42
(4)	Dacca Division[d]	718	0.29
(5)	9 Districts[c]	1,373	0.35

Notes: *Source:* Table A-II.

Z_{t-1} = Price of jute relative to rice in year t−1.

J_t = Area under *aus* and *aman* rice crops (lakh acres) in year t.

$\left(\frac{J}{R+J}\right)_t$ = Jute acreage as a proportion of the total rice and jute acreage in year t.

$\left(\frac{J}{A+J}\right)_t$ = Jute acreage as a proportion of the total *aus* and jute acreage in year t.

*Significant at 1-per-cent level.

**Significant at 5-per-cent level.

[a]The figures in parentheses are the standard errors of the regression coefficients.

[b]Acreage used is the provincial total.

[c]Acreage used is the total for the nine important jute-growing districts: Dacca, Mymensingh, Faridpur, Comilla, Rajshahi, Rangpur, Bogra, Pabna, and Jessore.

[d]Acreage used is the total for the three largest jute-growing districts: Dacca, Mymensingh and Faridpur.

TABLE IV

PRICE ELASTICITIES OF ACREAGE IN PAKISTAN

Commodity	Period	Short-run elasticity
Krishna[a]		
Cotton (American)	1922–41	0.72
Cotton (*desi*)	1922–43	0.59
Sugarcane	1915–43	0.34
Rice (Punjab)	1914–45	0.31
Maize	1915–43	0.23
Wheat (irrigated)	1914–43	0.08
Wheat (unirrigated)	1914–45	*nil*
Bajra	1914–45	0.09
Gram	1914–45	*nil*
Jowar	1914–43	*nil*
Falcon[b]		
Cotton		0.42
Wheat (irrigated)		0.2
Wheat (unirrigated)		*nil*
Ghulam Muhammad[c]		
Cotton	1935/36—1962/63	0.5
Clark[d]		
Jute	1931/32—1954/55	0.6
Venkataramanan[e]		
Jute	1911—1938	0.46
Our Results (nine districts in East Pakistan)		
Rice (*aus* and *aman*)	1948—1963	0.05
Rice (*aus* only)		0.12
Jute	1948—1963	0.4

Source: *a*) from [7, p. 485].
b) from [4, Pp. 67, 130 and 144].
c) from [5, p. 509].
d) from [2, p. 7].
e) from [7].

are given in Table IV. The elasticities of the cash crops range from 0.31 and 0.34 for rice (undivided Punjab) and sugarcane to 0.6 for jute and 0.72 for cotton (American). The price elasticity of acreage for subsistence crops is lower, though it is significantly positive for irrigated wheat (estimated at 0.08 by Krishna and 0.02 by Falcon) and Bajra (0.09). For unirrigated wheat, gram and *jowar*, constituting about 30 per cent of the total cropped area in West Pakistan, there is no significant response to price changes.

Also included in Table IV are our results for the nine important jute-growing districts: jute elasticity 0.4 and rice elasticities 0.05 and 0.12. The elasticity of 0.4 for jute is comparable with that of the other cash crops listed and, in particular, is quite close to Venkataramanan's jute estimate. The rice elasticities of 0.05 and 0.12 are very low compared with Krishna's estimate of 0.31 for rice in the Punjab, but they are quite comparable with his estimated elasticities for wheat, the comparable subsistence cereal in the Punjab.

Since large variations in the relative price of rice are common in East Pakistan (*see*, Figure I and Table A-II), annual changes in acreage and output may be substantial, even though the acreage elasticity is low. For example, a 50-percent increase in the relative price of rice has been associated, on the average, with an increase in rice area of about 280,000 acres in the nine districts and about 300,000 acres in East Pakistan as a whole; this means an increase in output in excess of 100,000 tons at the average yields prevailing in recent years. While this is a very small proportion of total output, it approximates from one-fourth to one-third of the provincial rice deficit.

Although these studies cover different periods and employ different methods of analysis, the results are roughly comparable and warrant the conclusion that Pakistani farmers growing cash crops are quite responsive to price changes. The responsiveness in the case of subsistence crops is less; since farmers employ most of their land to produce rice (East Pakistan) or wheat (undivided Punjab) for their own consumption, little land is left for making a choice among the various crops on the basis of relative prices. Nevertheless, it is an important conclusion of this study that, although the price elasticity of rice acreage in East Pakistan is low, it is significantly positive.

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Appendix A

TABLE A-I

ACREAGE, PRODUCTION AND YIELD OF RICE IN EAST PAKISTAN
1947/48 to 1962/63

Year	Area	Production	Yield	Area	Production	Yield
	(000 acres)	(00 tons)	(Maunds per acre)	(Index 1947/48 = 100)		
1947/48	19,007	6,736	9.6	100	100	100
1948/49	19,424	7,673	10.8	102	113	112
1949/50	19,528	7,337	10.3	102	109	107
1950/51	20,007	7,343	10.0	105	109	104
1951/52	20,300	7,034	9.0	106	104	97
1952/53	20,778	7,335	9.6	109	108	100
1953/54	22,010	8,245	10.1	115	122	105
1954/55	21,336	7,589	9.7	112	112	101
1955/56	19,486	6,384	8.9	102	94	92
1956/57	20,055	8,185	11.1	105	121	115
1957/58	20,235	7,598	10.2	106	112	106
1958/59	19,643	6,921	9.6	103	102	106
1959/60	21,151	8,484	10.9	111	125	113
1960/61	21,886	9,519	11.7	115	141	121
1961/62	20,963	9,466	12.2	110	140	127
1962/63	21,484	8,730	11.0	113	129	114

Sources: 1) Figures for the period 1947/48 to 1959/60 are from [3].

2) Figures for 1960/61 to 1962/63 are unpublished estimates issued by the Department of Marketing Intelligence and Agricultural Statistics, Ministry of Food and Agriculture, Rawalpindi.

TABLE A-II

RELATION BETWEEN AREA AND PRICE OF RICE AND JUTE IN EAST PAKISTAN: 1948/49 to 1962/63

Year	Rice acreage				Jute acreage			Price of rice divided by Price of jute	Price of jute divided by Price of rice
	Aus prov.	(*Aus* and *aman*) Provincial	9 Districts	Dacca Division	Provincial	9 Districts	Dacca Division		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	(........................*in thousand acres*........................)								
1948/49	4,753	18,612	11,196	4,812	1,877	1,607	827	0.89	1.11
1949/50	4,673	18,686	11,272	4,770	1,561	1,321	650	1.40	0.71
1950/51	5,259	19,206	11,613	4,808	1,701	1,460	749	0.67	1.48
1951/52	5,448	19,475	11,913	5,086	1,779	1,576	758	0.79	1.25
1952/53	5,499	19,941	12,155	5,170	1,907	1,620	838	2.20	0.45
1953/54	6,324	21,169	13,100	5,547	965	832	435	1.39	0.71
1954/55	6.033	20,478	12,410	5,096	1,243	1,076	608	0.89	1.11
1955/56	5,820	18,798	11,626	4,712	1,634	1,393	729	0.95	1.05
1956/57	5,992	19,369	12,158	4,917	1,230	1,037	540	1.27	0.78
1957/58	5,787	19,419	11,867	4,873	1,563	1,340	678	1.11	0.89
1958/59	5,646	18,792	11,272	4,658	1,528	1,326	692	1.30	0.76
1959/60	5,945	20,234	12,436	5,257	1,375	1,301	760	1.25	0.79
1960/61	6,300	20,878	12,904	5,317	1,518	1,402	826	0.56	1.78
1961/62	5,874	19,956	12,008	5,044	2,061	1,852	989	0.60	1.64
1962/63	6,192	20,413	12,264	5,192	1,723	1,696	804	—	—

Sources: Column (2) to Column (8): Same as Table A-I. Column (8) and Column (9): Table A-III.

TABLE A-III

PRICE OF RICE AND JUTE (EAST PAKISTAN)

Year	Average harvest price of jute in rural areas	Average harvest price of *aus* rice (medium quality) at Dacca	Average harvest price of *aman* rice at Dacca and Mymensingh	Average harvest price of *aus* and *aman* rice at Dacca and Mymensingh
(1)	(2)	(3)	(4)	(5)
	(.................*in rupees per maund*..................)			
1948/49	32.31	29.01	25.62	27.31
1949/50	22.12	31.13	17.20	24.16
1950/51	28.69	19.37	13.85	16.61
1951/52	27.37	21.87	18.30	20.08
1952/53	10.69	23.62	15.95	19.78
1953/54	15.44	21.50	10.65	16.07
1954/55	16.02	14.37	9.00	9.00
1955/56	18.84	17.94	15.50	15.40
1956/57	26.36	33.62	21.00	20.25
1957/58	27.48	30.56	22.50	21.50
1958/59	21.70	28.37	21.00	23.00
1959/60	20.72	26.03	20.90	22.56
1960/61	41.00	23.00	22.91	23.40
1961/62	37.44	22.75	22.75	23.12

Sources: Columns (2) and (3): Except 1961/62, the prices are from [6, p. 20]. Average harvest price of rice for 1961/62 is from the National Income Division, Central Statistical Office, Karachi, and the harvest price of jute for 1961/62 is from [8]. (Since the jute price given was wholesale, 10 per cent has been deducted to approximate marketing charges). Columns (4) and 5 are from the National Income Division, Central Statistical Office, Karachi.

Maund = 82.28 lbs.

Marketable Surplus Function: A Study of the Behaviour of West Pakistan Farmers

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and
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Marketable Surplus Function: A Study of the Behaviour of West Pakistan Farmers

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INTRODUCTION

I.1 Introduction

Food shortages have become a harassing problem for Pakistan. Though foodgrains received under the provision of the United States Public Law 480 have reduced the immediacy of the problem considerably, it is necessary that this breathing space provided by aid be used to understand the nature and magnitude of the problem and to attempt its solutions. One aspect of the problem is, of course, the general inadequacy of the total production to meet the overall food requirements. The general concern about increasing the volume of total production, and the whole range of policies directed towards this, spotlight one facet of the problem. The other aspect is the release from subsistence consumption of increasing amounts of food output for the market as more and more people are transferred to the urban centres and made dependent on the market. Success in solving the first aspect of the problem may not necessarily lead to any relaxation of the second.

To understand the nature of forces that govern the marketing decisions of farmers in Pakistan is, therefore, a separate and important objective. The experience of Western countries with universal market-oriented farm production cannot be of much help in Pakistan where most farmers produce primarily for the self-sufficiency of their own consumption. Changes in output and price may derive altogether different reaction from farmers in Pakistan. Policies undertaken in the field of food planning, such as price controls, cordon on the movements of foodgrains and changes in the land tenure system, have important repercussions on the marketing of food. Policy measures adopted in total ignorance of these possible effects may be positively harmful. Yet there is complete absence of any theoretical analysis or empirical study of the problem in Pakistan.

I.2 Empirical Studies in this Field

Not much empirical research has been done about the determinants of the marketable surplus of food. Two such studies have been made in India recently by Dharm Narain [3] and Ezekiel and Mathur [2].

The former is a study of aggregate marketable surplus and its response to the size of holding. It shows a mixed character of the marketable surplus in terms of its response to the farmers' income and price. While a part of marketable surplus will show an expected (direct) relation to price changes, the other part is likely to show an inverse relation to price change. This is because only half of the aggregate marketable surplus is truly a commercial surplus. The other half may be called a distress surplus which is necessitated by the cash obligation of the farmer. Higher prices reduce this distress surplus and lower prices increase it.

The basic argument of the Ezekiel-Mathur thesis is that the farmers in an underdeveloped economy market only that part of output necessary to earn them the cash that they require. This argument is discussed more fully in Section III.

I.3 Objective of the Present Study

In view of the situation mentioned above, it is desirable that any existing (relevant) data be analysed to shed some light on the various aspects of the problem. The Central Statistical Office's National Sample Survey of Family Expenditure Schedules is a source of such data. The following information on the farmers of West Pakistan is available from the Survey for 1959: the composition and size of the family, area cultivated and yield received for each crop, tenanted and owned proportion of total cultivated area, disposal of each crop, total cultivated area, total family expenditure on each of the food and nonfood items, total income, extent of barter transaction, and the proportion of each crop.

On the basis of these data, we examine the patterns of behaviour of West Pakistan farmers with respect to the marketing of food. As the data are cross-sectional, the study will reveal the extent to which differences in marketing behaviour among farmers can be explained in terms of important variables distinguishing them at a given point of time. It is, however, thought that this study will also provide an indirect indication of the behaviourial pattern of individual farmers over time with respect to the same set of variables. The actual hypotheses tested and the relationships estimated are discussed in Section III. In Section II, we discuss the sample and the data.

II. THE SAMPLE AND THE DATA

II.1 The Sample

The data that form the basis of this study are derived from a subsample of survey schedules completed for the National Sample Survey of Family Expenditure conducted by the Central Statistical Office (CSO) in 1959. The subsample yielded eighty-seven households as the representative of all the cultivating households of West Pakistan[1]. The accuracy and reliability of the data remains more or less as insured by the CSO survey procedures. The accuracy has been improved upon to some extent by checking for internal consistency and obvious mistakes.

II.2 Definitions

Although most of the terms used appear to explain themselves, it is still useful to state clearly at the outset what they mean so that the possible danger of ambiguity is minimized.

The terms 'marketable surplus' and 'marketed quantity' are used interchangeably to refer to the amount of food sold for cash. It excludes both the amount that is paid to the landlord and the labourers and the part that ultimately flows back to the market from those sources. Thus, the sum of the marketable surpluses of the individual cultivators is to be distinguished from the actual aggregate surplus that finally enters the market. Since some of the cultivators later buy back a part of what they marketed soon after the harvest, the marketed quantity is the *net* amount sold for cash. It is obtained by subtracting the value of the quantity bought back by the farmer from the value of the quantity sold for cash. This, however, is not done for the farmers who do not sell any of the food crops for cash; in all such cases, the marketed quantity is taken to be zero.

It is difficult to draw a borderline between food and cash crops. One cannot find a practical criterion which is easily defensible on *a priori* grounds. Justifi-

[1]A more detailed account of the original CSO sample and method of obtaining the subsample is given in the Appendix.

cations can be found for including tobacco and sugarcane either as food or as cash crops. Ideally, these should have been treated as food crops in case of those farmers who produce them primarily for own consumption, and as cash crops in case of those who produce them primarily to sell for cash. It is readily recognized that it is hard to apply this criterion. We define food as *grains, pulses* and *vegetables*. The rest of the agricultural crops are classified as cash crops. This is arbitrary to a great extent, but is still a useful rule of thumb.

Barter is defined to cover only a small part of the total nonmonetary transactions. The quantity bartered for production purposes (*e.g.*, the wages paid in kind) is not included. Only the value of the quantity bartered for consumption purposes (*i.e.*, the quantity bartered to obtain goods and services for the cultivators' own consumption) is included.

Rent is paid in cash, in kind, or in both. In this study, rent is defined to include the total payment to the landlord — in kind and in cash.

Total income is defined to include the total amount received by all members of the family during the whole year in cash or in kind. Income from fixed salary, wages, rent, and the balance-sheet items, such as the income from the sales of ornaments, is included in it. "Other income" refers to the nonagricultural income of the farmers (*e.g.*, income from fixed salary).

II.3 The Method of Obtaining the Measurement of the Variables

Information about the actual physical quantities of marketable surplus of food, cash crop, barter, and rent can be obtained from the sample survey. In order to express these variables in terms of their value in rupees, some price has to be used. In this study, the *harvest prices* of the *district centres* are used. These prices are published for each district [7]. The farmers of Sind districts are excluded from this study because no harvest prices for these districts are available from the same source. In a few cases, harvest prices, being nonavailable, certain adjustments are made[2].

The variables used in this study are, in most cases, measured per "adult unit". For this purpose, the total value of each variable is divided by the number of standard adult units in the household. The method of transforming a family into adult units is the same as the one used by Coale and Hoover in estimating food requirements for India[3].

[2]For details, *see*, Appendix.

[3]*See*, Appendix.

II.4 Notation

The following notations are used throughout the text:

1) M = Marketed quantity of food per standard adult unit

2) X = Output of food per standard adult unit

3) X_c = Output of cash crops per standard adult unit

4) X_o = "Other income" per standard adult unit

5) R = Total rent payment per standard adult unit

6) Y = Total income per standard adult unit

7) B = Barter of food per standard adult unit

	where X > median of X's (122.75)	where X < median of X's (122.75)
8) X_1 =	median (122.75)	X
9) X_2 =	X—median (122.75)	0

10) Q_1
11) Q_2
12) Q_3
13) Q_4
= X's as defined below:

	$0 \leqq X \leqq 81.07$	$81.07 \leqq X \leqq 122.75$	$122.75 \leqq X \leqq 192.81$	$192.81 \leqq X$
Q_1 =	X	81.07	81.07	81.07
Q_2 =	0	X — 81.07	122.75 — 81.07	122.75 — 81.07
Q_3 =	0	0	X — 122.75	192.81 — 122.75
Q_4 =	0	0	0	X — 192.81

Median = 122.75, 1st Quartile = 81.07, 2nd Quartile = Median = 122.75
3rd Quartile = 192.81

The notations 8 through 13 perhaps need a little clarification. The variables X_i and Q_i are values of food output at various ranges. The variables assume values as specified in the tables in different ranges of the value of food output. For example, the meanings of X_1 and X_2 (notations 8 and 9) are as follows: when food output is between zero and 122.75 (median), X_1 takes the value of the actual observation while X_2 takes the value of zero. Similarly, when food output falls within the range of 122.75 and infinity, X_1 takes the value of the median while X_2 takes the value of the actual observation less the median. Notations 10 through 13 indicate further breakdown of food output showing the values Q_i take as the value of food output falls in different quartiles. The reason this classification is made is stated in Subsection III.4. The values of X_i and Q_i are so "complicated" (*i.e.*, different for each range) simply to allow marketable surplus as functions of X_i's and Q_i's to become a *continuous* function of food output (X).

Note: The number of observations below median are 45, and those above median are 32. The quartiles also split the series into four parts which are somewhat unequal. ($Q_1 = 22$; $Q_2 = 22$; $Q_3 = 21$; $Q_4 = 21$). These discrepancies arise from the fact that all the 3 observations, dropped out of the original sample of 90, have above-median output, while the old median has been retained to avoid a lot of unnecessary recalculations. $Q_1 + Q_2 + Q_3 + Q_4$ is one less than 87 because the twenty-third observation is the first quartile and, hence, not included in either Q_1 or Q_2. Its value is automatically considered.

III. THE MARKETABLE SURPLUS FUNCTION

III.1 Theoretical Hypotheses

An enquiry into the factors which determine the marketable surplus of food for the individual farmers of West Pakistan may be attempted on the basis of the data obtained from the CSO National Sample Survey of Family Expenditure Schedules. A number of theoretical hypotheses may be advanced about the determinants of marketable surplus. The purpose of this section is to examine statistically a few such hypotheses advanced to explain variations in the marketable surplus of the individual farmers.

One important way to look at the marketable surplus of food crops is to consider it as the surplus of production over minimum consumption requirements which the producers sell in the market. The money income thus obtained is utilized for consumption and investment purposes while the balance is held in the form of monetary saving. According to this hypothesis, the principal determinant of the marketable surplus is the output of food. As output of food

increases the consumption of food will probably rise but the incremental consumption ratio is likely to be less than one[4]. Thus, the marketable surplus is likely to increase as a result of an increase in the output of food crops.

An alternative hypothesis states that the cultivators in an underdeveloped economy sell that amount of their output which is sufficient to satisfy their cash requirement while they retain the rest for consumption and saving in kind. In a year of high food-prices, the farmers have to sell less to earn the required cash than in a year of low food-prices. The hypothesis, therefore, suggests that the marketed quantity varies inversely with the food prices[5].

The first of the two hypotheses stated above can be tested on the basis of the information derived from the sample; we have information about marketed quantity and food output for each farmer in the sample. A rigorous test of the second hypothesis would require time-series data on food prices and marketable surpluses over a reasonably long period of time. Since we have only cross-section data, we can at best examine this hypothesis incompletely and partially.

The second hypothesis suggests that the marketed quantity is determined by the demand for cash. The greater the availability of cash from alternate sources the smaller would be the amount of food that has to be surrendered to acquire additional cash. Thus, the marketed quantity should vary inversely with the availability of cash from alternate sources. A farmer, having a high amount of cash crop and cash income from other sources, would market less than a farmer with small cash crop and cash income. Since we have data on 'cash crops' and 'other incomes' we are in a position to test this hypothesis. It should, however, be stressed that this is by no means a conculsive test of the hypothesis which says that the marketed quantity is determined by cash requirements. We are implicitly assuming that cash requirements of the farmers are fixed, and not trying to specify the factors which cause variations in the individual farmer's cash requirements.

[4]In fact, the marginal consumption ratio dC/dX should depend on the level of output of the farmers. This will be high for the farmers with low per caput output and fairly low for the farmers with high per caput output. At very high levels of per caput output, this is likely to approach zero.

[5]This hypothesis is put forward by P. N. Mathur and H. Ezekiel in a recent article. They mention the result of an empirical study in two districts of Maharashtra (India) in 1955/56 and 1956/57 where it was found that marketed quantity of food decreased by 7.5 per cent while price increased by 33 per cent between the two years. This happened in spite of 38 per cent increase in food production [2].

The following variables are studied as independent variables or "determinants" of per caput marketable surplus (M):

1) per caput food-crop production (X)

2) per caput rent (R)

3) per caput cash-crop production (X_c)

4) per caput "other income" (X_o)

An attempt is made below to find out how the 'dependent variable' (*i.e.*, per caput marketable surplus) is related to each of these four independent variables. The first hypothesis suggests that the marketable surplus should vary positively with food-crop production and negatively with rent. The second hypothesis implies that the marketable surplus should vary inversely with the value of cash crops and "other incomes".

Toward the end of this section an attempt is made to see whether certain other factors (*e.g.*, per acre yield, the composition of output, acreage, family size, and the bartered quantity) influence the marketed quantity.

III.2 The Marketers and the Nonmarketers

Of the 87 farmers in the subsample, 36 (or nearly 41 per cent) market a part of their food-crop output while the rest do not market any food. It may be useful to discuss the differences in the basic characteristics of the marketers and the nonmarketers.

Both food- and cash-crop output (per caput) of the marketers are higher than those of the nonmarketers. Per caput rent is higher for the marketers than for the others but rent per unit of output $\left(i.e., \frac{R}{X+X_c}, \text{ which seems to be the more relevant magnitude} \right)$ is considerably higher for the nonmarketers than for the marketers.

The two types of farmer households do not differ significantly with respect to family size. Average size of the farm and productivity per acre are, however, much higher for those who market than for those who do not market.

TABLE I

ANNUAL AVERAGES OF CERTAIN MAGNITUDES FOR MARKETERS AND NONMARKETERS

Magnitude	Marketers (1)	Nonmarketers (2)	All farmers (3)
Per caput food output (*Rs.*)	195.40	125.64	154.51
Per caput cash crop (*Rs.*)	84.35	43.32	60.30
Rent per caput (*Rs.*)	58.57	50.51	53.84
Rent per unit of output	0.20	0.30	0.25
Family size (*adult units*)	5.07	5.10	5.09
Farm size (*acres*)	13.14	9.61	11.07
Productivity per acre (*Rs.*)	107.88	89.73	98.73

III.3 Marketable Surplus Function for the Farmers who Market a Part of their Output

The marketable surplus function is estimated at two different levels: one for the marketers only, and the other for all the farmers in the sample[6]. In this subsection, we estimate the marketable surplus function for the 36 farmers who actually market a part of their food-crop production.

In order to test the hypothesis that the marketable surplus is determined by output and rent, we formulate a function of the following type:

$$M = a + bX + cR \quad \ldots\ldots (1)$$

To examine the hypothesis that the availability of cash from other sources influence the marketed quantity, we formulate two more equations:

$$M = a + bX + cR + dX_c \quad \ldots\ldots (2)$$

$$M = a + bX + cR + eX_0 \quad \ldots\ldots (3)$$

[6] Sample henceforward means our subsample unless otherwise stated.

TABLE II

LIST OF ESTIMATED EQUATIONS

Serial No.	Equation	No. of degrees of freedom	Coefficient of correlation	Coefficient of determination	Standard error of estimate
For the marketers	(1) M=—13.39*+0.3486**X—0.2058**R (5.32) (0.0142) (0.0155)	33	.7628	.5818	30.58
	(2) M=—12.14*+0.3462**X—0.1947**R—0.0170Xc (5.48) (0.0144) (0.0157) (0.0197)	32	.7634	.5828	31.015
	(3) M=—10.09 + 0.3434**X—0.2063**R—0.0354Xo (5.46) (0.0448) (0.0490) (0.0565)	32	.7662	.5870	30.86
For marketers and nonmarketers (whole sample)	(4) M=—7.3581*+0.2149*X₁+0.2806**X₂—0.2205**R (3.0150) (0.0910) (0.0284) (0.0360)	83	.6650	.4422	27.46
	(5) M=—4.7343+0.1650Q₁+0.2002Q₂+0.3513*Q₃+0.2651**Q₄—0.2177**R R (3.0823) (0.1706) (0.2098) (0.1432) (0.0375) (0.0375)	81	.6668	.4446	27.74
For marketers and nonmarketers in less irrigated districts	(6) M= 2.2664+0.0245X₁+0.3771**X₂—0.2457**R (4.0948) (0.1158) (0.0480) (0.0648)	35	.8226	.6767	24.22
For marketers and nonmarketers in more irrigated districts	(7) M=—15.5610**+0.3541**X₁+0.1848**X₂—0.1646**R (4.2855) (0.1308) (0.0346) (0.0575)	44	.5189	.2693	28.43

Figures in parentheses indicate the standard errors of the coefficient below which they appear.
*Significant at 5-per-cent level of confidence.
**Significant at 1-per-cent level of confidence.

The least-squares fit of equation (1) is as follows:

$$M = -13.39 + 0.3486X - 0.2058R \quad \ldots\ldots (1')$$
$$(5.32) \quad (0.0142) \quad (0.0155)$$

The signs of the regression coefficients are consistent with the hypothesis. Both the regression coefficients and the constant term are significantly different from zero at 1-per-cent level of confidence. Nearly 60 per cent of the variation in the marketable surplus is explained. The output elasticity of marketable surplus is + 1.60 at the mean[7].

Figure 1 represents the fitted equation (1'). The estimated function is plotted against output of food, holding rent:

a) equal to zero in drawing the marketable surplus function M_1,

b) equal to some "average rent" (Rs. 50 per caput) in drawing the marketable surplus function M_2,

c) at a high level (Rs. 100 per caput) in showing the marketable surplus function M_3.

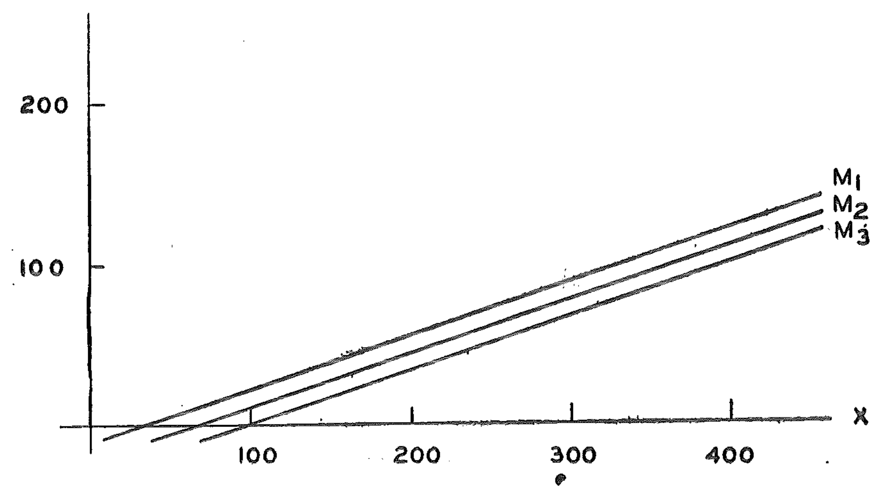

Figure 1

[7]Elasticity at the mean is : $\frac{\bar{X}}{\bar{M}} \cdot \frac{dM}{dX}$ where $\bar{X}$ = mean food output, $\bar{M}$ = mean marketable surplus, and $\frac{dM}{dX}$ = incremental marketing ratio first derivative of 'M' with respect to 'X').

The interpretation of equation (1′) is as follows: For the West Pakistan farmers, a change of one unit in the output of food appears, on the average, to have been directly associated with a change of 0.3486 unit in the marketable surplus of food while a change of one unit in rent appears, on the average, to have been inversely associated with a change of 0.2058 unit in the marketed quantity.

The least-squares fits of equations (2) and (3) are:

$$M = -\underset{(5.48)}{12.14} + \underset{(0.0144)}{0.3462X} - \underset{(0.0157)}{0.1947R} - \underset{(0.0197)}{0.0170X_c} \ldots\ldots\ldots (2')$$

$$M = -\underset{(5.46)}{10.09} + \underset{(0.0448)}{0.3434X} - \underset{(0.0490)}{0.2063R} - \underset{(0.0565)}{0.0354X_o} \ldots\ldots\ldots (3')$$

The signs of the coefficient of cash crop in equation (2′) and that of "other income" in equation (3′) are consistent with the hypothesis that marketed quantity varies inversely with the availability of cash from other sources. None of these coefficients is, however, significantly different from zero at 5-per cent level of confidence. Moreover, the inclusion of these variables does not significantly increase the explained portion of the variation in the marketable surplus. This, however, cannot be taken as a conclusive evidence against the hypothesis that variations in the alternate sources of cash influence the marketed quantity for reasons mentioned above. The relation between the marketed quantity of food and the availability of cash crop is examined more elaborately toward the end of this section.

III.4 Marketable Surplus Function for the *Entire* Sample

Of the 87 cultivator households in the sample, 51 do not market any food crop. The next stage of the enquiry is to estimate the marketable surplus function for the entire sample of 87 cultivator households. Marketed quantity of food is again expressed as a function of food output and rent, the former variable being split into two parts[8].

$$M = a + bX_1 + cX_2 + dR \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

[8]It may be useful to remind the reader the definitions of the two parts:

	X < median of X's	X > median of X's
$X_1=$	X	median
$X_2=$	0	X − median

The underlying hypothesis is that the "above-median output" (X_2) should influence the marketed quantity differently from the "below-median output" (X_1). Unit change in the "above-median output" should induce a greater increase in the marketed quantity than a unit change in the "below-median output"[9]. This is because the incremental marketing ratio is likely to increase as output increases[10].

The least-squares fit of the estimated equation gives following:

$$M = -\underset{(3.0150)}{7.3581} + \underset{(0.0910)}{0.2149X_1} + \underset{(0.0284)}{0.2806X_2} - \underset{(0.0360)}{0.2205R} \ldots\ldots\ldots\ldots (4')$$

The regression coefficients are consistent with the hypothesis — larger for the "above-median output" than for the "below-median output". All the regression coefficients are significant at 5-per-cent level. More than 44 per cent of the variation in the marketed quantity is explained. The coefficient of X_2 is, however, *not* significantly different from that of X_1; *t*-value in this case is less than one.

Figure 2 represents equation (4′). The estimated marketable surplus function is plotted against the output of food. M_1 represents the marketable surplus

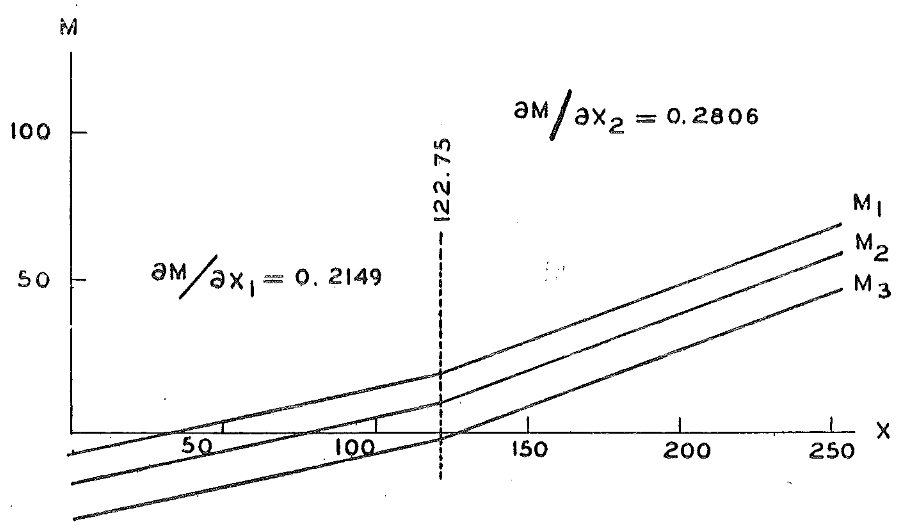

Figure 2

[9]This means that the estimated regression line of the marketed quantity on the output of food has a kink at the level of median food output.

[10]Argument for this is the same as that for the saving function; as income rises not only saving but also the incremental saving ratio tends to increase.

function given zero rent while M_2 and M_3 represent the same with "average rent" (Rs. 50 per caput) and "high rent" (Rs. 100 per caput) respectively. The curve shows a kink at the level of median output of food (Rs. 122.75). Equation (4′) shows that the marketed quantity of food is influenced by below-median output differently from above-median output. A change of one unit in the food output of a farmer *where food output is less than Rs.* 122.75 appears to have been associated with a change of 0.2149 unit in the marketable surplus in the same direction. A change of one unit in the food output of a farmer *whose food output is more than Rs.* 122.75 appears to have been associated with a greater change in the marketable surplus — 0.2806 unit also in the same direction.

The distribution of the residuals of equation (4′), however, fails to satisfy one of the basic assumptions of the least-squares technique. One assumption of this technique requires that the variance of the residuals should be the same for all observations. This is called the assumption of homoskedasticity. The variances of the residuals of equation (4′) do not satisfy this condition; they are highly correlated with one of the independent variables — per caput food output.

The existence of heteroskedasticity—as the inconstancy of the variance of residuals is named — does not, however, affect the unbiased property of the coefficients estimated by the least-squares technique. Heteroskedasticity only implies that the estimates given by the fitted equation (*i.e.*, equation (4′) above) "will not be of minimum variance, that is, they are inefficient" [6, Pp. 55-57][11].

To push the hypothesis underlying equation (4′) further (*i.e.*, to see how the incremental marketing ratio varies with the levels of food output) the output of food is split into four quartiles and the following hypothesis is formulated[12]:

$$M = a + bQ_1 + cQ_2 + dQ_3 + eQ_4 + gR \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

The expectation about the coefficients is $b < c < d < e$, so that incremental marketing ratio increases as output of food varies from one quartile to a higher quartile. The least-squares fit of the equation is as follows:

11For a proof of the above statements about heteroskedasticity, *see*, [6].

12It is useful to repeat the definition of the Q's:

	$0 \leqq X \leqq 81.07$	$81.07 \leqq X \leqq 122.75$	$122.75 \leqq X \leqq 192.81$	$192.81 \leqq X$
$Q_1 =$	X	81.07	81.07	81.07
$Q_2 =$	0	X — 81.07	122.75 — 81.07	122.75 — 81.07
$Q_3 =$	0	0	X — 122.75	192.81 — 122.75
$Q_4 =$	0	0	0	X — 192.81

where 81.07 = first quartile, 122.75 = second quartile (median), and 192.81 = third quartile.

$$\begin{aligned} M = &- 4.7343 + 0.1650Q_1 + 0.2002Q_2 + 0.3513Q_3 \\ &\ \ (3.0823) \quad (0.1706) \quad (0.2098) \quad (0.1432) \\ &+ 0.2651Q_4 - 0.2177R \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (5') \\ &\ \ (0.0375) \quad (0.0375) \end{aligned}$$

A comparison of equations (4′) and (5′) reveals the following things: *a*) Equation (5′) does not significantly improve the explained variation in the marketed quantity over equation (4′). While the coefficient of determination is 0.4446 for equation (5′), it is 0.4422 for equation (4′). *b*) The coefficients of Q_1 and Q_2 are not significantly different from zero[13]. *c*) While the coefficients of equation (4′) are consistent with the hypothesis the coefficients of equation (5′) are not. It is, indeed, difficult to find a theoretical explanation of the decline in the incremental marketing ratio at very high levels of food output as is revealed by equation (5′). An explanation is attempted later in this section. Here, it may be mentioned that the coefficient of Q_4 is not significantly different from the coefficient of Q_3[14].

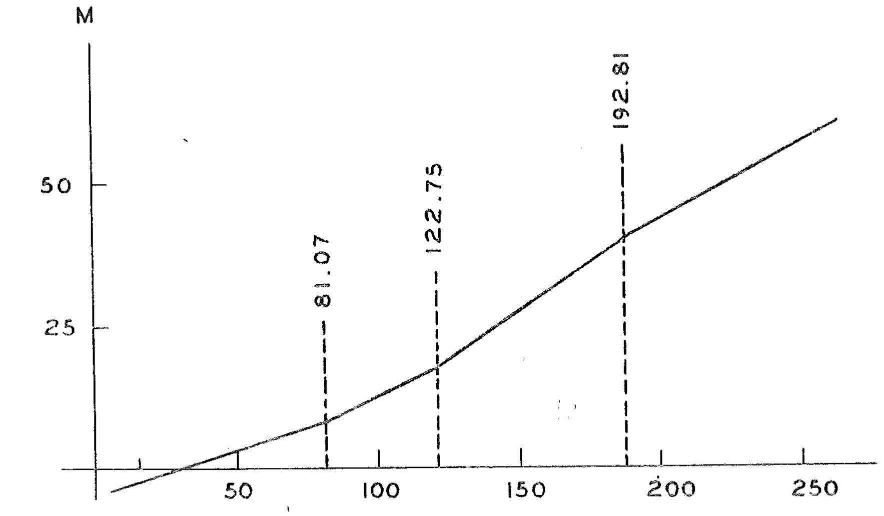

Figure 3

Figure 3 represents equation (5′) with zero rent. As food output increases from first to second to third quartiles, the slope of the curve increases; but, finally, the slope declines as output reaches fourth quartile. The curve has kinks at three levels of food output — 81.07, 122.75 and 192.81.

13 *t*-value in each of these cases is less than one.

14 *t*-value, in this case, is less than one. In fact, the coefficient of no 'Q' is significantly different from that of any other 'Q'; *t*-value, in no case, is more than about 1.5.

III.5 The Influence of Certain Other Variables on the Marketable Surplus

The influence on the marketed quantity of food of a number of other variables is examined from an analysis of the relation between each of these variables and the residuals of equation (4′). The following variables are considered:

a) *Per caput cash crop.* The possible effect of variation in cash-crop output on the marketable surplus has been indicated above.

b) *Ratio of wheat output to total food output.* Marketing should be influenced by the composition of food output in relation to consumption habits. A farmer, who produces plenty of rice but predominantly consumes wheat, will market most of his rice output. But he will probably buy wheat for consumption. The implicit assumption is, however, made that the farmer's propensity to consume his own product is higher than that for the food bought from others.

c) *Per acre yield.* The higher the per acre yield, the smaller the unit cost is likely to be and the greater the surplus of the farmer, so that the farmer is able to market a higher proportion of his output.

d) *Per caput quantity of barter.* The quantity bartered may influence the marketed quantity of food crops in two possible ways: *i*) as bartered quantity increases, there are less food crops left for disposal in other directions including marketing; *ii*) secondly, the higher the quantity bartered, the smaller is the demand for cash.

e) *Per caput "other income" of the household.* The direction in which variations in this may cause variations in the marketed quantity has already been indicated.

None of the above variables, however, appears to add to the explained variation in the marketed quantity of food.

III.6 Marketable Surplus Function for More Irrigated and Less Irrigated Districts

The distribution of the residuals of equation (4′) for the observations in the more irrigated districts appears to be different from that of the less irrigated districts. It is, therefore, believed that it is not proper to use the same equation to explain the behaviour of marketable surplus in the two different types of districts. A separate function may be fitted for each type of districts.

The following are the more irrigated districts[15]: Sialkot, Shahpur, Montgomery, Lahore, Jhang, Sheikhupura, Lyallpur, and Multan. The other fourteen are the less irrigated districts. The two types of districts do not differ significantly with respect to per caput food output. They, however, differ quite significantly with respect to cash-crop production. Per caput cash crop in the more irrigated area (Rs. 83.66) is about twice as high as that in the less irrigated area (Rs. 43.54). Only 33 per cent of the farmers in the less irrigated area produce cash crops while 88 per cent of them in more irrigated area are partly engaged in cash-crop production. Other differences between the two groups are shown in Table III below.

TABLE III

ANNUAL AVERAGES OF CERTAIN MAGNITUDES FOR MORE IRRIGATED AND LESS IRRIGATED DISTRICTS

Magnitudes	Farmers in more irrigated area	Farmers in less irrigated area	All farmers
Per caput food output (*Rs.*)	156.28	152.33	154.51
Per caput cash crop (*Rs.*)	83.66	43.54	60.30
Rent per caput (*Rs.*)	73.13	31.33	53.84
Rent per unit of output	0.30	0.16	0.25
Average family size (*adult units*)	4.73	5.38	5.09
Average farm size (*acres*)	9.71	12.79	11.07
Productivity per acre (*Rs.*)	116.88	82.37	98.73

A function of the type of equation (4) is fitted to explain the marketed quantity for each of the two areas. The estimated regression equation for the less irrigated area is:

$$M = 2.2664 + 0.0245X_1 + 0.3771X_2 - 0.2457\,R \quad \ldots\ldots\ldots\ldots\ldots (6')$$
$$(4.0948) \quad (0.1158) \quad (0.0480) \quad (0.0648)$$

[15]The classification is made on the basis of the findings of an unpublished work done in the Institute's Fiscal and Monetary Section.

The signs and the relative magnitudes of the coefficients are in conformity with expectations. The constant term and the coefficient of below-median food output (X_1) are not significantly different from zero[16]. The other two coefficients are, however, significant at the 1-per-cent level. The independent variables together explain 68 per cent of the variation in the marketed quantity. The coefficient of X_2 is significantly higher than that of X_1 at 1-per-cent level of confidence.

The least-squares estimate of the equation for the more irrigated area, however, gives a completely different fit:

$$M = -\underset{(4.2855)}{15.5610} + \underset{(0.1308)}{0.3541}X_1 + \underset{(0.0346)}{0.1848}X_2 - \underset{(0.0575)}{0.1646}R \ldots\ldots\ldots (7')$$

All the coefficients are significantly different from zero at 1-per-cent level of confidence. But the coefficient of above-median output, contrary to expectation, is smaller than the coefficient of below-median output. The difference between the two coefficients is significant at 1-per-cent level. Only 27 per cent of the variation in the marketed quantity is explained.

It is indeed difficult to find an explanation of the decline in the incremental marketing ratio at high level of food output. One possible explanation is found by analysing one special characteristic of the farmers in more irrigated area: unlike the farmers in the less irrigated area, these farmers usually have high per capita cash-crop production. For these farmers there exists a definite relation between food output and cash-crop output. High food output is usually associated with high cash crop; the coefficient of correlation between the two is +0.68.

Since cash crop is high at high levels of food output, unsatisfied cash requirement of the farmers is low; most of the required cash is obtained by selling the cash crop. Thus, the farmers can satisfy their cash requirement by marketing a small part of their food output. This explanation, incidentally, renders support to the Ezekiel-Mathur hypothesis mentioned above.

IV. Conclusions

The main findings of the study are mentioned at each stage of the analysis. It is still considered useful to state the broad conclusions in a summary form.

a) For the 36 farmers who market a part of their food output nearly 60 per cent of the variation in the marketed quantity is explained by their food output and rent payment. Marketed quantity is an increasing function of food output and a decreasing function of rent payment. The output elasticity of marketable surplus at the mean is + 1.60.

b) Nearly 44 per cent of the variation in the marketable surplus of *all* farmers in the sample is explained by food output and rent. Incremental marketing ratio is found to increase as output of food increases (except at very high level of food output).

c) While 68 per cent of the variation in the marketed quantity is explained for the farmers in the less irrigated area, only 27 per cent is explained for those in the more irrigated area. We were not able to find out why the fit is so much worse for the latter.

d) It is not possible to test rigorously the hypothesis which states that the marketed quantity is determined by cash requirement of the farmer. The indirect evidences were both in favour and against this hypothesis. While alternate cash sources do not seem to influence the marketable surplus significantly either for the marketers or for the entire sample, the unexpected behaviour of marketable surplus at high levels of output (especially in case of the more irrigated area) makes us suspect the operation of some such influence on the marketing decisions of the farmers.

[16]In each case, *t*-value is less than one.

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Appendix

On the Sample

This appendix is intended to describe the procedures followed in drawing up the sample for the Family Expenditure Survey of the Central Statistical Office (CSO) and to explain the method of obtaining the present subsample from the former.

The CSO Family Expenditure Survey of 1959 was conducted to gather information on the income and expenditure pattern of the rural population of Pakistan "to know what they earn, how they spend their income, their family size, their expenditure on food, clothing, rent and other miscellaneous items" [4, p. 1]. A *multistage, proportionate, stratified, random sample* of rural households in each of the former provinces of West Pakistan was drawn. The method used is briefly stated in the following paragraphs.

The sample survey involves the following stages: *first*, the entire area is divided into topographically homogeneous and geographically contiguous regions; *second*, *tehsils* within each region are grouped to form a stratum on the basis of population density; *third*, one *tehsil* is selected from each stratum with probability proportional to the population size; *fourth*, villages are selected from each *tehsil* with probability proportional to their population size; *fifth*, eight households are selected at random from each village from a complete list of households prepared for each of the selected villages.

The technique obtains complete randomness in the selection of each household, while the geographical stratification ensures proportional representation of each area by preventing the possibility of chance concentration.

Our subsample is taken out of the above-mentioned sample frame. It maintains the same principles of randomness and proportional geographical representation but reduces the size of the sample for the convenience of the type of analysis involved. In the subsample, one village is selected from each stratum with probability of selecting a village equal to the following:

$$\frac{\text{number of households in the } i\text{-th village}}{\text{total number of households in all the villages of the } j\text{-th stratum}}$$

Four households are then selected at random from among the sample households of each subsample village. The size of the subsample, thus obtained, is 224 (4 households taken from each of the 56 villages). The number used in this study, however, is 87. The remaining 137 are dropped out due to the following reasons:

a) The CSO Family Expenditure Survey Schedules for sixteen subsample households happened to be among those which are either found blank or not traceable.

b) Eighty households are excluded because they are noncultivators.

c) Thirty-eight cultivating households of the former province of Sind could not be included because the harvest prices required for the valuation of farm outputs are not available for those districts[1].

d) The remaining ninety schedules are then checked for internal inconsistency and other errors. Three schedules are excluded in the process because of serious discrepancies. Schedules having minor inconsistencies which can be explained and adjusted are, however, retained.

The final subsample satisfies the test of being a random sample. Each household is chosen with equal probability. The factors responsible for the elimination of any of the households are due purely to chance. All the cultivating rural households of West Pakistan, therefore, have equal chance of being included in the subsample. This, however, involves the assumption that the ratio of cultivating households to total households is the same for each stratum, *tehsil* and village.

To check how the distribution of the actual numbers of households in our sample compares with those expected on the basis of the nonmetropolitan population of each of the sample districts, we have used the chi-square test[2]. However, we have combined the expected number of households for each division because most of the expected numbers of households for districts are lower than five[3]. The number of households selected in the sample from each division is found to be more or less proportional to the size of its nonmetropolitan population. The discrepancy between the actual numbers and the expected numbers is statistically not significant.

The exclusion of all the households of the former province of Sind is also due to chance nonavailability of harvest prices for that area. This could happen

[1]*See*, Subsection II.3 of this paper.

[2]The size of the nonmetropolitan population of each district as percentage of the total nonmetropolitan population of all the sample districts is given on p. 291.

[3]Use of chi-square test is ruled out if the expected frequencies of observations are less than five.

A Districtwise Breakdown of Sub sample Households

Our code		Division	District	Total No. of families	Percentage of nonmetropolitan population of the sample districts
From	To				
1.1	1.4	'Pindi	Attock	4	2.88
2.1	2.4	Peshawar	Hazara	4	5.48
3.1	—	Peshawar	Peshawar	1	3.48
4.1	4.3	Peshawar	Mardan	3	2.96
5.1	5.3	D. I. Khan	Bannu	3	1.62
6.1	6.3	D. I. Khan	D. I. Khan	3	1.31
7.1	7.3	'Pindi	Gujrat	3	4.84
8.1	8.3	Lahore	Gujranwala	3	3.96
9.1	9.5	Lahore	Sialkot	5	5.61
10.1	—	Sargodha	Sargodha (Shahpur)	1	4.95
11.1	11.5	Sargodha	Mianwali	5	2.53
12.1	12.11	Multan	Montgomery	11	7.93
13.1	13.8	Lahore	Lahore	8	4.25
14.1	14.8	Sargodha	Jhang	8	3.79
15.1	15.2	Lahore	Sheikhupura	2	3.95
16.1	16.9	Sargodha	Lyallpur	9	8.83
17.1	17.4	Multan	Multan	4	8.89
18.1	18.2	Bahawalpur	Rahim Yar Khan	2	3.77
19.1	—	Bahawalpur	Bahawalpur	1	9.27
20.1	20.6	Multan	D. G. Khan	6	2.84
21.1	—	Multan	Muzaffargarh	1	3.84
22.1	22.3	Bahawalpur	Bahawalnagar	3	3.00
			Total:	**90**	**100.00**

in the case of other districts as well. Even if the districts of Sind have important regional differences, the subsample can still be regarded as representative of West Pakistan excluding Sind.

Adjustments Made in the Data

a) Harvest prices for *moong*, *masur*, *mash*, and mustard are not available. So these have been estimated by deflating their wholesale prices 20 per cent. The wholesale prices are taken in each case from the Institute's *A Measure of Inflation in Pakistan* [5].

b) Mustard price has been used for rye as well. Harvest price of chillies is assumed to be Rs. 2.00 per seer.

c) Harvest prices of the adjacent district have been used in some cases where local harvest prices are not available:

> Cotton price of Multan is taken for Muzaffargarh; Shahpur prices for rice, tobacco, and maize are used for Mianwali; Lahore prices for *jowar* and cotton are used for Sialkot.

d) The following method has been used for transforming a family into adult units:

Male 10 years and above	= 1.0 adult unit
Female 10 years and above	= 0.9 adult unit
Both male and female below 10 years	= 0.5 adult unit

See, [1, p. 88, footnote].

e) Conversion ratios used for local area measurements are:

1 *qila*	=	1 acre
2 *jareeb*	=	,,
8 *kanal*	=	,,
240 *marla*	=	,,

A Summary of the Questionnaire Used in CSO Family Expenditure Survey

Blocks I, II & III: Identification of interviewee, the enumerator and the administrative process.

Block IV: Family composition on the date of enquiry.

Blocks V & VI: Births and deaths (last year) respectively.

Block VII(a): Area cultivated to each crop; tenanted and owned proportion of area in each; quantity produced; yield per acre.

Block VII(b): Details of the total uses of each crop: quantity paid in kind for harvesting *etc.*; quantity paid to landlord; quantity sold for cash; quantity bartered; quantity used for seed and fodder; quantity purchased; quantity received as wages, rent, or share of crop; quantity consumed.

Blocks VIII to XI: Consumption of food; apparel, textile and footwear; housing and household accessories; miscellaneous, such as personal care, medical expenses, servants' salary, *etc.*

Block XII: Saving and insurance.

Block XIII: Receipts: income classified according to source.

Marketed Surplus Function of Major Agricultural Commodities in Pakistan

Mohammad Raquibuzzaman

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Dr. Raquibuzzaman, continues to be on the research staff of the Institute.

Marketed Surplus Function of Major Agricultural Commodities in Pakistan

Mohammad Raquibuzzaman

INTRODUCTION

The marketed surplus of agricultural commodities plays a significant role in the economic development of a low-income country where agriculture is the principal source of income. This surplus is the main source of capital accumulation, since it provides the basic wage goods to the urban sector. A rise in the marketed surplus makes the terms of trade favourable to the urban sector which enables it to enhance the size of its profits. This, in turn, helps the rapid growth of the economy. The marketed surplus not only provides the nonagricultural sector with food, but also enables it to get raw materials, liquid capital and foreign exchange. It reduces the need for importing foodstuffs and thus relieves pressures on the balance of payments. The role of marketed surplus in economic development is so well known that further elaboration is superfluous[1].

Given the present high rate of population growth now estimated at 2.7 per cent [17] and the rate of increase in per capita income it is unlikely that the marketed surplus of agricultural commodities has kept pace with the growing demand. Attempts are being made to raise the productivity of agriculture. Productivity, though of prime importance, is not the only factor that determines the size of the surplus. The marketed surplus is determined by the interplay of

[1]A good many articles are now available which deal with the role of marketed surplus in economic development. A few are [4; 5 ; 10 ; 11].

different independent economic variables. Unless the pattern of behaviour of these variables is known any policy aimed at raising the size of the surplus may be ineffective. Therefore, the need for a study of the marketed surplus function becomes important. Despite the importance of this problem, few attempts have been made to study it in Pakistan. Empirical work on this subject has been very limited in the past. Recently, some attempts have been made in India to study the problem there[2].

Kahlon and Dwivedi [7] studied the marketable surplus function of the major crops (wheat, gram, maize, groundnut and *desi* cotton) of the Ludhiana district of the East Punjab state in India. They found that the volume of production was the principal determinant of the marketed surplus. Domestic consumption affected adversely the marketed surplus of food crops but had no influence on the surplus of cash crops. Dharam Narain's study [13] related the aggregate marketable surplus and its response to the size of holding. He found that a part of the marketable surplus showed a direct relation to price changes, the other part showed an inverse relation. That latter part was the "distress surplus" which was necessitated by the cash obligation of the farmer. The Mathur-Ezekiel argument [12] was that farmers in an underdeveloped economy part with that portion of their output necessary to meet fixed cash requirements. From this it followed that higher prices would reduce the marketed surplus whereas lower prices would increase it. Dandekar [2] refuted the arguments of Mathur-Ezekeil and showed that their thesis did not apply in the case of large farmers whose contribution to the marketed surplus was of prime importance. The Mathur-Ezekiel thesis was only partially true in the case of small farmers. Raj Krishna attempted to find out the elasticity of the marketable surplus of a single subsistence crop, wheat, for the Indian economy. He found that "if elasticity of output is positive, albeit small, the likelihood of a perverse market supply behaviour is extremely small" [9].

The only attempt to find out the "marketable surplus function" in Pakistan was made by A. R. Khan and A. H. M. N. Chowdhury [8]. Their study showed the marketable surplus function for agricultural goods in the Northern Zone of West Pakistan. The authors, in their study, dealt with such independent variables as: *i*) per capita food crop production, *ii*) per capita rent, *iii*) per capita cash-crop production, and *iv*) other per capita income. The study was based on the National Sample Survey (First Round) [14].

The aim of this paper is essentially to extend the work of Khan and Chowdhury in terms of both time period and area covered. The methodology followed in this study is slightly different from theirs. In our study we have used physical quantities rather than value magnitudes since we believe that in studying problem of marketed surplus, the value figures are apt to be misleading, as variations of prices, due to a variety of reasons, will show spurious variations in the value of the marketed surplus in different regions, or within the same region at different time periods, *i.e.*, variations which do not correspond to physical changes. To get a more accurate picture of the marketed surplus, we believe that one should concentrate on physical quantities in order to abstract from demand effects which would enter our results if we used price data. We have, in addition, included some additional variables such as: *i*) tenurial status; *ii*) consumption of cash goods; *iii*) size of family; and *iv*) size of holdings[3] and excluded the variable "other income". The exclusion of the latter is necessitated primarily because our sample does not contain the relevant data. Absence of this variable is likely to have little effect on our conclusions, however, as this variable was found to have a relatively small influence on the marketed surplus in the study by Khan and Chowdhury [8, p. 372].

[2]Mention may be made about the studies of A. S. Kahlon and H. N. Dwivedi [7]; Dharam Narain[13]; P. N. Mathur and H. Ezekiel[12]; S. N. Sinha[18]; V. M. Dandekar [2]; Raj Krishna [9]; and the discussions that were made about the problem of the marketed surplus at the Twentieth Conference of the Indian Society of Agricultural Economics [3].

Finally, we have relied primarily on the data as collected in the National Sample Survey (Second Round) [15]. Not only do these data reflect a more recent time period but also there is some reason to believe that certain statistical problems encountered in the first round of the National Sample Survey were overcome in the later survey[4].

II. DEFINITIONS OF THE CONCEPTS USED IN THIS STUDY

We use marketed surplus in two senses. Marketed surplus in the gross sense has been defined here as the total quantity of gross output produced by the farming household minus the part used for payments to labour and landlord and the part retained for home consumption and other uses[5]. Marketed surplus in the net sense has been defined as the gross marketed surplus minus the "buy back". For brevity, *net* marketed surplus will be written simply as "marketed surplus".

Data on family size from the National Sample Survey have been converted into adult units by following Coale and Hoover's conversion ratios [1, p. 88]. On

[3]It is clear that inclusion of the variable "size of holdings" as well as the variable of "production" in any formal model will lead to a problem of multicollinearity. We have, therefore, included "size of holdings" only in our tables, as distinct from our regression model, since we nevertheless feel that it is useful and interesting to see how the percentage of marketed surplus varies among different size of holdings.

[4]For the sources of data, *see* Appendix A.

[5]All measures about commodities are in terms of *maunds* (roughly 82.3 pounds). As harvest prices of all commodities in all areas were not available, and if available not adequate, no attempt was made to convert the quantities into value terms in this paper.

this basis, "large family size" has been calculated as that which contains more than 4.7 adult units, while "small size family" refers to units which contain 1 to 4.7 adult units.

Holding size has been defined in this study as the total land area under crop by a farming household. This is different from actual holding size in the case of those families who put the same acre of land to more than one crop in a particular year. Land areas have been converted into acres from different local area measurements [8, p. 375].

In this study wheat, rice, *jowar*, maize, and *bajra* together constitute foodgrains for West Pakistan and rice for East Pakistan. Cash crops are defined as those which are produced mainly for market; jute, cotton and sugarcane are defined as belonging to this category.

Consumption of cash goods include those items which the farmers purchase in cash for consumption[6]. Finally, owner-farmers are those who cultivate their own lands. The farmers who hire lands from landlords for cultivation are tenant farmers. By owner-tenant farmers we mean those farmers who cultivate their own lands as well as lands hired from landlords.

Production and Marketed Surplus

Table I shows the marketed surplus of foodgrains in East and West Pakistan for different volumes of production. Sales as percentage of quantity produced rise from 4 per cent to 14 per cent in East Pakistan and from 8 per cent to 24 per cent in West Pakistan, as the volume of production rises from less than 20 maunds to 81 maunds and above. In East Pakistan, the marketed surplus is the largest in the range of 61-80 maunds of production. The reason for the lower percentage sale in the next higher volume of production in East Pakistan is not quite clear[7]. In case of West Pakistan, the percentage sale is, however, the highest where the volume of production is the largest. Aside from the exceptional case in East Pakistan mentioned above, the other observations show that higher the volume of production the larger is the marketed surplus.

[6]The items are: mustard oil, vegetable *ghee*, *ghee*, meat, fish, salt, spices, sugar, *paan*, tobacco and tobacco products, kerosene, matches, materials for house repairs, kitchen accessories, clothes, footwear, soaps, hair oil, and medicine.

[7]The average family size in the higher production group is 12.7 adult units as compared to 7.9 units (*cf* NSS Schedules) [15] in the range of 61-80 maunds. This might have resulted in larger proportion being consumed and hence a smaller proportion marketed. In case of West Pakistan, the average family size in the two groups are respectively 4.6 and 6.1 adult units. The per capita production being higher (19.65 maunds) in the higher production group as compared to per capita production of 15.13 maunds in the production group of 61-80 maunds, the marketed surplus is higher in the former group (*cf* NSS Schedules) [15].

TABLE I

VOLUME OF PRODUCTION AND MARKETED SURPLUS OF FOODGRAINS IN EAST AND WEST PAKISTAN

Volume of production	Number of farms		Quantity produced		Quantity sold		Sales as percentage of quantity produced	
	East Pakistan	West Pakistan	East Pakistan	West Pakistan	East Pakistan	West Pakistan	East Pakistan	West Pakistan
(*maunds*)			(. . . . *maunds* . . . .)		(. . . . *maunds* . . . .)			
Below 20	39	18	329.40	196.00	14.34	15.83	4.4	8.0
20—40	30	47	792.31	1,374.50	57.88	141.02	7.3	10.3
41—60	3	27	143.33	1,370.66	11.25	170.32	7.8	12.4
61—80	4	21	287.99	1,474.00	53.33	249.66	18.5	17.0
81 and above	5	21	560.00	2,655.32	82.82	625.16	14.8	23.5
Total	81	134	2,113.03	7,070.48	219.62	1,201.99	10.39	17.0

Source: NSS Schedules.

It appears from Table I that about 10 per cent of the quantity produced was marketed in East Pakistan and about 17 per cent in West Pakistan[8].

Holding Size, Tenurial Status and Marketed Surplus

Tables II through IV show the marketed surplus of foodgrains and cash crops in relation to holding size and tenurial status.

Percentage sales of foodgrains show a direct relationship with the size of holdings. In Table II we find that the surplus of foodgrains in East Pakistan increases from about 6 per cent to 13 per cent as the size of holding increases from less than 2.5 acres to more than 12.5 acres. In Table III we find that in West Pakistan also the percentage of sales is positively associated with holding size.

Table III also shows that the marketed surplus is larger in the case of owner farmers, less in the case of owner-tenant farmers and the least in tenant farmers. The percentages are 29.4, 10.8 and 9.7 respectively. Since a part of the rent payments may flow back to the market after passing through the renter, nothing can be said directly about the proportion of the final marketed surplus generated by the farmers belonging to each of these three tenurial groups. However, one observation can safely be made — owner farmers contribute relatively more to the monetisation of the economy than either of the other two groups.

Cash crops, as the very name suggests, are mainly produced for markets. The marketed surplus for these crops depends primarily on the tenurial status. The marketed surplus of cash crops is generally very large in the case of owner farmers. This is evident from the case of cotton and jute where the average percentages of sale are respectively 96.6 and 95.1. Sugarcane is both a food and a cash crop and as such the surplus is lower in case of owner farmers (58.5 per cent) compared to other cash crops. Tenant farmers pay half of their produce to landlords and most of the remainder is sold by them in the market. The tenant farmers sell 50 per cent and 45 per cent of their cotton and sugarcane produce in the market.

Consumption, Family Size and Marketed Surplus

Form Table V it can be seen that the higher the average consumption, the lower the percentage of sales. The marketed surplus is lower in the case of small-size families, since we find that their average consumption is higher than for large-size families (*cf.* Table V). Another reason for this may be that farmers having large families sell a larger proportion of their output because they have a greater need for cash.

[8] *See* Appendix B for a comparative study of our results with those obtained by the *Survey on Utilization of Agricultural Commodities* [16].

TABLE II

MARKETED SURPLUS IN RELATION TO HOLDING SIZE OF OWNER FARMS FOR FOODGRAINS AND CASH CROP EAST PAKISTAN

Holding size	Number of farms		Quantity produced		Quantity sold		Sales as percentage of quantity produced	
	Foodgrains	Jute	Foodgrains	Jute	Foodgrains	Jute	Foodgrains	Jute
(*acres*)			(. . . . *maunds* . . . .)		(. . . . *maunds* . . . .)			
Below 2.5	42	11	420.08	53.33	26.00	50.00	6.2	93.8
2.5—4.9	24	12	276.12	61.00	47.16	58.50	8.2	95.9
5.0—7.4	7	6	190.00	26.50	20.00	26.00	10.5	98.1
7.5—12.5	4	2	308.00	29.00	35.00	27.50	11.4	94.8
Above 12.5	3	3	433.33	81.00	55.00	76.50	12.7	94.4
Total	80	34	1,927.53	250.83	183.16	248.50	9.5	95.1

Source: NSS Schedules.

TABLE III

MARKETED SURPLUS IN RELATION TO HOLDING SIZE AND TENURIAL STATUS FOR FOODGRAINS WEST PAKISTAN

Holding size	Number of farms			Quantity produced			Quantity sold			Sales as percentage of quantity produced		
	Owner farms	Tenant farms	Owner tenant farms	Owner farms	Tenant farms	Owner tenant farms	Owner farms	Tenant farms	Owner tenant farms	Owner farms	Tenant farms	Owner tenant farms
(*acres*)				(...... *maunds* ......)			(...... *maunds* ......)					
Below 5	27	13	5	641.50	292.50	222.50	107.43	8.00	12.25	16.7	2.7	5.5
5.0—7.49	9	18	5	416.00	706.33	102.00	117.00	53.82	11.66	28.1	7.6	11.4
7.5—12.49	11	19	3	636.00	1,111.49	189.00	188.50	74.91	22.50	29.6	6.7	11.9
12.5—24.99	8	12	4	926.00	961.00	362.00	357.00	129.50	48.00	38.6	13.5	13.3
25.00—50.99	0	3	0	0	530.00	0	0	84.00	0	0	15.8	0
Total	55	65	17	2,619.50	3,601.32	875.50	769.93	350.23	94.41	29.4	9.7	10.8

Source: NSS Schedules.

TABLE IV

MARKETED SURPLUS IN RELATION TO HOLDING SIZE AND TENURIAL STATUS OF CASH CROPS WEST PAKISTAN

Holding size	Number of farms				Quantity produced				Quantity sold				Sales as percentage of produced quantity			
	Cotton (OW)	Cotton (T)	Sugarcane (OW)	Sugarcane (T)	Cotton (OW)	Cotton (T)	Sugarcane (OW)	Sugarcane (T)	Cotton (OW)	Cotton (T)	Sugarcane (OW)	Sugarcane (T)	Cotton (OW)	Cotton (T)	Sugarcane (OW)	Sugarcane (T)
(*acres*)					(........ *maunds* ....)				(........ *maunds* ....)							
Below 5	4	3	1	0	49.50	24.00	8.00	0	47.75	12.35	6.00	0	96.0	51.0	75.0	0
5.0—7.49	4	10	0	1	58.00	184.00	0	4.50	54.50	77.13	0	2.25	94.0	42.0	0	50.0
7.5—12.49	3	13	2	5	64.00	367.00	18.00	150.00	60.00	132.80	8.00	55.50	94.0	36.0	44.00	37.0
12.5—24.9	5	6	1	1	230.00	272.00	80.00	246.00	225.50	130.00	48.00	123.00	98.0	48.0	60.00	50.0
25.00—50.00	0	2	0	0	0	41.00	0	0	0	20.00	0	0	0	49.0	0	0
Total	16	34	4	7	401.50	888.00	106.00	400.50	387.75	372.28	62.00	180.75	96.6	50.0	58.5	45.0

OW = Owner farmers
T = Tenant farmers

Source: NSS Schedules.

TABLE V

MARKETED SURPLUS OF FOODGRAINS IN RELATION TO FAMILY SIZE WEST PAKISTAN

Holding size	Number of farms		Number of adult units		Quantity produced		Quantity consumed		Average consumption		Quantity sold		Sales as percentage of quantity produced	
	S.S.F.	L.S.F.	S.S.F.	L.S.F.	S.S.F.	L.S.F.	S.S.F.	L.S.F.	S.S.F.	L.S.F.	S.S.F.	L.S.F.	S.S.F.	L.S.F
(acres)					(..*maund*..)		(..*maund*..)		(..*maund*..)		(..*maund*..)			
Below 5	40	9	118.9	62.9	907.50	278.00	809.96	305:20	6.8	4.9	97.88	42.30	10.8	15.2
5.00—7.49	14	18	37.8	113.5	475.00	758.33	249.28	598.45	6.6	5.3	58.66	117.16	12.3	15.4
7.5—12.49	15	19	43.2	124.7	832.00	1,115.98	374.41	766.75	8.7	6.1	108.00	188.00	13.0	16.8
12.5—25.00	11	12	34.7	99.9	907.00	1,408.00	292.00	69 1.00	8.4	6.9	220.00	324.50	24.3	23.0
Total	**80**	**58**	**234.6**	**401.0**	**3,121.50**	**3,560.32**	**1,725.65**	**2,361.40**	**7.4**	**5.9**	**484.54**	**671.96**	**15.5**	**18.9**

S.S.F. = Small-size family.
L.S.F. = Large-size family.

Source : NSS Schedules.

TABLE VI

MARKETED SURPLUS OF FOODGRAINS IN RELATION TO FAMILY SIZE: EAST PAKISTAN

Holding size	Number of farms		Number of adult units		Quantity produced		Quantity consumed[a]		Average consumption		Quantity sold		Sales as percentage of quantity produced	
	S.S.F.	L.S.F.	S.S.F.	L.S.F.	S.S.F.	L.S.F.	S.S.F.	L.S.F.	S.S.F.	L.S.F.	S.S.F.	L.S.F.	S.S.F.	L.S.F.
(acres)					(*maunds*)		(*maunds*)		(*maunds*)		(*maunds*)			
Below 2.5	42	8	120.7	49.2	342.24	147.32	728.29	251.98	6.3	5.8	12.07	0	3.5	0
2.5—4.9	19	8	68.4	51.4	464.96	205.15	488.63	316.66	7.3	6.2	35.85	11.31	7.7	5.5
5.0—7.4	0	8	0	52.4	0	170.00	0	322.66	0	6.5	0	14.32	0	8.4
7.5—12.5	0	7	0	52.7	0	543.32	0	418.33	0	8.9	0	58.32	0	10.7
Above 12.5	0	4	0	49.5	0	433.00	0	350.65	0	7.1	0	47.32	0	10.8
Total	61	35	189.1	255.2	807.20	1,498.79	1,216.92	1,660.28	6.44	6.51	47.92	131.27	5.9[b]	8.8[b]

S.S.F. = Small-size family.
L.S.F. = Large-size family.

[a]Consumption figures may be higher than production figures as consumption includes production as well as purchases from the market. Quantity sold refers to gross surplus. Otherwise it could be negative.

[b]Since this table includes owner, tenant, and owner-tenant farms, the average percentage of sale is lower (*i.e.*, 7.8) as compared to Table I, where we only include owner farmers.

Source: NSS Schedules

As regards Table VI, we should note that small-size families do not apparently have any land holdings above 4.9 acres[9]. We can, therefore, only look at the sales by large-size families in relation to different size of holdings. Here again, the larger the average consumption, the larger is the size of the surplus.

This section does not make any attempt to rigorously specify the actual relationship between family size and marketed surplus. This will be explained in Section III where we derive the marketed surplus function.

III. MARKETED SURPLUS FUNCTIONS

The discussion and results presented in Section II are clear indications of the fact that the marketed surplus is not the function of any one single variable. The interplay of the different variables determines the size of the surplus. In this section, therefore, attempts will be made to determine the surplus function of foodgrains with the help of two separate models. Model I applies only to owner farmers while model II is formulated for tenant farmers.

Model I: Owner Farmers

In this model, the "marketed surplus" per farmer family has been considered a function of production and family size. We have not introduced holding size in this model as we found a high correlation between production and the size of holding. These two variables cannot be considered together to determine the surplus function without raising the problem of multicollinearity[10]. Our model I, therefore, can be written as:

$$S = f(X_2 \, ; \, X_3) \ldots\ldots (1)$$

where : S = "marketed surplus" of foodgrains per farmer family,
X_2 = production per farmer family, and
X_3 = family size.

By applying multiple-regression analysis, the surplus functions of foodgrains have been derived. The regression equation for East Pakistan is as follows[11]:

$$S = 1.07 + \underset{(0.02)}{0.67X_2} - \underset{(0.23)}{5.76X_3} \ldots\ldots (2)$$

9 It is not clear whether this represents the actual situation correctly or whether this result reflects on sampling error on the part of the National Sample Survey.

10For an exposition of the problem of multicollinearity, *see* [6, Pp. 201-207].

11The coefficients in a regression equation show the marginal change in the dependent variable, because of this, the regression coefficient of family size is not equal to average consumption of the families. In interpreting equations where we write "on the average" we mean marginal change on the average and not the simple average change.

The bracketed figures are the standard errors. The adjusted coefficient of determination $\overline{R}^2 = 0.93$. The regression equation for West Pakistan is:

$$S = 5.27 + \underset{(0.04)}{0.51X_2} - \underset{(0.56)}{4.34X_3} \ldots\ldots (3)$$

The $\overline{R}^2 = 0.71$.

The regression coefficients are significantly different from zero at the 1-percent level of significance. Ninety-three per cent of the variations in the "marketed surplus" of foodgrains in East Pakistan is explained by the interplay of the two variables, *i.e.*, production and the size of family. They explain 71 per cent of the variations in the surplus in the case of West Pakistan[12].

The interpretation of the equation for East Pakistan is as follows: for the East Pakistani farmers a change in one unit of production is, on the average, associated with a direct change of 0.67 unit in the "marketed surplus", while a change of one unit in the family size appears to bring about, on the average, a negative change of — 5.76 units in the "marketed surplus".

The partial elasticity[13] of the surplus with respect to production at the mean is 1.9 and for family size — 2.9. The output elasticity of the "surplus" shows that a percentage change in production is associated with a change of about 2 per cent in the "marketed surplus"; and the family-size elasticity of the "surplus"

12As our study is based on cross-section data, it is implied that the results we obtained are subject to the given set of prices which prevailed at the time of the survey. Presumably the effect of changed prices would be to shift the whole regression line (surface). This has been pointed out to us by Professor Falcon of Harvard University.

13Elasticity of the "surplus" with respect to production at the mean is

$$b_2 \left[\frac{\overline{X}_2}{\overline{S}} \right]$$

where: $\overline{X}_2$ = mean food production,
$\overline{S}$ = mean "marketed surplus" and

$$b_2 = \frac{ds}{dx_2} = \text{incremental marketing ratio}$$

Elasticity of the "surplus" with respect to family size at the mean is

$$b_3 \left[\frac{\overline{X}_3}{\overline{S}} \right]$$

where $\overline{X}_3$ = mean size of family

$$b_3 = \frac{ds}{dx_3} = \text{incremental marketing ratio}$$

shows that the percentage change in the surplus in response to a percentage change in family size is approximately minus 3 per cent. Thus, the "marketed surplus" is quite responsive to both the changes in production and family size.

The interpretation of the regression equation for West Pakistan is as follows: for West Pakistani farmers a change of one unit in production is associated, on the average, with a direct change of 0.51 unit in the "marketed surplus", while a change by one unit in the family size leads, on the average, to a change in the "marketed quantity" of — 4.34 units.

The production elasticity and family-size elasticity of the "marketed surplus" at the mean are 3.4 and — 3.2 respectively. Thus, we see that marketed surplus is more responsive to changes in both production and family size in case of West Pakistan than in East Pakistan. Looking at the regression equations above, we find that the intercept is much larger in the case of West Pakistan than in East Pakistan. West Pakistan appears to be both absolutely and marginally more "monetized".

The above analysis shows that: *i*) a change in production is associated with a less than proportionate change in the marketed surplus, albeit in the same direction; and *ii*) family size, production being given, is negatively related to the marketed surplus.

Model II: Tenant and Owner-cum-Tenant Farmers

In this model, per capita "marketed surplus" of a farmer family has been considered to be a function of per capita production and per capita rent paid (in kind) to the landlord[14].

The function can be written thus:

$$S^p = f(X_2^p\,;\,X_4^p) \qquad \ldots(4)$$

where S^p = "marketed surplus" per capita,

X_2^p = production of foodgrains per capita, and
X_4^p = rent payment to landlord in kind per capita.

The model is applied to tenant and owner-tenant farmers. It was found that owner-tenant farmers, both in East and West Pakistan, yield statistically insignificant results. The model is, therefore, applicable only to tenant farmers[15].

[14]In order to reduce the number of explanatory variables in the function we divided all the magnitudes by family size. This procedure reduced the computational work involved.

[15]We could not study the tenant farmers in East Pakistan as the number of observation available was less than ten.

The regression equation for foodgrains "surplus" in West Pakistan for tenant farmers is as follows:

$$S^p = -\ 4.07 + \underset{(0.11)}{0.60\,X_2^p} - \underset{(0.19)}{0.62\,X_4^p} \qquad \ldots(5)$$

where the bracketed figures are the standard errors. The adjusted coefficient of determination ($\bar{R}^2$) is 0.60. This shows that 60 per cent of the variations in the "marketed surplus" is explained by these two variables in the case of tenant farmers. Both the coefficients of per capita production and per capita rent paid are significantly different from zero at the 1-per-cent level of significance.

The interpretation of the above equation is as follows: for tenant farmers in West Pakistan a change in per capita production by one unit is associated, on the average, with a direct change of 0.60 units in the marketed quantity, while a unit change in the per capita rent payment is inversely related, on the average, with the "marketed surplus" by 0.62 units.

The above analysis shows that the size of the surplus decreases with rent payment obligations in kind. We should also point out that for owner-tenant farmers the sign of the coefficient for rent payments is negative. This suggests that rent payment in kind reduces the "marketed surplus". However, as the value of the coefficient is found to be statistically insignificant, we cannot say more than that our hypothesis has received a modicum of support.

IV. CONCLUSIONS

The major findings of the paper may be summed up as follows:

a) Ninety-three per cent of the variation in the "marketed surplus" of foodgrains in East Pakistan is explained by production and family size. In the case of foodgrains in West Pakistan these variables explain 71 per cent of the variation in the "marketed surplus".

b) Sixty per cent of the variation in the "marketed surplus" for tenant farmers is explained by per capita production and rent payment. For owner-tenant farmers, rent payments do not explain the variance in the "marketed surplus".

c) Almost all the quantities produced are marketed in the case of cash crops. The marketed surplus of jute is about 95 per cent and that of cotton about 96 per cent. Tenant and owner-tenant farmers sell in the market whatever is left after paying rent in kind to landlords.

d) Consumption of cash goods has little relationship with the "marketed surplus" of foodgrains in the case of both East and West Pakistan.

From the study it appears that the improvement in the yields of crops and reduction of family size are the two most important measures for increasing the size of the marketed surplus in this country.

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Appendix A

SOURCES OF DATA

i) The Family Expenditure Schedules of the *National Sample Survey* [15] (Second Round, 1960—referred to as NSS) provided the data which formed the basis of this study. The sample survey was carried out on the basis of a three-stage stratified sampling design. The total number of schedules collected by the NSS was two thousand and nine hundred for East Pakistan and eleven hundred for West Pakistan. An examination of the schedules revealed that a large number were internally inconsistent. Some did not report the variables which were relevant to our analysis and some were referred to units other than farmers. Out of the remaining schedules we randomly selected 180 returns for West Pakistan and 120 for East Pakistan. Because of the poorer quality of the original sample returns in East Pakistan, our subsample consists of only 13.3 per cent of the total returns obtained from that province. In the case of West Pakistan the subsample consists of 16.4 per cent of the total returns for that province. The total number of schedules in our subsample is three hundred.

ii) The Family Expenditure Schedules of the NSS gave the following information:

a) family composition, on date of enquiry,

b) births during survey year,

c) deaths during survey year,

d) name of crop: area cultivated under each crop; owned and tenanted proportion of area for each; quantity produced; yield per acre,

e) quantity paid in kind for harvesting, threshing *etc.;* quantity paid to the landlord as share of crop or rent in kind; quantity sold for cash; quantity for purchase of goods or services rendered, excluding harvest *etc.*, but including menials and milling; quantity given for repayment of loans; quantity used for seed; quantity used for fodder; quantity wasted; other uses, quantity purchased, quantity received as wages in kind for harvesting and other services by family members; quantity received as rent in kind or share of crop and quantity consumed,

f) consumption of food; clothing and household accessories; miscellaneous articles,

g) savings and insurance,

h) receipts, disbursements.

Appendix B

ANALYSIS OF THE RESULTS

Table I shows that about 10 per cent of the quantity produced was marketed in East Pakistan and about 17 per cent in West Pakistan. These results can be compared with the results obtained by the *Survey on Utilization of Agricultural Commodities* [16, Pp. 3-5]. For West Pakistan, the *Survey* found that about 16 per cent of foodgrains production was marketed. This compares favourably with our result. For East Pakistan, however, the comparison leads to a less reassuring conclusion. The *Survey* [16] shows that about 17 per cent of foodgrains produced was marketed in East Pakistan, as compared with our result of only 10 per cent. Thus not only is there a major discrepancy in the level of foodgrains marketed in East Pakistan but, according to the *Survey*, the per cent marketed in East Pakistan is higher than in West Pakistan while our results show a reverse situation. Although we cannot give any definitive answer to these discrepancies, we suggest two possibilities. The *Survey* [16, p. 11] points out that although the "survey year" was 1959/60, the study in many cases had to be continued well after the end of the survey year. ". . . . the field staff was small . . . . . . the schedule was detailed and the sample was large. This necessitated continuation of the study till after the expiry of the year 1959/60 with increased dependence on the memory of the farmers" [16, p. 11]. Given the difficult terrain in East Pakistan and the fact that the sample size there was relatively large, it may be that the results for East Pakistan suffered more from the limitations mentioned above than West Pakistan. Furthermore, our results are based on a carefully selected subsample from the NSS schedule returns. We have, thus, had an opportunity to scrutinize the returns and use only those which were internally consistent (*see* Appendix A). On the other hand, we have no assurance that a similar careful process of selection was undertaken for the *Survey*. Although these reasons may help to account for the differences in survey result and the result we obtain from the NSS schedule, a more thorough explanation will have to await a detailed analysis of the returns used for the *Survey*.

Part 3

Institutional Arrangements in Agriculture

The Development of Institutional Agricultural Credit in Pakistan

Mohammad Irshad Khan

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The Development of Institutional Agricultural Credit in Pakistan

Mohammad Irshad Khan

The main purpose of this paper is to analyse the development of institutional agricultural credit in Pakistan since independence[1]. Although much has been written about the problems of rural credit in this country, the emphasis was usually on the role of the traditional village money-lender who was, and in many cases still is, the only significant source of credit for the small agriculturist[2]. Very little information is available on the operation of public or semi-public agricultural credit institutions, their relative growth in different areas of Pakistan, their sources of finance or their importance in view of the aggregate credit requirements.

It is today generally recognized in advanced as well as in less developed countries that the credit needs of agriculture cannot be met from private sources alone. Government-owned or government-supported credit institutions must carry a significant burden of the credit supply to agriculture if any major development is to take place in that sector. Even in countries as highly developed as the United States, government agencies, such as the Farmer's Home Administration, have been established to fill the big credit gap left by the commercial banking system. If private banks find it unprofitable in the United States to lend to

[1]The term "institutional credit" as used in this paper refers to credit extended by governmental, semi-governmental and private credit institutions (banks) but not to credit given by village money-lenders.

[2]The most exhaustive and authoritative study which has appeared in this field is by Sir Malcolm Darling [3].

agriculture on any significant scale, it is reasonable to expect this to be even more true in a relatively less developed country such as Pakistan. The need for government action in the rural credit field is further accentuated by the fact that many of the village money-lenders (predominantly non-Muslims) left Pakistan after Partition and migrated to India.

Assuming that the government's vital role in the rural credit field is accepted, our main interest in the present paper is to explore how these governmental credit agencies have performed over the past fifteen years and to what extent they have filled the rural credit needs of agriculture in both wings of the country. The study is, therefore, confined to the credit operations of the government, the cooperatives and the Agricultural Development Bank of Pakistan.

Before one can appraise the importance and the performance of any one, or all of these credit agencies, it seems desirable to obtain some quantitative estimates of total credit needs in agriculture. The first part of this paper will, therefore, attempt to provide such a yardstick. At the same time, it will highlight the empirical problems encountered in estimating aggregate credit requirements under conditions where very little is known about private savings and input-output relationships either on the firm level or in the aggregate.

The second part of this paper will give a brief history of the existing credit institutions and show their relative contribution to total credit flow since 1947/48.

The regional distribution of loans and some of the factors which seem to determine size of loans as well as the purpose for which loans have been extended will be analysed in the third part, followed by a summary of policy-conclusions which emerge from the analysis.

ESTIMATION OF CREDIT REQUIREMENTS FOR AGRICULTURE IN PAKISTAN

This section deals with some of the theoretical and empirical problems encountered in the estimation of credit requirements for agriculture.

Here it seems appropriate to distinguish first of all between 'maintenance credit' and 'productive credit'. The former is needed so that the agriculturist may borrow during lean months or bad crop-years and repay at the following harvest period or in years when production and income are high. The village money-lender and to some extent the government through its *taccavi* loans have traditionally performed the function of extending this type of credit.

'Productive credit', our major concern in this paper, is needed in agriculture in order to meet the production targets of the development plan. Assuming that in Pakistan the marginal productivity of labour in agriculture is close to zero, it is likely that every addition to total agricultural output over present levels requires additional capital investments either on the land already under cultivation or for new land developments. The total amount of capital needed in order to meet the production targets depends upon the shape of the production function in each producing unit. The additional capital requirement can be met either out of savings within or through capital transfers from outside the agricultural sector or through a combination of both.

Assuming for the moment that savings in agriculture are evenly distributed over all producing units according to the size of the output of each firm, then the amount of capital to be transferred from outside the agricultural sector minus that amount of capital which is public investment in agricultural overhead facilities (canals, drainage systems, *etc.*) provides a lower estimate of the total productive credit requirements.

If we relax the assumption that savings are equally distributed within the agricultural sector, then the function of the agricultural credit system is not only to infuse capital from outside but also to redistribute or reallocate that capital which has been generated within the sector through private savings. It is obviously difficult to make any realistic estimates of those components. To what extent a redistribution of savings within the sector is necessary depends furthermore on the government's plans for expanding output. Rather than attempt a uniform percentage increase of output over all producing units, the government may decide to concentrate credit and public overhead investment on those areas where the marginal productivity of capital is likely to be the highest — these are also the areas where private savings are likely to be high.

Officially, the agricultural credit requirement in Pakistan has been estimated to be in the range of Rs. 3,000 million per annum on the assumption that a minimum ratio of credit to output flow in agriculture is 25 per cent [10, chap. III, p. 7]. This estimate of credit requirements as given in the *Credit Enquiry Commission Report* does not appear to be based on the actual input requirements in agriculture. The *Report* does not indicate how this ratio has been obtained; it merely says: "It was represented before us that a minimum ratio of credit to output flow in agriculture was 25 per cent. . . . ." It is also not clear as to whether this refers to all credit or only productive credit as defined earlier in this paper. The concept of a ratio of credit to output flow is obviously an arbitrary criterion for estimation of credit requirements. A theoretically sound estimate of credit needs should be related to the production function, the savings ratio and the repayment capacity of the individual firms in the agricultural sector.

If we begin by looking at the individual firm and we let c_r denote the total annual credit requirements, i_r the value of the total additional inputs required to achieve a given increase in output and s_a the savings generated annually on the farming unit, then the credit requirement is equal to the input requirement minus privat savings:

1) $c_r = i_r - s_a$ (for any firm 'i')

Summing over all the individual firms in the agricultural sector would give us an estimate of total credit requirements in any one production year as indicated in Equation (2) below:

2) $C_r = I_r - S_a$

In order to estimate the input requirements (I_r), we would have to know the shape of the production function for all the individual production units. Since this is impossible to know, we will attempt to get an approximation based mainly on an estimate of the aggregate production function in agriculture.

In order to estimate the aggregate production function, we have to consider that on a fixed land area output (X) depends upon *i*) current inputs (C_i), *ii*) fixed capital inputs (K), and *iii*) labour (L). If we assume, however, that fixed capital is combined with labour in certain fixed proportions, then X can be made to depend only upon C_i and L so that the production function can be defined as

3) $X = \left[a(C_i) + b(L) \right]$ or $dX = \left[a(dC_i) + b(dL) \right]$

where a and b refer to marginal physical productivity of C_i and L (equipped with K) respectively and d means change in the variables.

Assuming that the cash wages paid to labour in agriculture are negligible because most of it is made up of family labour, then the cash input requirements (I_r), necessary to produce X + dX output, can be reduced to:

4) $I_r = C_i + d(C_i) + F_i$

where F_i means that part of fixed capital (K) which will be required to equip the increased labour force as well as to replace worn-out capital. It follows from Equation (3) that:

5) $C_i = \frac{1}{a} [X - b(L)]$ and

6) $dC_i = \frac{1}{a} [d(X) - b(dL)]$.

Since F_i is required to equip additional labour as well as to replace worn-out and obsolete fixed capital, it can be defined by the following equation[3]:

7) $F_i = f(dL) + i(K) = f(dL) + i(fL)$

where

f = capital-labour ratio in agriculture
i = rate of depreciation on fixed capital
K = total fixed capital in agriculture.

Substituting Equations (5), (6), and (7) into Equation (4), we obtain

8) $I_r = \frac{1}{a} (X + dX) + dL\left(f - \frac{b}{a} \right) + L\left(fi - \frac{b}{a} \right)$

Since $(X + dX) = X(1 + r)$ (where r = rate of change in output) and $dL = p(L)$ (where p = rate of change in the agricultural labour force), Equation (8) can be rewritten as follows:

9) $I_r = X\left(\frac{1+r}{a} \right) + L\left[f(p + i) - \frac{b}{a} (1 + p) \right]$

On the basis of Equation (9), we can get an estimate of the total input requirements.

The next step is to assess the savings of the individual farming units in agriculture. By savings we mean the aggregate surplus of income on all the farming units over their consumption[4]. Consumption is a function of income and, therefore, savings depend upon the inverse of the consumption coefficient or, in other words, upon the propensity to save (s). The average propensity to save will enable us to obtain an estimate of aggregate savings of all the farmers such that

10) $S_a = X(s)$.

Substituting Equations (9) and (10) into Equation (2), we obtain an expression which will measure total 'productive credit' requirements in agriculture in any single year:

11) $C_r = X\left[\frac{1+r}{a} - (s) \right] + L\left[f(p + i) - \frac{b}{a} (1 + p) \right]$

[3]In order to get our formula based on ratios, we replace K by fL, which are equal to each other.

[4]Savings here include only private savings which are accumulated in the hands of farmers. Savings through public policies and fiscal measures like taxation and price control are not savings which will offset the credit requirements of the farmers. Savings, as understood here, will depend upon the average propensity to save of the farmers alone, and not the entire agricultural sector.

There are seven parameters in this equation of which two, namely 'a', the marginal productivity of current inputs, and 'i', the rate of depreciation on fixed capital in agriculture, are assumed to be constant over time. Others are likely to vary over time depending upon factors both inside and outside agriculture and the availability of credit itself. The remaining parameters have been estimated in the following way.

The rate of change in the agricultural labour force (p) will depend upon the rate of growth of population and the rate of growth of employment opportunities outside agriculture; it will be positive, zero, or negative depending upon whether the rate of growth of employment opportunities outside agriculture is less than, equal to, or more than, the rate of growth in population. At the present rate of growth of population (2.1 per cent), the total working force will increase by 3.3 million by the end of the Second Plan. It has been estimated that 1.87 million will be provided employment opportunities outside agriculture [4, p. 80]. This means that by the end of the Second Plan the agricultural labour force will increase by 1.43 million at a compound rate of 1.27 per cent per annum. Therefore, the p in our equation is .0127.

The rate of growth in agricultural output (r) is a postulated rate (on the basis of the Second Plan) and its realization depends to a large extent upon the availability of credit, assuming that there is no change in the labour productivity (b). The Second Plan envisages an increase of 14 per cent in agricultural output, [15, p. 5] which comes to annual compound rate of about 2.66 per cent. Therefore, the r in our equation is .0266.

It is expected that the incremental output in agriculture at the end of the Second Plan will be Rs. 2,448 million of which Rs. 1,794 million are due to the application of current inputs[5]. The rest is attributable to fixed capital and labour. The Second Plan provides Rs. 688 million for current inputs [15, p. 192]; and, therefore, the marginal productivity of current inputs is assumed to be

$\frac{1,794}{688} = 2.6$ rupees. As we have assumed that fixed capital and labour are

combined in a fixed proportion, the rest of the incremental output can be attributed to the increase in labour which is equipped with fixed capital provided in the Second Plan. Therefore, the marginal productivity of equiped labour is

$$\frac{2,449 - 1,794}{1.43} = 458 \text{ rupees.}$$

[5][15, p. 142]. Physical quantities have been converted into value on the assumption that prices will rise by 20 per cent at the end of the Second Plan. Prices have been obtained from [18, December-1955].

In order to estimate the private capital-labour ratio in agriculture, we need an estimate of private capital-output ratio and output-labour ratio in agriculture. Agricultural output averaged Rs. 12,343 million during the period from 1954 to 1960 [15, p. 45]. According to the census of 1961 the population of Pakistan stood at 93.7 million persons in 1960/61. The 1951 Census indicated that the ratio of working force to total population was 31.3 per cent and that the agricultural labour force was 75 per cent of the total working force. Assuming that these ratios have been maintained, the agricultural labour force can be estimated at about 22 million in the middle of 1960/61. Assuming on this basis that the private capital-output ratio in agriculture is 2.2, the private capital-labour ratio comes to about Rs. 1,250[6] per worker. Therefore, the 'f' in our equation is 1,250.

The CSO deducts 5 per cent of the agricultural income for maintenance, repairs and depreciation of agricultural implements and farm buildings, *etc.* [2, p. 81]. This come to about 2.41 per cent of the fixed capital in agriculture. The rate of depreciation 'i' is, therefore, assumed to be .0241.

We are now in a position to estimate on the basis of Equation (11) the credit requirements from 1960/61 to 1964/65. On this basis, the average annual credit requirement is estimated at Rs. 1,953 million which comes to about 14.84 per cent of the average annual output flow in agriculture. It must be emphasized again that this estimate does not include public investment in overhead facilities (*e.g.*, irrigation and drainage works).

Table I presents a summary statement of estimated credit requirements from 1960/61 to 1964/65. It is apparent that according to this estimate the productive credit requirements of agriculture never exceed 15 per cent of the annual ouput flow in agriculture.

In addition to these estimates which are based on the most likely values of the parameters, we also estimated credit requirements under changing assumptions about labour productivity, capital-labour ratio, and rate of growth in output. Alternatively, we shall see how much improvements can be brought about in labour productivity and what level of rate of growth in output can be achieved with varying amounts of credit. These estimates are shown in Table II. Accordingly, it appears that, at the present level of productivity and rate of

[6]Capital here refers only to private capital and excludes public investment in agriculture. The assumption that the private capital-output ratio in agriculture is 2.2 seems to be realistic and conforms with similar estimates for India. *See*, in this connection: [7, p. 167; 6, p. 28; 8, Pp. 4 & 5]. The average value of total capital per farm in West Bengal is Rs. 1,165 and for East Punjab is Rs. 3,195, the average of these two being Rs. 2,180. Assuming that each farm consists of two labourers on the average [7, p. 23; 6, p. 15], the capital-labour ratio comes to Rs. 1,090 which is close to our capital-labour ratio estimate of Rs. 1,250.

TABLE I

ESTIMATED CREDIT REQUIREMENTS IN AGRICULTURE
(1960/61 to 1964/65)

Year	Output in agriculture[a] (X)	Credit requirements (C_r)	Credit required as a per centage of output during the previous year $\left(\frac{C_{r(t+1)}}{X_t}\right)$
	(. . . . *million*	*rupees* . . . .)	(*per cent*)
1959/60	12,578	—	—
1960/61	12,862	1,811	14.40
1961/62	13,153	1,880	14.62
1962/63	13,450	1,951	14.83
1963/64	13,754	2,024	15.05
1964/65	14,065	2,100	15.27
Total	65,797	9,766	14.84
Average	13,159	1,953	14.84

[a]Assuming that the output (X) increases annually at a compound rate of 2.66 per cent starting from a level of 12,578 in 1959/60 [14, Statistical Appendix, p. 7]. In the total of this column, output of 1959/60 is included; and the output of 1964/65 is excluded because of a lagged relationship between output and credit required, *i.e.*, credit required in year (t+1) is expressed as a percentage of output in year t).

growth in the labour force, the agricultural sector needs annually about Rs. 1,682 million of credit merely to maintain the present level of annual output. This credit requirement comes to about 13.4 per cent of the existing level of output in agriculture. On the other hand, if credit were increased to Rs. 2,166 million (which is 17.2 per cent of the annual output), output could be expected to rise by 10 per cent. If fixed inputs increased by 6.6 per cent, the capital-labour ratio would increase by about 5 per cent. At the present rate of growth in agricultural labour and with these changes in the capital-labour ratio, the productivity of labour is likely to increase. Assuming that the productivity of labour also rises by 5 per cent, output could be increased by 10 per cent with a credit of Rs. 2,012 million (which is about 15.7 per cent of the output in agriculture). If the rate of increase in employment opportunities in the nonagricultural sector is such that the entire increase in the labour force is absorbed there, then for a 10-per-cent rise in output, a credit of Rs. 1,858 million (14.8 per cent of the output) would be required. A 2-per-cent reduction in the agricultural labour force could lead to a 10-per-cent increment in output with only Rs. 1,376 million as credit and so on.

TABLE II

ESTIMATED CREDIT REQUIREMENT IN AGRICULTURE UNDER VARIOUS ASSUMPTIONS

Credit required for percentage increase in output (X) → / Credit required with percentage changes in b, f, and L ↓	For no increase in output (X)		For 2% increase in output (X)		For 4% increase in output (X)		For 6% increase in output (X)		For 8% increase in output (X)		For 10% increase in output (X)	
	C_r	% of X	C_r	% of X	C_r	% of X	C_r	% of X	C_r	% of X	C_r	% of X
	(*million rupees*)		(*million rupees*)		(*million rupees*)		(*million rupees*)		(*million rupees*)		(*million rupees*)	
With the present value of b, f & p	1,632	13.4	1,779	14.9	1,876	14.9	1,973	15.7	2,069	16.5	2,166	17.2
With 5% increase in f	1,726	13.7	1,823	14.5	1,920	15.3	2,017	16.0	2,113	16.8	2,210	17.6
With 5% increase in b	1,481	11.8	1,581	12.6	1,678	13.3	1,775	14.1	1,871	14.9	1,968	15.7
With 5% increase in f and b	1,528	12.2	1,625	12.9	1,722	13.7	1,819	14.5	1,915	15.2	2,012	16.0
With p=o	1,374	10.9	1,471	11.7	1,568	12.5	1,665	13.2	1,761	14.0	1,858	14.8
With p=o and 5% increase in b	1,176	9.4	1,273	10.1	1,370	10.9	1,467	11.7	1,563	12.4	1,660	13.2
With p=o and 5% increase in f & b	1,220	9.7	1,317	10.5	1,414	11.2	1,511	12.0	1,607	12.8	1,704	13.6
With p= —.02	892	7.1	989	7.9	1,086	8.6	1,183	9.4	1,279	10.2	1,376	10.9
With p= — .02 and 5% increase in f	899	7.2	996	7.9	1,093	8.7	1,190	9.5	1,286	10.2	1,383	11.0
With p=.02 and 5% increase in f & b	723	5.6	820	6.5	917	7.3	1,014	8.1	1,110	8.8	1,207	9.6

b=marginal productivity of agricultural labour
f=private capital-labour ratio in agriculture
p=rate of change in agricultural labour force
C_r=annual credit required by agriculture
X=annual output in agriculture

The main conclusion derived from this analysis is that the strategic factor in the growth of agriculture is the rate of change in the agricultural labour force and labour productivity in agriculture. A rate of change in the agricultural labour force which is less than the rise in labour productivity will lead to rapid growth in agricultural output. The labour productivity can be raised by raising the capital-labour ratio in agriculture, *i.e.*, investing more in fixed inputs. Since saving in agriculture is low, credit must be provided to finance the investments in fixed inputs at the initial stages of growth unless the propensity to save increases sufficiently.

In the following section, we shall compare our estimates of credit requirement with the credit actually provided to agriculturists from institutional sources.

CREDIT INSTITUTIONS IN AGRICULTURE

1. CREDIT AGENCIES

At the present time, there are three main institutional sources which provide credit facilities to agriculture; they are the government (revenue department), the cooperatives, and the Agricultural Development Bank of Pakistan.

The Government

The government is the oldest lending agency in the field of agriculture. Government loans are granted under *i*) the Land Improvement Loans Act of 1883, and *ii*) the Agriculturists' Loans Act of 1884. Loans under the Act of 1883 are granted for the purpose of making any improvement on land[7]. Loans under the Act of 1884 are granted for the prevention or relief of distress, for the the purpose of purchasing seed or cattle or for any other purpose not specified in the Act of 1883 but connected with agricultural objects. In East Pakistan, loans are granted only under the Act of 1884. The government's loan operations are administered by the revenue departments of the provincial governments.

In West Pakistan, the following rules are applicable in the case of government loans: for loans granted under the Act of 1883, the land to be improved serves as a security while loans under the Act of 1884 can be secured by any transferable interests in immovable property. Movable property is rarely accepted as security. Personal security is accepted (even that of one person) provided that his

[7]Improvement means any work which adds to the rental value of the land. It includes *i*) construction of wells, tanks, and other works for the storage, supply, or distribution of water, *ii*) drainage, reclamation, and protection from flood or erosion or other damage, *iii*) preparation of land for irrigation, *iv*) reclamation, clearance, enclosure or permanent improvement of land, and *v*) any other work declared by the provincial government as constituting an improvement.

solvency is certain. For large loans, immovable property is invariably taken as security.

In East Pakistan, government loans are issued to groups of co-villagers varying from 8 to 20 on a joint bond system according to which the borrowers are jointly and severally liable for repayment. The total amount granted to each group ordinarily does not exceed Rs. 350.

Interest is charged on all loans at the prescribed rate. At present, the government charges 6.5 per cent per annum on loans for relief and distress in East Pakistan [15, p.181]. Loans in West Pakistan were charged at a rate of 4.25 per cent per annum which was raised to 4.5 per cent in April 1956 and to 5.5 per cent after the raising of the bank rate in January 1959 [10, Pp.14-15].

The Cooperatives

With the passing of the Cooperative Societies Act in 1904, Primary Credit Societies were organized. This Act was amended in 1912 as a result of which central societies came into existence. The structure of the cooperative system is made up of Provincial Cooperative Banks at the highest level, Central Cooperative Banks below them and the Primary Cooperative Credit Societies affiliated with the central banks. The main purpose of the primary societies is to provide credit to their members and "to encourage the habit of thrift". Their areas of operation are small villages. The central banks are confined to *taluka* or district towns, and their primary function is to meet credit needs of societies but generally they also perform ordinary banking business, accept deposits from the public on current and fixed accounts; collect bills, cheques, *hundis;* issue drafts and make advances to individual members against movable securities[8].

Since the idea underlying cooperative credit is that a group combining to furnish a collective guarantee can obtain loans at low rates of interest, a society's assets have been called "the funded honesty of its members". Loans are, therefore, given commonly on the security of two co-members.

The rate of interest charged by the Cooperative Credit Societies is beween 8 to 9.5 per cent per annum [15, p.181]. The provincial and the central cooperative banks charge 2 to 10 per cent in West Pakistan and 2 to 9 per cent in East Pakistan [16, Pp. 54-73].

The Agricultural Development Bank

Realizing that the credit needs of the agriculturists especially for improvement and investment purposes were not adequately met by the existing credit ins-

[8]For a detailed description of the cooperative system in Pakistan, *see:* [17 specially, Chap. II, Pp. 11-30; 5, specially, Chaps. II and III, Pp. 40-275].

titutions, the government established in 1952 the Agricultural Development Finance Corporation with a head office at Karachi and three regional offices at Dacca, Lahore, and Sukkur. Later, in 1955, the corporation opened additional regional offices under the direction of the central government. In 1961, following the recommendation of the Credit Enquiry Commission, it was merged with the Agricultural Bank of Pakistan [9; 10, p. 60]. The latter had been established in 1957 mainly to help small cultivators.

The Agricultural Development Bank of Pakistan is the result of the merger of these two organizations in February of 1961. The ADBP took all the assets and liabilities of the two predecessor agencies as of that date. In 1960/61, it had twenty-one branches, five subbranches, and eleven pay-offices in West Pakistan and sixteen branches, sixteen subbranches and nine pay-offices in East Pakistan. The authorized capital is Rs. 200 million of which Rs. 102.5 million has been issued and Rs. 95 million has been paid up.

The ADBP requires pledge, mortgage, hypothecation or assignment of movable or immovable property of the borrower or his surety against its loans. The bank also accepts pledge or assignment of gold, government securities and life insurance policies as security[9]. Interest is charged at the fixed rate of 6 per cent.

2. AMOUNT OF CREDIT EXTENDED TO AGRICULTURE FROM INSTITUTIONAL SOURCES

During the period 1947/48 to 1959/60 the agricultural sector has received an average annual amount of 230 million rupees against an estimated minimum requirement of 1,682 million rupees. Since a substantial portion of credit provided by the cooperative banks has gone to marketing intermediaries, the 230-million figure overstates the amount actually received by agriculturists. Excluding the cooperative banks, the average annual credit flow has been 45 million rupees, approximately 3 per cent of estimated minimum credit requirements. Data on the average amount of credit provided by various agencies are shown in Table III.

Regional Differences in Credit Flow

During the period 1947/48 to 1959/60, West Pakistan's agricultural sector had received an average annual amount of 216,299 thousand rupees whereas East

[9]The amount of an individual loan shall not exceed: *i*) 80% of the market value or face value (whichever is lower) of the government securities; *ii*) 75% of the appraised value of tea crops; *iii*) 75% of the surrender value of life insurance policies; *iv*) 70% of the value of gold determined at Rs. 100 per tola for gold of maximum fitness; and *v*) 50% appraised value of the security in other cases and in certain cases where land is offered as of the security upto 60%.

TABLE III

ANNUAL CREDIT FLOW TO AGRICULTURE
(1947/48 *to* 1959/60 *Average*)

Agency	Credit provided	% of total
	(000 *Rs.*)	
Government	12,809	5.6
Primary Cooperative Societies	22,123	9.6
Cooperative banks[a]	184,663	80.4
ADBP	9,960	4.3
All agencies	229,555	100.0
All agencies excluding cooperative banks	44,892	19.6

[a]Credit extended by cooperative banks refers to loans granted to individuals only and excludes loans by banks to primary societies.

Pakistan's agricultural sector had received only 13,256 thousand rupees over the same period. This difference in the flow of credit in the two wings of Pakistan is largely explained by the successful growth of cooperatives in West Pakistan and its rapid decline in East Pakistan. The major portion of the credit in West Pakistan has been provided by cooperatives.

The annual flow of credit from all agencies is shown in Table IV. The share of cooperative credit in the total credit of West Pakistan during 1947/48 to 1959/60 is 93.1 per cent while the share of cooperative credit in the total credit in East Pakistan is only 41.3 per cent. The government, on the other hand, has provided only 3.5 per cent of the total credit in West Pakistan whereas it has provided 39.8 per cent of the total credit in East Pakistan. The credit shares of the Agricultural Development Bank in the total credit of East and West Pakistan are 18.9 and 3.4 per cent respectively.

There is also a wide annual fluctuation in the annual credit flow into agriculture as shown in Table V and Figures 1 to 4. Government credit has shown the greatest year-to-year fluctuations, between 2.5 million to 16.0 million in West Pakistan and between 1.0 million to 14.0 million in East Pakistan[10]. The credit provided by the Primary Cooperative Credit Societies has been steadily rising in West Pakistan and constantly declining in East Pakistan. Starting with a very low base, the statutory bodies (*i.e.*, ADFC and Agricultural Bank and now the Agricultural Development Bank) have provided a rapidly rising

[10]These fluctuations are explained in detail in the following section of this article where they are related to variations in crop production.

TABLE IV

AVERAGE ANNUAL CREDIT FLOW TO AGRICULTURE IN EAST PAKISTAN (From 1947/48 to 1957/58) AND WEST PAKISTAN (From 1947/48 to 1959/60)

Credit agencies	East Pakistan			West Pakistan		
	Amount	Percentage of		Amount	Percentage of	
		Total credit	Total credit excluding cooperative banks		Total credit	Total credit excluding cooperative banks
	(000 *Rs.*)			(000 *Rs.*)		
Government	5,270	39.8	52.0	7,539	3.5	21.7
1883 Act—cattle purchase loans[a]	1,427	10.8	14.1	2,422	1.1	7.0
1884 Act	3,843	29.0	37.9	5,177	2.4	14.7
Cooperatives	5,476	41.3	—	201,310	93.1	—
Cooperative societies	2,350	17.7	23.2	19,773	9.2	56.9
i) Ltd. primary cooperative society[b]/multipurpose societies	661	12.7	6.5	9.021	4.2	26.0
ii) Unltd. primary cooperative societies	1,689	5.0	16.7	10,751	5.0	30.9
Central cooperative banks	181	1.4	—	155,546	71.9	—
Provincial cooperative banks	2,945	22.2	—	25,991	12.0	—
Agricultural Development Bank	2,510	18.9	24.8	7,950	3.4	21.4
Total all agencies	13,256	100.0		2,16,299	100.0	
Total all agencies except cooperative banks	10,130		100.0	34,762		100.0

[a]Loans under the Act of 1883 are granted only in West Pakistan; cattle purchase loans refer to loans granted only in East Pakistan.

[b]There are no limited primary cooperative societies in East Pakistan and similarly there are no multipurpose societies in West Pakistan.

TABLE V

CREDIT FLOW IN AGRICULTURE SINCE 1947/48

Year	East Pakistan							West Pakistan						
	Government	Primary societies	Multi-purpose societies	Central cooperative banks	Provincial co-operative banks	Agricultural Bank	Total	Government	Limited societies	Unltd. societies	Central cooperative banks	Provincial co-operative banks	Agricultural Bank	Total
	(... *in thousand rupees* ...)													
1947/48	—	1,973	—	—	—	—	1,973	4,707	442	2,652	29,601	8,759	—	46,161
1948/49	—	1,545	—	—	55	—	1,600	15,739	1,190	3,467	64,948	9,822	—	95,166
1949/50	3,843	937	731	195	1,346	—	7,052	3,508	2,383	4,366	1,06,914	13,318	—	1,30,489
1950/51	1,281	329	1,019	685	8,942	—	12,256	7,229	44,157	5,465	1,76,683	21,727	—	2,15,261
1951/52	5,168	831	3,013	247	10,766	—	20,025	2,656	5,443	6,602	1,77,623	52,282	—	2,44,606
1952/53	8,536	726	6,631	404	—	—	16,297	3,306	6,182	7,828	1,28,089	19,148	—	1,64,553
1953/54	3,508	231	792	7	1,261	673	6,472	6,770	8,332	8,620	1,46,338	40,126	2,107	2,12,293
1954/55	6,257	163	632	10	5,799	688	13,549	3,200	10,793	9,803	1,55,216	39,721	1,558	2,20,291
1955/56	1,124	175	777	3	—	817	2,896	5,493	13,343	12,956	1,87,024	31,704	1,333	2,51,653
1956/57	13,416	216	1,563	46	1,283	2,388	18,911	6,108	4,617	16,700	2,23,278	25,092	3,005	2,77,800
1957/58	4,296	149	44	28	*n.a.*	7,985	12,502	11,473	14,182	17,387	2,42,037	34,898	6,491	3,26,468
1958/59	31,000	*n.a.*	*n.a.*	*n.a.*	*n.a.*	11,276	*n.a.*	15,908	18,092	19,986	2,16,451	24,820	11,110	3,09,367
1959/60	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	24,749	*n.a.*	11,914	28,111	24,943	1,64,898	16,468	34,193	2,80,527
1960/61	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	41,078	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	36,500	*n.a.*

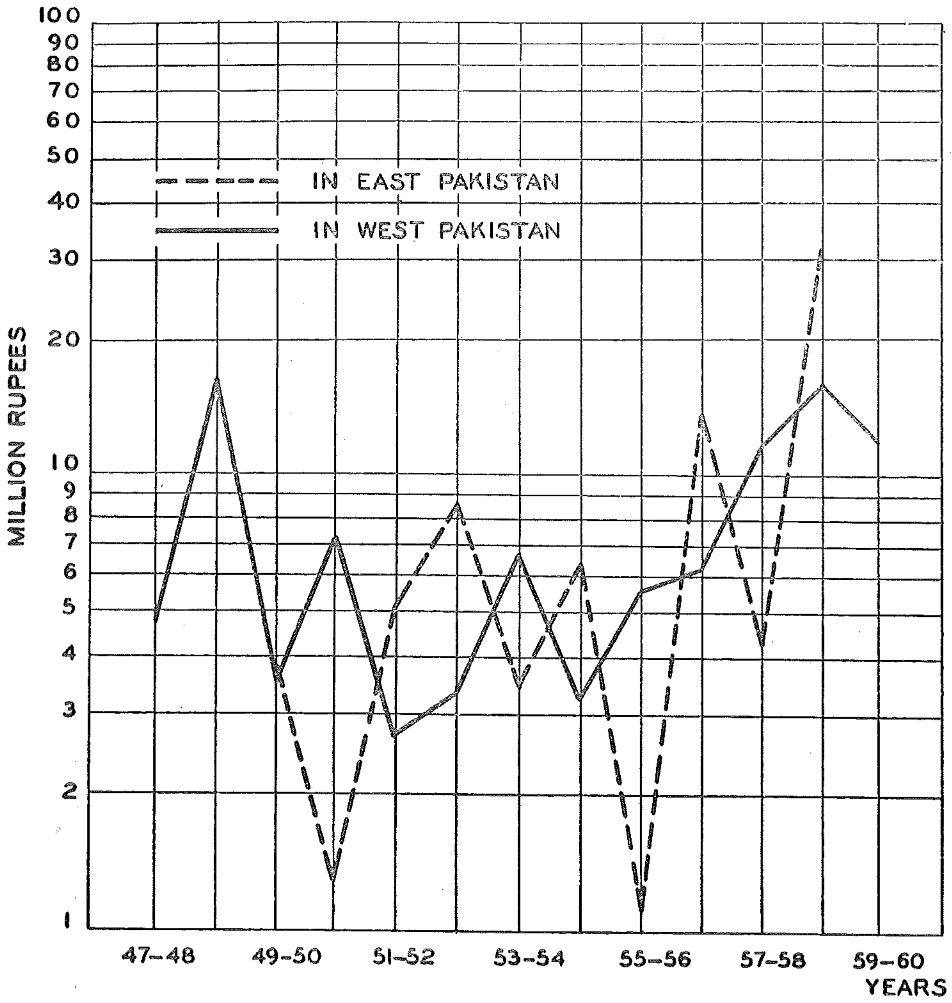

Figure 1. Loans Provided by the Government

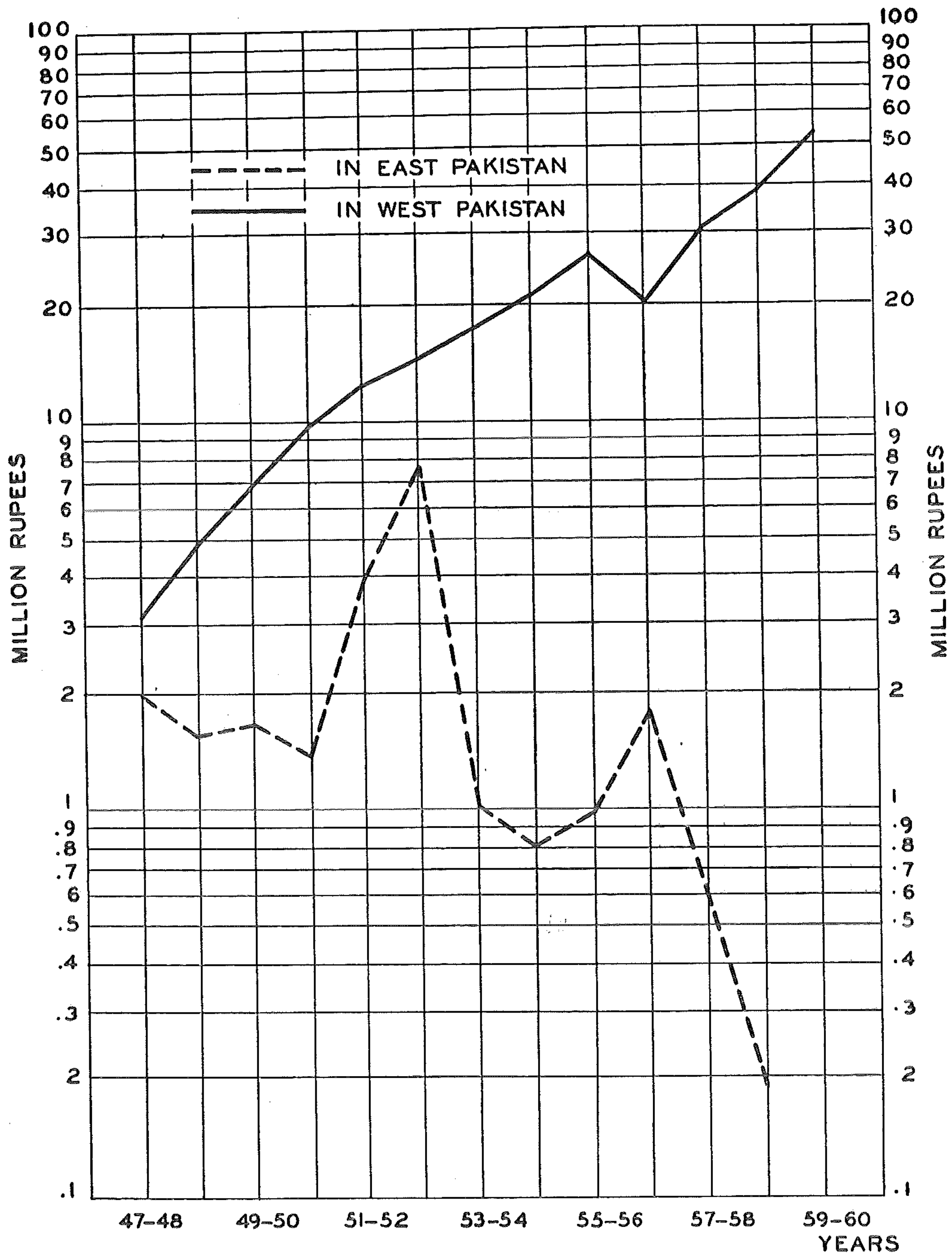

Figure 2. Loans Provided by Cooperative Societies

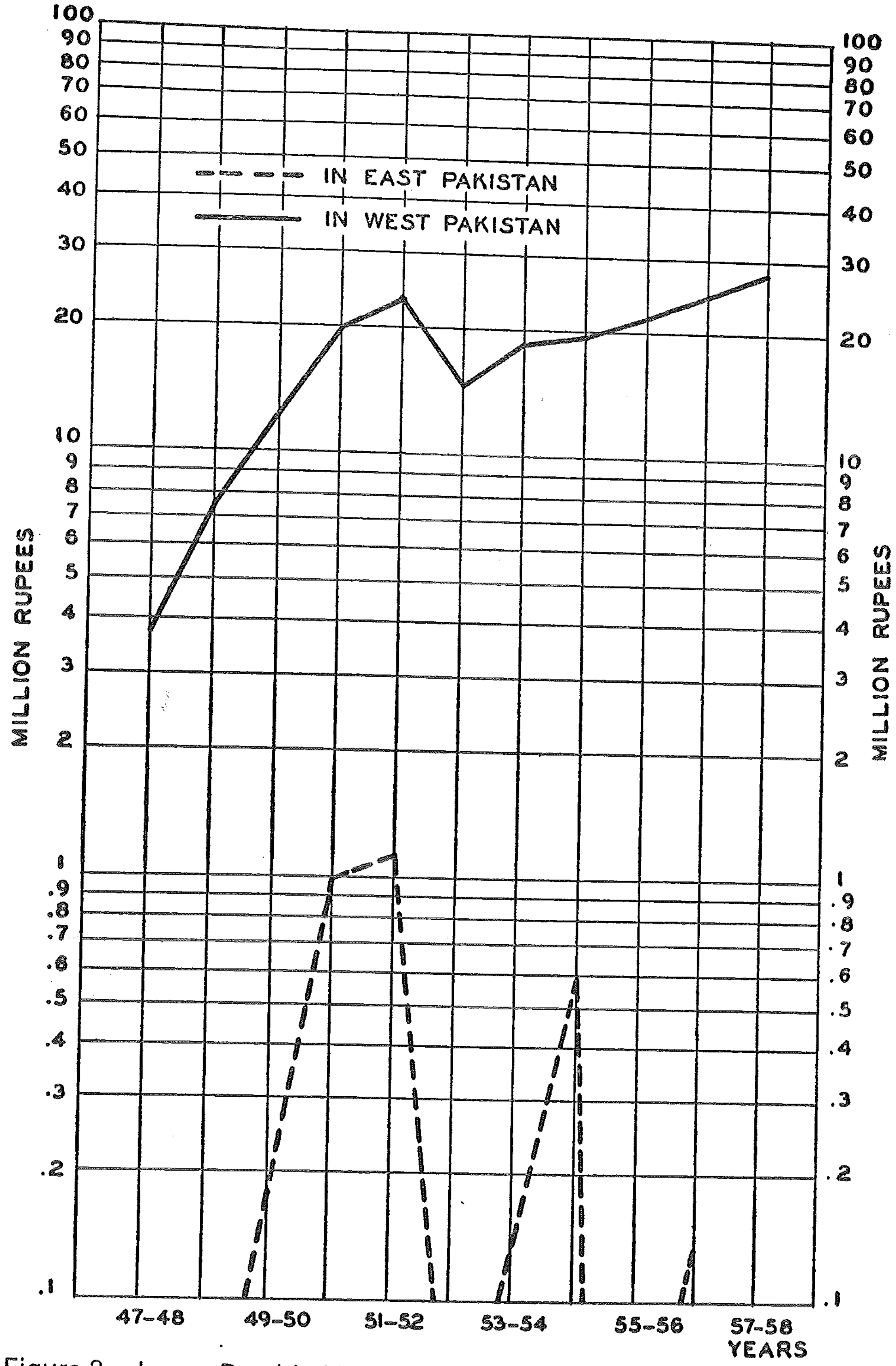

Figure 3. Loans Provided by Cooperative Banks (to Individuals only)

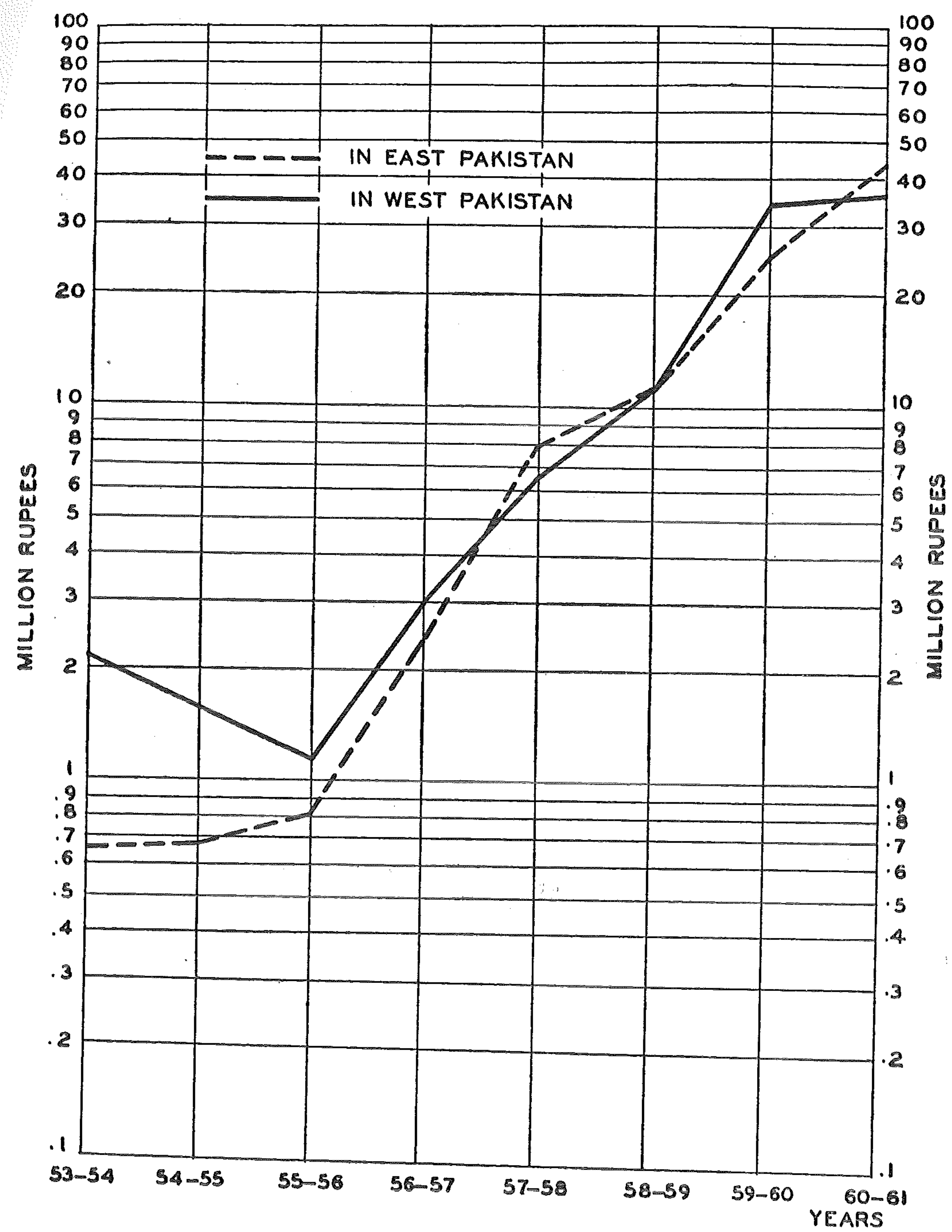

Figure 4. Loans Provided by Agricultural Development Bank

amount of credit to the agriculturists in both wings. There has been very little year-to-year fluctuation in the lending operations of the Agricultural Development Bank.

Although the total amount of credit received by farmers in West Pakistan is still far short of requirements, it is significant that credit provided by the Primary Cooperative Credit Societies has been steadily rising. One reason behind this growth appears to be the presence of landlords who provide the major part of the funds to these societies. It appears that in West Pakistan the migration of non-Muslims did not affect the cooperative movement as severely as it did in East Pakistan because there was a sufficient number of wealthy Muslim landlords to take the place of the non-Muslim financiers.

In East Pakistan, in the absence of a big landlord class prior to Partition, the mirgation of wealthy non-Muslims appears to be mainly responsible for the failure of the cooperatives. It is an encouraging development, therefore, to see the relatively rapid expansion of government credit in the East Wing.

FACTORS AFFECTING VARIATIONS IN AGRICULTURAL CREDIT

In this section, we will examine 1) the factors determining annual variation in government loans, 2) factors affecting regional differences in the quantity and type of loan received, and 3) the purpose for which credit has been given.

Annual Variation in Government Loans

We have shown previously that the amount of government loans has been fluctuating considerably from year to year. This fluctuation can be explained largely by the variation in crop production. A good crop reduces, and a bad crop raises, the borrowing from government in the following year.

Let L denote the amount of government loans extended and C the physical quantity of production of major food and cash crops. Then the average variation of loans as a result of bad and good crops can be measured by the following expression :

$$V = \frac{\Delta \bar{L}}{\Delta \bar{C}}$$

Where V is the average variation, $\Delta\bar{L}$ the average change in the amount of loans taken and $\Delta\bar{C}$ is the average percentage change in the production of

crops[11]. We shall add subcript 'g' (for good crop years) if we are measuring the change in the amount of loan due to positive changes in crop production and 'b' (for bad crop years) for negative changes in crop production. In addition to the relationship between variation in total crop production and variation in the amount of credit extended, it may be of interest to determine this relationship also for food (F) and cash crops (N) separately. These relationships are shown in Table VI.

TABLE VI

AVERAGE VARIATION OF GOVERNMENT LOANS RELATED TO VARIATION IN CROP PRODUCTION[a]

Region	East Pakistan			West Pakistan		
	Food	Cash	All	Food	Cash	All
Variation in government loans related to crops	$\frac{\Delta\bar{L}}{\Delta\bar{F}}$	$\frac{\Delta\bar{L}}{\Delta\bar{N}}$	$\frac{\Delta\bar{L}}{\Delta\bar{C}}$	$\frac{\Delta\bar{L}}{\Delta\bar{F}}$	$\frac{\Delta\bar{L}}{\Delta\bar{N}}$	$\frac{\Delta\bar{L}}{\Delta\bar{C}}$
	(...............	......	thousand	rupees......	......	.......)
V_b	994	948	1,339	229	46	43
V_g	—258	374	—241	—291	—12	—16

[a]Crop-production data have been obtained from [19, April 1962].

On the average, for every 1-per-cent increase in the production of food crops in East Pakistan, government loans go down by 258 thousand rupees in the following year. Every 1-per-cent decline in the production of food crops is followed by an increase of 994 thousand rupees in the following year. The remaining figures in Table VI can be interpreted by the reader in the same way. It appears that in East Pakistan good cash-crops have not decreased government

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$$\Delta \bar{L} = \frac{1}{n} \sum_{i=1}^{n} \Delta L \text{ where } \Delta L = L_t - L_{t-1}$$

$$\text{and } \Delta \bar{C} = \frac{1}{n} \sum_{i=1}^{n} \Delta C \text{ where } \Delta C = \left[\frac{C_{t-1}}{C_{t-2}} - 1 \right] . 100.$$

loans to the same extent apparently because a number of good cash-crop years have been accompanied by below-average food production.

Variation in crop production apparently has a significant effect on variations in the volume of government loans. It also appears that the average variation in government loans is much more in East Pakistan than in West Pakistan which is explained by the fact that the average variability in crop production is much higher in East than in the West Wing.

The extent to which increase in loans due to bad crops is more or less than the decrease in loans due to good crops, given equal percentage rate of decrease and increase in crop production, can be measured by the ratios between the average percentage variation in good years and the average percentage variation in bad years. Denoting this ratio by r, we can measure it by the following equations:

1) $r(F) = \frac{\Delta \bar{L}_b}{\Delta \bar{L}_g} \times \frac{\Delta \bar{F}_g}{\Delta \bar{F}_b}$ (for major food crops[12])

2) $r(N) = \frac{\Delta \bar{L}_b}{\Delta \bar{L}_g} \times \frac{\Delta \bar{N}_g}{\Delta \bar{N}_b}$ (for major cash crops)

3) $r(C) = \frac{\Delta \bar{L}_b}{\Delta \bar{L}_g} \times \frac{\Delta \bar{C}_g}{\Delta \bar{C}_b}$ (for all major crops)

The value of r, in case of East Pakistan, is 3.78 for food crops, 1.35 for cash crops and 5.51 for all crops[13]. In case of West Pakistan, it is 1.43 for food crops, 3.84 for cash crops and 2.73 for all crops. The following conclusions can be drawn from this analysis:

1) Food-crop growers or subsistence farmers are the most important group of borrowers of government loans.

2) The influence of bad crops on raising the amount of government loans is much higher than the influence of good crops in lowering it. This suggests that there may be an increasing number of farmers who need government loans irrespective of bad or good crops while there are others who need government loans only when there is a bad crop particularly when there is a bad food-crop.

3) *Taccavi* loans are mainly taken for the consumption needs of the farmers.

Areas Receiving Credit

The availability of credit depends to a large extent on the nature of the area where credit is needed. In areas where incomes and repayment capacity are better credit appears to be more easily available. The income, and thus the repaying capacity of an agricultural region, is determined partly by the size of the holdings in that area and partly by the value of production per acre.

Seven regions for which data relating to the Agricultural Development Bank are available have been analysed to determine the relationship between the average size of loans granted by the bank, the average size of cultivator's holdings and the percentage share of acreage under cash crops in the total acreage of that region. The relevant data are shown in Table VII. The average size of loan

TABLE VII

Average Size of Loans Related to Average Size of Cultivators' Holdings and Percentage Share of Acreage under Cash Crops

Region	Average size of loans (Y)	Average size of cultivators' holdings (X_1)	Percentage share of acreage under cash crops in total acreage (X_2)
Dacca	352	2.9	9.02
Rajshahi	324	5.1	7.71
Khulna	426	3.8	5.29
Rawalpindi	599	5.4	16.98
Lahore	1,197	6.2	25.98
Multan	2,413	10.8	38.83
Sukkur	2,073	8.8	39.20

Source: Average size of cultivator's holdings (X_1) from [11 ; 12]

[12] The value of r can be less than, equal to, or more than, one ; and its implications are:

1) $r(F) < 1$ means that increase in loans due to bad food crops is less than the decrease in loans due to good food crops, given equal percentage rate of decrease and increase in food-crop production.

2) $r(F) > 1$ means just the reverse of (1).

3) $r(F) = 1$ means that increase and decrease in loans are equal, given the equal rate of decrease and increase in food-crop production. Similar is the case with r(C) in respect of production of all crops and r(N) in respect of production of cash crop.

[13] The value of r(N) for East Pakistan (which is 1.35) suggests that increase in *taccavi* loans due to bad cash-crops is more than *increase* (not decrease) in *taccavi* loans due to good cash-crops.

appears to be highly correlated with the average size of cultivators' holdings as well as the percentage share of acreage under cash crops in the total cultivated area.

Two simple linear equations were computed, one relating the average size of loans to the average size of cultivators' holdings and the other relating the average size of loans to the percentage share of acreage under cash crops in the total cultivated area. The equations obtained are of the following form:

1) $Y = -784.37 + 299.41\, X_1$

2) $Y = -138.66 + 58.42\, X_2$

The results have been plotted in Figures 5 and 6. The coefficient of correlation for Equation (1) is .96 and for Equation (2) it is .97. Apparently because they have a much higher repayment capacity, big landholders and cash-crop growers have received most of the bank's loans.

The concentration of credit in the relatively wealthy cash-crop producing areas is brought out further by the data in Table VIII. Taking the total number of loan applications approved as 100, it appears that three districts, namely Lahore, Multan, and Sukkur, had only 13 per cent of all loan applications but they accounted for 43 per cent of the total amount of loans sanctioned whereas in the three East Pakistan regions 83 per cent of all approved loan applicants received only 53 per cent of the total amount of loans granted. A similar picture emerges within regions: Dacca, the principal cash-crop producing region of East Pakistan appears to have received a greater share of total credit extended in that province whereas the poorest region of West Pakistan, Rawalpindi, has received much less credit than the remaining areas of that province.

On the basis of the data provided by the 1960 Agricultural Census and on the basis of certain assumptions about the average size of cooperative and government loans for which no detailed information on size of individual loans was available, an attempt has been made to estimate the average number of farmers (annually) who are likely to have received loans from any of the credit agencies. For West Pakistan the number of 'farmers' as used here includes only landlords and peasant proprietors and owner-tenants but excludes tenants on the assumption that loans received on farms operated by tenants the landlord usually receives and repays the loan. Moreover, on larger landholdings operated by several tenants one loan received by a landlord may affect several tenant holdings. Excluding tenants from the agriculturists results in a more liberal estimate of the percentage of agriculturists who are likely to have been affected by credit from institutional sources. As shown in Table IX even under these liberal assumptions only 8.5 per cent of all farmers in Pakistan have received credit from *any* ins-

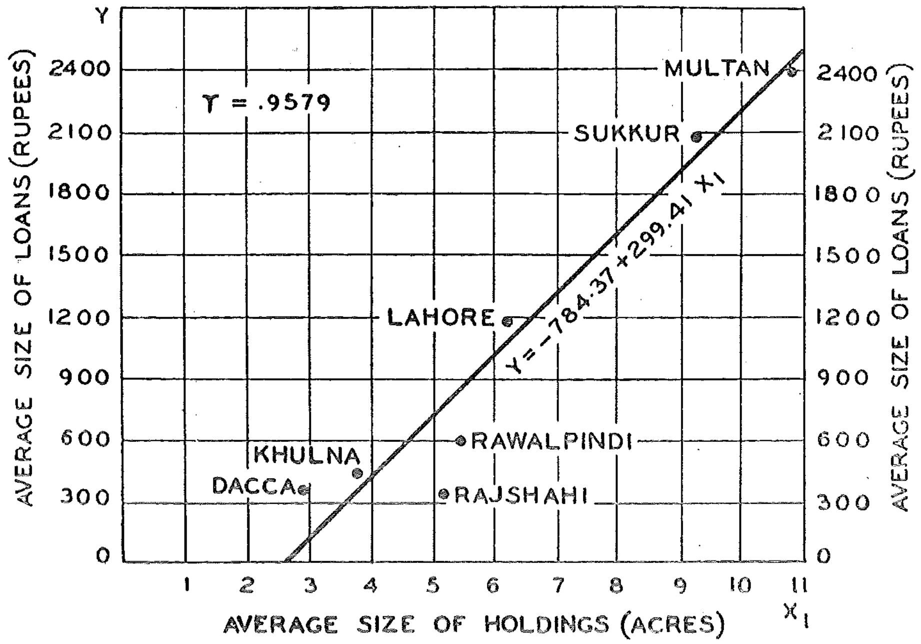

Figure 5. Average Size of Loans Granted by ADBP (Y) Related to Average Size of Holdings (X_1)

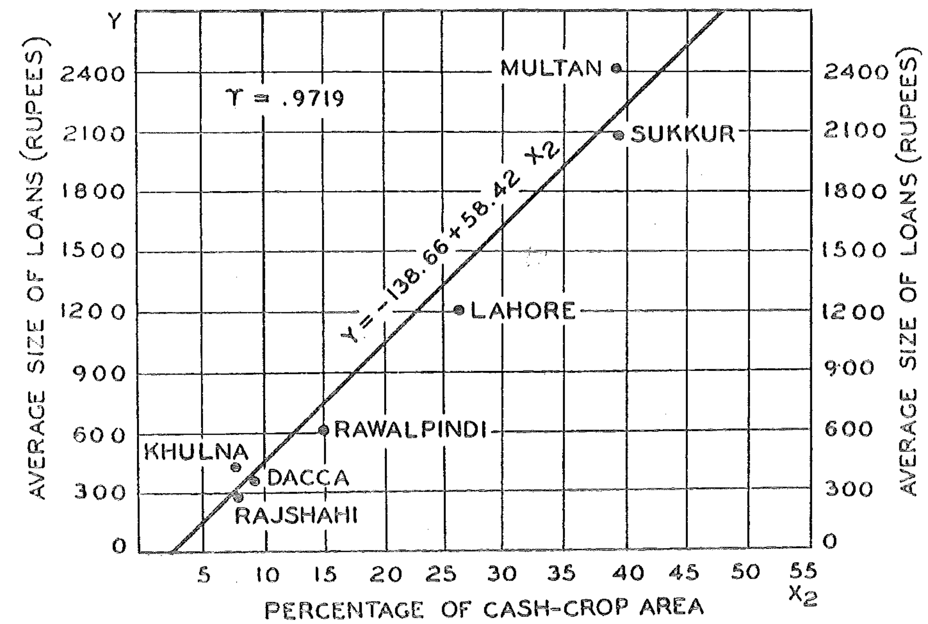

Figure 6. Average Size of Loans Granted by ADBP (Y) Related to Percentage Share of Acreage under Cash Crops in the Total Cultivated Area (X_2)

TABLE VIII

ACREAGE UNDER CASH CROPS AND LOAN SANCTIONED BY ADBP

Region	Acreage under cash crops in 1957/58[a]								Loans sanctioned in 1960/61[b]			
	Jute/Cotton		Tea/Tobacco		Sugarcane		Total		No. of applications approved		Amount sanctioned	
	Acres	%	Acres	%	Acres	%	Acres	%	No.	%	Rs.	%
	(000)		(000)		(000)		(000)				(000)	
Dacca	798	19	76	52	63	6	937	17	61,342	44	21,590	28
Rajshahi	323	8	—	—	109	10	432	8	33,236	24	10,778	14
Khulna	239	6	—	—	75	7	314	6	20,425	15	8,710	11
Lahore	467	11	21	14	352	23	840	15	6,872	5	8,228	11
Rawalpindi	7	0	32	22	157	14	196	4	5,111	4	3,060	4
Multan	1,577	38	13	19	306	28	1,896	35	6,986	5	16,867	21
Sukkur	757	18	4	3	30	3	791	15	4,030	3	8,355	11
Total	4,168	100	146	100	1,092	100	5,406	100	1,38,002	100	77,578	100

N.B. Jute and tea relate to East Pakistan while cotton and tobacco relate to West Pakistan.

Sources: [a]From [13, Pp. 65–69, 72–76].
[b]From Agricultural Development Bank of Pakistan, Karachi.

TABLE IX

AVERAGE NUMBER OF LANDOWNERS RECEIVING CREDIT FROM INSTITUTIONAL SOURCES ANNUALLY

(1947/48 to 1959/60 Average)

Area	Total number of peasant proprietors and landlords[a]	Government loans		Cooperative loans		Agri. Dev. Bank loans		All agencies	
		Number[b]	%	Number[b]	%	Number	%	Number[c]	%
East Pakistan	61,70,610	2,10,800	3.42	94,000	1.52	1,15,003	1.86	4,19,803	6.80
West Pakistan	22,37,678	75,390	3.37	1,97,730	8.84	22,999	1.03	2,96,119	13.20
All Pakistan	84,08,288	2,86,190	3.40	2,91,730	3.47	1,38,002	1.64	7,15,922	8.51

Sources: [a]From [p. 9; 11, 12, p. 13]

[b]The number of cultivators receiving loans from government and cooperative societies in East and West Pakistan has been estimated on the assumption that the average size of government and cooperative loans in East and West Pakistan is Rs. 25 and Rs. 100 respectively.

[c]There may be overlapping in this respect as one cultivator may receive loans from all of these three agencies. But the possibility of extending loans to a person who is already indebted to others is very small and therefore the overlapping may not be very significant.

titutional source whereas the ADBP loans have reached only about 1—2 per cent of the total farm population.

Purpose for which Credit has been Given

One aspect of this study has been the analysis of various purposes for which credit has been extended to buy current inputs, such as fertilizer, to make investments in land improvements or to buy capital items. The former would contribute mostly to raise output along an existing production function whereas the latter would produce in the long run an upward shift in the production function, thereby raising the marginal productivity of labour and other inputs.

Table X shows the purposes (or type of inputs) for which the special agencies have provided credit to the agriculturists in Pakistan.

TABLE X

LOANS SANCTIONED BY SPECIAL AGENCIES FOR VARIOUS PURPOSES

Purpose	ADFC(1953-59)		ABP(1957-59)		ADBP(1960/61)		Total	
	Amount	Per cent	Amount	Per cent	Amount	Per cent	Amount	Per cent
	(000 *Rs*)		(000 *Rs*)		(000 *Rs*)		(000 *Rs*)	
Livestock (bullocks)	17,665	38	9,837	40	27,589	41	55,091	40
Levelling of land	3,537	8	—	—	30,028	5	6,565	5
Excavation and embankments	2,838	6	—	—	1,344	2	4,182	3
Tractors, implements and equipments	8,649	19	480	2	5,172	8	14,201	10
Tubewells and other wells	9,566	21	3,307	13	10,904	16	23,777	17
Power pumps and engines	1,486	3	—	—	595	1	2,081	2
Seeds	1,627	3	—	—	5,088	8	6,715	5
Fertilizers	782	3	—	—	1,922	3	2,704	2
Labour charges	427	1	—	—	11,436	17	11,863	9

It appears that a major part of the loans, granted by the statutory agencies has gone to finance the purchase of bullocks. Capital items have claimed up to 77 per cent of the loans given by these agencies. Whereas the share of loans extended for fertilizers and seeds seems to be relatively insignificant. This suggests one of two things: *i*) statutory lending agencies are convinced that the marginal productivity of current inputs in agriculture is lower than that of capital inputs; or *ii*) what is more likely, they follow the traditional pattern of all lending agencies in Pakistan which is to lend on the basis of tangible assets rather than on the basis of prospective increases in output. It is well known that the farmers in Pakistan lack good fertilizer as well as good seeds although their awareness of availability and profitability of these inputs may be limited. To raise the existing productivity in agriculture, good seeds and scientific manures are essential. It may be advisable, therefore, on the part of the ADB to infuse the knowledge and advantages of good seeds and fertilizer into the farming population by granting loans of fertilizer and seeds in kind rather than to extend cash loans.

Data regarding regional differences in the purpose for which loans have been extended are shown in Table XI. The data cover only the loan operations of the Agricultural Bank and its successor the Agricultural Development Bank of Pakistan.

TABLE XI

LOANS SANCTIONED BY ABP AND ADBP FOR VARIOUS PURPOSES

Purpose	ADBP				ABP[a]			
	E. P.		W. P.		E. P.		W. P.	
	Amount	Per cent	Amount	Per cent	Amount	Per cent	Amount	Per cent
	(000 *Rs*)		(000 *Rs*)		(000 *Rs*)		(000 *Rs*)	
Livestock (bullocks)	18,955	52	8,633	28	6,472	38	3,865	49
Levelling of land	946	3	2,082	7	—	—	—	—
Exacavation and embankments	1,233	3	111	0	—	—	—	—
Tractors, implements and equipments	214	1	4,958	16	31	0	450	7
Tubewells and other wells	—	—	10,904	35	1,165	10	1,227	18
Power pumps and engines	49	0	546	2	—	—	—	—
Total fixed inputs[a]	21,397	59	27,234	88	7,668	46	5,042	73
Seeds	3,703	10	1,385	5	—	—	—	—
Fertilizers	851	2	1,071	4	—	—	—	
Labour charges	10,299	28	1,137	4	—	—	—	—
Total current inputs[a]	14,853	41	3,593	12	9,178	54	1,895	—
Total	36,250	100	30,827	100	16,846	100	6,937	100

[a]Total current inputs are not classified into seeds, fertilizers and labour charges. Only the total figure was made available.

These data suggest that loans for fixed inputs are proportionately much greater in West Pakistan than in East Pakistan. For example, the ADBP has granted 88 per cent of the loans for fixed inputs in West Pakistan in comparison with only 59 per cent in East Pakistan. Loans for capital items such as tractors have been insignificant in East Pakistan but of much greater importance in the West Wing where the scope for mechanized farming is certainly much greater.

CONCLUSION

The analysis of institutional agricultural credit presented in this paper suggests that even under the most optimistic assumption about input-output coefficients, the credit presently supplied to agriculture from institutional sources falls far short of credit requirements. The implications of this conclusion for the development of agriculture in Pakistan are obvious: unless private capital investments can be increased substantially, the probability of achieving the targets of the Second and subsequent five-year plans in the agricultural sector remains small. The method of estimating credit requirements for agriculture as used in this paper is new in the sense that an attempt has been made to base it on the best available estimates of production-function parameters. Although this method is more sound conceptually than the informed guess used by the Credit Enquiry Commission, it still is deficient in a number of ways: *i*) The production-function parameters used are averages for the entire country. Regional deviations from this average are likely to be large in the sense that in certain areas of Pakistan the marginal productivity of capital is much higher than in others. If the major share of the planned increase in agricultural output is expected to come from these areas then it may be for this reason that the total credit requirements are lower than estimated in this paper. *ii*) Our estimation procedure ignores direct and indirect government investment in agriculture which has the effect of either raising the existing production function or, if it results in opening new land areas, contributes to absorb the annual increase in the rural labour force. Failure to incorporate this factor again leads to an upward bias of the estimated credit requirement.

In addition to pointing out the vast discrepancy between credit needs and credit requirements, the analysis has shown that Partition and the consequent departure of non-Muslim financier class had a profound effect on the then existing credit institutions. Particularly, East Pakistan experienced a rapid decline, and we may say almost a complete collapse of the cooperative credit structure. The Agricultural Development Bank has attempted to fill this vacuum although to-date it has not been able to do this completely. In West Pakistan, based on a much larger class of wealthy Muslim landlords, the cooperative credit movement did not decline in importance as it did in East Pakistan.

Analysis of the lending pattern of existing credit institutions suggests that at the present time their activities have been concentrated largely in the relatively

wealthy cash-crop producing areas and within these areas mostly among the biggest landlords. The acquisition of bullocks and other capital items has been the major purpose for which the loans were used. Less than 10 per cent of the funds extended appear to have been used for current inputs such as fertilizer and improved seeds where the prospective increase in output is the only security to the lending agencies. Although this result is not surprising in view of the banking traditions prevailing in most underdeveloped countries[14], it is nevertheless important to point out that real development in the agricultural sector as envisaged in the country's development plans requires that scarce resources be used where their potential contribution to output is greatest. In order to achieve this goal, substantial changes in the lending philosophy of credit institutions will be required. The credit worthiness of a potential borrower will have to be determined not only on the basis of the tangible assets which the bank can claim in case of default but rather on the basis of the potential repayment capacity out of increased production. In this connection one may cite in conclusion the practice of the Farm Home Administration, a government agency lending to small farmers in the United States. This agency requires every loan application to be accompanied by a detailed plan of operation for the farm, showing land use, crop rotation as well as a summary of expected costsand returns covering the entire loan period. On the basis of such a feasibility plan, it is possible for a lending agency to make an appraisal of the repayment capacity out of the revenue surplus and consequently determine the size of the loan as well as its duration. If a similar scheme were started in Pakistan by the Agricultural Development Bank, it would be possible to gain a better understanding of potential repayment capacity out of current production. At the same time, it would yield criteria for the minimum farm size necessary to qualify for credit in different areas. For production units falling below that size, it will be necessary for the government to develop schemes whereby consolidation of several of these subsistence units will raise their production potential to the point where they become creditworthy.

[14]For, a vivid description of lending practices in another underdeveloped country—Iran, *see* [1, Pp. 406–421]

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Welfare and Production Efficiency: Two Objectives of Land Reform in Pakistan

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Welfare and Production Efficiency: Two Objectives of Land Reform in Pakistan

Christoph Beringer

Among the policy measures used by governments of less developed countries in their effort to promote economic development, land reform occupies a place of great importance. In West Pakistan, the area under discussion in this paper, land and tenancy-reform laws aimed at changing the existing agrarian structure have been enacted periodically before as well as after Partition by the governments of the formerly individual provinces (Punjab, NWFP, Sind)[1]. In January 1959, shortly after the present government came to power, a land-reform law covering the entire province of West Pakistan was passed. It introduced a large number of reform measures designed to bring about a more equitable distribution of land-ownership rights as well as to provide the basis for a gradual increase in the productive capacity of the agricultural sector through appropriate tenancy reforms[2]. No systematic studies are available which show to what

[1]See for example: the Punjab Consolidation of Holdings Act, 1936 ; The North West Frontier Tenancy Law of 1950; and The Punjab Tenancy Law of 1952.

[2]The two most important provisions of the land-reform law of 1959 with which we will be concerned in this paper are *a*) the ceiling on individual landownership of 500 acres of irrigated land or 1,000 acres of nonirrigated land, *b*) the restrictions on further subdivision of existing holdings which provide that no holding should be subdivided below the size of a 'subsistence holding' defined as 12.5 acres in most areas of Pakistan. Holdings which are presently above the size of a subsistence holding but below the size of an 'economic holding' (50 acres) can only be partitioned if the split does not result in holdings which will fall below the size of a subsistence holding. The same rule applies to alienation through sale, gift or otherwise. Since it would not be appropriate in a paper of this kind to restate all the other provisions of the land-reform law, the reader is referred to the following three documents for a complete account of these individual provisions: [10; 11; 14].

extent and how successfully the earlier laws have been implemented. As regards the law presently in force it might still be too early to try to assess the impact on agricultural production or to determine the number of rural people and agricultural holdings which have been actually affected. Nevertheless, it seems worthwhile to study some of the data on size of holdings and land fragmentation for a few districts of West Pakistan in order to gain a better perspective of the land-tenancy problem in general as well as the *potential* impact of the land reforms law presently in force.

In Section I of this paper certain background material will be presented which might contribute to a better understanding of the existing land-tenure situation. Section II will present data on size of holdings, subdivision and fragmentation which were collected recently in the former NWFP of West Pakistan. Section III will evaluate this information in terms of the provisions of the land-reform law and draw certain conclusions for the possible future direction of land-reform policy in West Pakistan.

I

Traditionally, the concept of land reforms has been associated with the breaking up of large landed estates so as to make it possible for an increasing number of cultivators to become land owners in their own right. Welfare and efficiency considerations both played important roles, although the emphasis was clearly on the former. Under the conditions prevailing in West Pakistan excessive concentration of ownership is, however, only one aspect of the entire land-tenancy problem. Equally important are the problems of subdivision and fragmentation of cultivator's holdings as well as the problem of rental arrangements between landlords and tenants. And while welfare considerations are of some importance in land-reform laws, the major emphasis is and should be on those aspects of the land-tenure situation which stand in the way of an increase in the productivity of the agricultural sector.

There are other important differences between the traditional concept of land reforms and that applicable in West Pakistan. In some countries, it is conceivable that breaking up of large estates could lead to a decrease in efficiency and lower net output per acre due to increases in production costs per acre. In Pakistan, this problem seldom arises because large estates, although they may be owned by one individual or one family, are seldom cultivated in large compact blocks but rather by numerous tenants each cultivating a small part of the entire estate. The argument that by breaking up big estates greater welfare or social justice is achieved at the expense of reduced efficiency has, therefore, very little validity under these conditions. Nor is it necessarily inconsistent for land-reform laws in Pakistan to set an upper limit to the amount of land which can be owned by one individual and at the same time attempt to increase the size of the cultivator's holding. This brings us to an important distinction which will be adhered to throughout this paper: it concerns the difference between landlords on the one hand and cultivators (who may or may not be the owners of the land they cultivate) on the other. Accordingly, we can also distinguish between the two large problem complexes: the concentration of ownership in the hands of the few and the problems of subdivision and fragmentation.

In this connection, one frequently encounters the argument that Muslim and Hindu laws of inheritance carry the major burden of responsibility for the excessive degree of subdivision and fragmentation prevailing in the subcontinent. A study of the Quranic injunctions on inheritance of property reveals that the rules for such transfer are indeed spelled out in minute detail in the sense that they are very specific regarding the share which each heir is to receive of the parental property[3]. Although the Holy Quran nowhere mentions that the heir must receive his share in the physical form of land this is nevertheless the way in which the inheritance laws are usually interpreted and executed. Also, when a father of three sons leaves three parcels of land of equal size then each one of the heirs receives not merely one of the three parcels but usually a third of each, leaving a total of 9 separate fragments. In this way, an 'equitable' distribution is achieved in case there is any variation in the productivity of the three original plots.

Although the Islamic laws of inheritance are presently interpreted in this way, there is sufficient historical evidence to suggest that this has not always been the case and that their negative effects are of relatively recent origin. The main reason is that in India until the end of the Mughal rule the prevailing concept of property in land was of the communal rather than of the individual type. "The notion of an absolute estate is alien .... to the old Hindu and Mohammadan law" [5, p.*iii*]. As regards the ownership and cultivation of land there were certain differences among areas. In some places land was the common possession of all, in others it was owned by individual families [5, p.ii], but seldom was it customary for individual members of the family, even though they might have been nominally entitled to their share of the land, to leave the family and to set up independent units of cultivation.

With the gradual disintegration of Mughal rule and the coming of the British East India Company, it appears that the government found it increasingly difficult to collect directly from the cultivators the revenues necessary to finance government operations. Accordingly, intermediaries were appointed who were initially merely responsible for collecting the revenue from the cultivators in return for a certain percentage of the proceeds they collected. In the course of time, these revenue-collection rights ripened into rights of absolute owner-

[3]See in this connection: [1, Pp. 509-510].

ship and along with it came individual control over the land resources as well as control over the cultivators tilling the land. The subcontinent had, thus, experienced a gradual shift from what was essentially *ryotwari* tenure to the now predominant *zamindari* system[4], and *pari passu* a change from the traditionally communal concept of landownership to that of individual proprietorship and control over land resources. Once the individual in contrast to the communal proprietorship concept became dominant the inheritance laws began to contribute increasingly to a rapid process of subdivision and fragmentation of land. Mukerjee reports in this connection that ".... in one village investigated in the Deccan the average size of holding decreased from 40 acres in 1771 to 7 acres in 1915, at which time 60 per cent of the holdings were less than 5 acres" [9, Pp. 110-112].

In addition to the changing concept of property rights there was, of course, the more obvious factor of an increasing population pressure on the available land resources without a simultaneous improvement in the efficiency of agricultural production. Kingsley Davis estimates that the population of the Indo-Pakistan subcontinent was only about 100 million at the beginning of the 17th Century. If recent census estimates in India and Pakistan are considered the population of the subcontinent is now more than 5 times that much [3, Pp 25-27].

II

The data on land fragmentation and size of holdings presented in this section are based on a study[5] conducted during the year 1958/59 in the six settled districts of the former North West Frontier Province[6]. There are significant differences between these districts in climatic conditions as well as in the predominant cropping pattern. Only in two of the districts (Peshawar and Mardan) is the supply of irrigation water sufficient to irrigate the greatest part of the total cultivated area. The remaining districts have to rely much more on the available rainfall[7]. This difference in availability of irrigation water is reflected clearly in the prevailing cropping pattern; only in the Peshawar and Mardan districts where the supply of irrigation water is adequate is it possible to grow high-value

[4]The following paragaraph quoted from [4, Vol. IV, p. 207] explains the essential difference between *ryotwari* and *zamindari* tenure: ".... when the revenue is imposed on an individual or community owning an estate and occupying a position identical with or analogous to that of a landlord the assessment is known as *zamindari*, where the revenue is imposed on individuals who are the actual occupants of holdings the assessment is known as *ryotwari*".

[5]For a detailed account of the procedures used and the results obtained in this study, *see*: [2].

[6]These districts are: Hazara, Mardan, Peshawar, Kohat, Bannu, and Dera Ismail Khan.

[7]Mean annual rainfall for several of the cities located in these districts are as follows: Abbottabad, Hazara, 47.26 inches; Peshawar, 13.56 inches; Kohat, 24.0 inches; Bannu, 11.11 inches; Dera Ismail Khan, 9.09 inches. Separate data for Mardan are not available but rainfall conditions there are approximately the same as those in Peshawar.

crops such as sugarcane and fruit to any significant extent. Where irrigation water is insufficient to supply the entire cultivated area, we find the more drought-resistant grain varieties such as *jowar* and *bajra* which grow and mature even under relatively unfavourable soil moisture conditions.

Table I summarizes the importance of irrigated acreage in each of the six districts. As the ratio of irrigated to total cultivated acreage decreases the *rabi/kharif* ratio begins to show an upward trend indicating the relatively greater reliance on *rabi* (winter) cultivation. The only exception to this trend is the Hazara District where climatic conditions (especially in the upper part of the district) are such that a winter crop cannot be grown at all due to snowfall and the summer crop matures even without supplemental irrigation due to more favourable rainfall conditions. The type of agriculture practised in the upper part of Hazara District is more nearly comparable to that found in areas with temperate climates. A comparison between Hazara and the remaining districts lying in the semi-arid alluvial plains of West Pakistan is, therefore, not too meaningful. In relating the differences in tenancy patterns to various other factors such as land productivity and intensity of irrigation, we will, therefore, ignore the Hazara District for the time being and concentrate on those areas which are physiographically and climatically more nearly comparable. This is not to say that the data collected for Hazara are of no value, in fact they are probably very indicative of conditions found throughout many parts of the foot-hill area including the tribal areas adjoining West Pakistan.

TABLE I

IMPORTANCE OF IRRIGATION AND EXTENT OF DOUBLE CROPPING IN SIX DISTRICT OF THE FORMER NORTH WEST FRONTIER PROVINCE

District	Total area cultivated	Total area irrigated	Ratio irrig. to cultivated	*Rabi/kharif* ratio
	(.........*thousands*	*of acres*.........)		
Peshawar ..	459	431	.94	1.39
Mardan ..	469	347	.74	1.57
Bannu ..	577	136	.24	4.34
D. I. Khan ..	597	105	.18	3.19
Kohat ..	307	50	.16	2.43
Hazara ..	568	65	.11	.78

Source: [13].

In the analysis of the prevailing tenancy pattern a distinction was made between landlords, peasant proprietors and tenants. Landlords, for purposes of this study, were defined as persons who do not cultivate the major portion of the land they own, whereas peasant proprietors and tenants are themselves cultivators. As in most classifications certain ambiguities remain, for example, a small shopkeeper who owns a small parcel of land but does not cultivate it himself is classified as a landlord whereas a person owning 50 acres and cultivating it himself with the help of hired labour is classified as a peasant proprietor. Similarly in the case of tenants, a man who owns 3 acres and rents 4 would be classified as a tenant whereas one who owns 5 acres and rents 4 would be classified as a peasant proprietor.

The study was conducted in two phases: first household lists were prepared on a complete-count basis for all the villages included in the sample; later on, a representative subsample of about 800 holdings was chosen for detailed study.

The results of the complete enumeration of the sample villages are shown in Table II. They give an indication of the relative size of the three groups of agriculturists within the total agricultural population of the NWFP. More than half of the 14,526 persons enumerated were peasant proprietors while less than one-third were tenants.

The break-up by district reveals significant differences between the intensively irrigated and highly productive districts of Mardan and Peshawar and the remaining four districts where agricultural production is less intensive and crop output per acre and land values correspondingly lower. While the percentage of landlords in the two most productive districts is lower, the percentage of tenants is much more than in other districts suggesting that concentration of ownership in the hands of a few landlords tends to be a greater problem in these areas. The peasant proprietors represent a much larger proportion of all the agriculturists in the relatively less prosperous districts.

Average Size and Size Distribution of Holdings

Although the number of landlords is considerably smaller in Peshawar and Mardan than it is in the remaining districts, it was found in the second phase of the study that the average size of their holdings is more than twice the size of the average landlord's holding in the remaining districts. (*cf.* Table III). This evidence together with the data presented earlier suggests that the 'big landlords' tend to be concentrated in those districts where land values and productivity are highest, whereas the small- and medium-size landlords predominate in the less prosperous areas. Looking now at the average size of peasant proprietors and tenant holdings we find that the picture is just the opposite of that indicated earlier for landlords. Peasant proprietor and tenant holdings tend to be smaller on

TABLE II

TYPES OF TENANCY (NUMBER AND PERCENTAGE) IN SIX DISTRICTS OF FORMER NWFP
(RESULTS OF THE COMPLETE ENUMERATION OF SAMPLE VILLAGES)

Tenancy	Peshawar		Mardan		D. I. Khan		Kohat		Hazara		Bannu		Total NWFP	
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Landlords	181	7.1	343	8.1	104	17.3	175	26.4	900	20.9	347	16.0	2,050	16.1
Peasant proprietors	1,427	55.9	2,110	49.7	427	70.9	354	53.5	2,819	65.6	1,176	54.3	8,313	57.2
Tenants	943	36.9	1,792	42.3	71	11.8	133	20.1	580	13.4	644	29.6	4,163	28.6
Total	**2,551**	**100.0**	**4,245**	**100.0**	**602**	**100.0**	**662**	**100.0**	**4,299**	**100.0**	**2,167**	**100.0**	**14,526**	**100.0**

TABLE III

AVERAGE SIZE OF HOLDINGS FOR LANDLORDS, PEASANT PROPRIETORS AND TENANTS

District	Landlords		Peasant proprietors		Tenants		Ratio of irrigated area to total cultivated area
	No. of Landlords	Average size of holding	No. of peasant proprietors	Average size of holding	No. of Tenants	Average size of holding	
Peshawar Mardan	93	54.8	165	6.2	66	5.9	.84
D. I. Khan							
Kohat	51	21.6	129	11.9	34	9.6	.20
Bannu							
Hazara	67	8.7	132	5.6	4	4.1	.11
NWFP	211	32.2	426	7.7	104	7.1	.38

the average in the more prosperous areas suggesting that the true 'subsistence' farm tends to become smaller as average per acre productivity goes up.

Distribution by Size Groups

In addition to the average size it is interesting to study the size distribution of these holdings. Table IV shows this relationship. It is apparent that more than 80 per cent of all the landlords in our sample own farms below 50 acres in size but together this group owns only 31 per cent of the total land area whereas the remaining 18 per cent of the landlords own almost 70 per cent of the area. Considering the recommendations of the Land Reforms Commission as regards ceiling on ownership it is evident that only 1 out of 211 landlords in our sample could possibly be affected by this law although it is significant that this one landlord owned 11 per cent of the area held by all landlords in our sample.

It may be dangerous to generalize from this sample about the true nature of the upper end of the distribution because the probability of choosing a sample of 211 landlords which does not contain very many large-size holdings is quite high. There is also a possibility of underreporting on the part of landlords with large holdings even though the fieldwork in this particular study was carried out mostly before martial law and the promulgation of land reforms. While there is some doubt about the accuracy of the upper end of the distribution we have reason to be more confident about the mean and the areas closer to the mean. A more drastic reduction in the ceiling on land holdings to, say, 50 acres, as has been done in most states and provinces of India [6] would still involve only 18 per cent of all the landlords but it would affect almost 70 per cent of the total land area.

The size distribution of peasant proprietors and tenant holdings is also shown in Table IV. It is apparent that in our sample more than 75 per cent of the peasant proprietors had holdings of less than 10 acres in size which means, in terms of the definitions used in the Commission's *Report*, that the majority of holdings is already considerably below the size of a 'subsistence' holding. Only 4 out of 426 peasant proprietors (less than I per cent) had holdings of the size of an 'economic holding' as defined by the Commission.

In all districts there seems to be a very close correspondence between tenants and peasant proprietors as regards the average size of their holding. The important difference lies in the distribution by size groups. As compared to peasant proprietors, a much smaller percentage of tenants cultivate holdings below 1 acre in size and on the upper end of the distribution we find only 1 tenant with a holding larger than 25 acres. A graphic comparison between these two size distributions is shown in Figure 1. The conclusion that suggests itself here is that a peasant proprietor may find it possible, somehow, to produce enough to feed

TABLE IV

DISTRIBUTION OF HOLDING BY SIZE GROUPS AND TYPE OF TENANCY

Size group	Landlords				Peasant proprietors				Tenants			
	No. of Landlords	%	Acreage	%	No. of peasant proprietors	%	Acreage	%	No. of Tenants	%	Acreage	%
0 — <1	12	5.7	7.1	0.1	34	8.0	19.16	0.6	1	0.96	0.50	0.07
1 — <2.5	26	12.3	39.8	0.6	78	18.3	134.11	4.1	20	19.23	32.32	4.4
2.5 — <5	35	16.6	152.3	2.2	101	23.7	364.91	11.1	22	21.15	80.01	10.88
5 — <10	34	16.1	237.8	3.5	108	25.4	748.74	22.8	37	35.58	256.10	34.84
10 — <25	32	15.2	532.5	7.8	87	20.4	1,262.73	38.4	23	22.12	336.20	45.73
25 — <50	33	15.6	1,169.5	17.2	14	3.3	458.50	14.0	1	0.96	30.00	4.08
50 — <75	13	6.2	801.2	11.8	2	0.5	111.87	3.4	—	—	—	—
75 — <100	11	5.2	921.7	13.6	1	0.2	82.00	2.5	—	—	—	—
100 — <250	12	5.7	1,524.9	22.4	1	0.2	106.00	3.2	—	—	—	—
250 — <500	2	1.0	652.5	9.6	—	—	—	—	—	—	—	—
500 — <1000	1	0.5	745.0	11.0	—	—	—	—	—	—	—	—
1000 and above	—	—	—	—	—	—	—	—	—	—	—	—

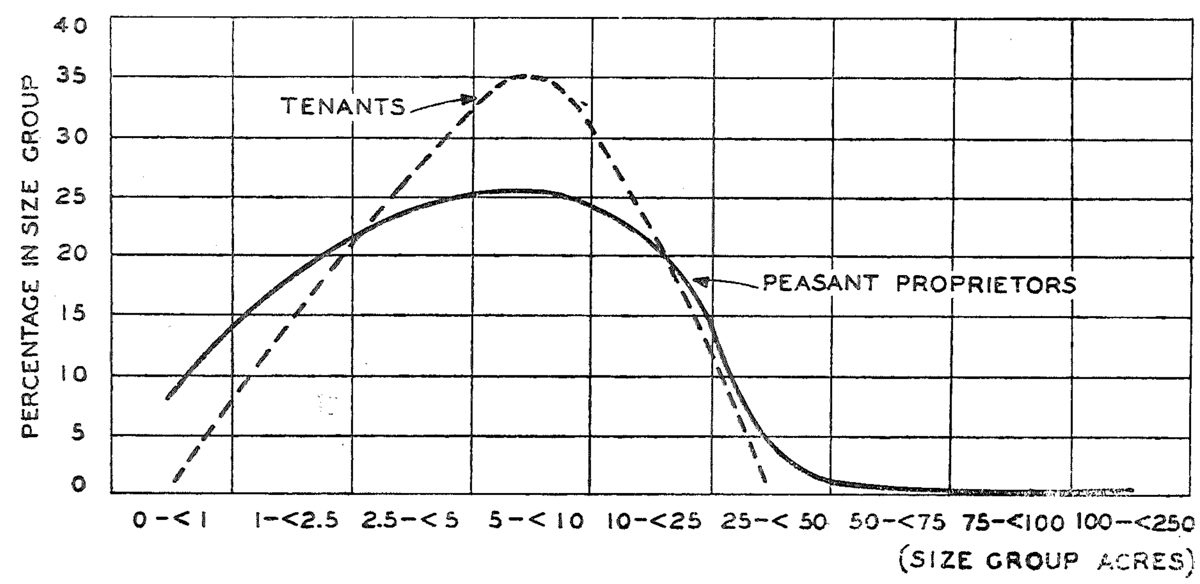

Figure 1. Size Distribution of Peasant Proprietors and Tenants' Holdings

himself and his family at a subsistence level even on an extremely small holding whereas a tenant who has to pay approximately 50 per cent of his total production as rent to the landlord may not be in a position to do this. The 'minimum subsistence' farm size appears, therefore, to be considerably lower for peasant proprietors than it is for tenants.

The Extent of Fragmentation on Agricultural Holdings in the NWFP

It was indicated earlier that the Islamic laws of inheritance have contributed considerably to the process of subdivision and fragmentation which is found throughout the subcontinent. In addition, there are economic reasons why these inheritance laws could manifest themselves in this, from the point of view of production efficiency, very negative way.

Excessive subdivision and fragmentation of land appears to be peculiar to all those countries whose economy is largely based on agriculture and where there have existed until recently few employment and investment opportunities in nonagricultural sectors of the economy. In a relatively stagnant economy, land fragmentation is the only way in which it is possible to ensure that successive generations will enjoy at least some measure of economic security. It is not surprising, therefore, that social prestige in the community has become very closely associated with land ownership and even though employment and investment opportunities in sectors other than agriculture are increasing we find that landowners are generally very reluctant to sell their land and invest their money elsewhere. When, as a result of family circumstances, a piece of land does come onto the market it is likely to command a price which is far higher than its actual earning capacity. Only when other economic assets begin to command a similarly high degree of confidence in their stability can we expect a gradual decrease in the prestige value attached to land.

The statistical picture on land fragmentation as it presents itself at the present time in the North West Frontier Province is shown in Tables V and VI. Column (2) of Table V shows the average number of fragments per holding for landlords as well as for peasant proprietors and tenants. While averages are of some interest here they conceal the fact that there are some holdings which are much more fragmented and some on which fragmentation is not as serious. Thus, we found one landlord whose holding of 62 acres was split into 50 separate fragments and on the other hand we encountered many holdings with only one or two fragments. The district break-up (Table VI) does not show very large differences in the average number of fragments per holding except for Dera Ismail Khan where the average number of fragments per holding is almost 7. It will be recalled (Table II above) that this district had by far the largest number of peasant proprietors (70 per cent) in relation to the total agricultural population in the district, suggesting that the problem of land fragmentation

TABLE V

Fragmentation of Holdings by Type of Tenancy
(Entire NWFP)

Tenancy	Average size of holding	No. of fragments	Average size of fragments	Average size of smallest fragments
	(acres)		*(acres)*	*(acres)*
Landlords ..	32.2	5.2	6.2	2.82
Peasant proprietors ..	7.7	3.8	2.0	0.86
Tenants ..	7.1	3.9	1.8	1.12
All cultivators ..	7.6	3.9	2.0	1.01

TABLE VI

Fragmentation of Cultivator's Holdings
(Peasant Proprietors and Tenants) by Districts

District	Average size of holding	Average number of fragments	Average size of fragment	Average[a] distance from largest fragment
	(acres)		*(acres)*	*(acres)*
Peshawar ..	4.84	3.35	1.44	0.87
Mardan ..	8.49	3.68	2.31	2.51
D. I. Khan ..	9.61	6.61	1.45	0.96
Kohat ..	11.65	3.90	2.99	0.99
Bannu ..	12.04	3.85	3.12	1.56
Hazara ..	5.32	3.76	1.41	0.97
Entire NWFP ..	7.58	3.86	1.96	1.39

[a]This column shows the average distance between each of the fragments and the largest fragment in the holding.

may be most serious in the poorest areas of the country where the small peasant proprietor predominates.

It is generally the impression among students of land reforms in Pakistan that the consolidation of holdings within villages is being implemented more speedily than other provisions of the land-reform law. No studies are, however, available which show where in the country the consolidation of holdings has been completed; nor do we have any indication of the administrative difficulties that are being encountered by the agencies responsible for carrying out this aspect of land reforms.

III

Several recent discussions in the economic literature have been concerned with the objectives of land reforms in underdeveloped countries in general and in Asia in particular. Some have suggested that very little increase in agricultural output can be expected in these areas unless major revisions in the ownership and tenancy pattern are first carried out. Included are usually such measures as forced acquisition of land by the government and reallocation of this land in size units which can be cultivated efficiently using modern agricultural implements[8]. Others have maintained that land-reform policies aiming at larger units of cultivation and the establishment of large cooperative farms using heavy equipment are undesirable on the basis that increases in output per acre are a much more important criterion in these countries than increases in the output per man hour[9]. All of these studies have used various aspects of Japanese agricultural development in recent years to support these conflicting claims.

In view of the differences in natural production conditions within the underdeveloped areas and even within individual countries such as India and Pakistan it may be impossible to devise a generally applicable land-reform policy for 'underdeveloped areas'. The Japanese land reform which made some significant changes in ownership pattern but left the small unit of cultivation largely undisturbed may have applicability in those parts of Asia, as for example East Pakistan, where natural production conditions are comparable to those existing in Japan. In semi-arid areas such as West Pakistan and large areas in the Middle East, where agriculture depends almost entirely on irrigation, the Japanese model may be much less relevant. The complicated technical problems of land and water management which have arisen in connection with irrigation of arid areas may dictate entirely different farm sizes and production techniques and, therefore, different land-reform policies than in countries where these problems are

[8]See for example: [7, Pp. 236-246; 12, Pp. 225-231].

[9]See in this connection: [8, Pp. 113-123].

not equally important. For example, it has become quite apparent in West Pakistan that the present governmental programme of reclaiming waterlogged and saline lands by lowering the ground watertable might have been partly unnecessary if the cultivators had had the private capital and the managerial skill to own and operate their own groundwater pumps. Private investment in these pumps, 20 to 30 years ago, could have checked the rise in the ground watertable and at the same time it would have helped overcome the shortage of surface water thereby contributing to higher production per cultivated acre. Similar arguments of technical interdependence apply with respect to the construction and maintenance of drainage facilities.

As regards land-management practices in irrigated areas there is growing evidence that much heavier equipment may be required for proper cultivation than in areas adequately supplied by rainfall.

If it is true that the range of substitutability of labour for capital in irrigated agriculture, as it is found in many areas of West Pakistan, is much narrower than is commonly assumed then it may be that in spite of low labour cost and widespread rural underemployment a capital-intensive technology for agriculture is indicated. The pattern of land tenancy prevailing in West Pakistan, as shown in this paper may be in many ways inconsistent with a more capital-intensive technology.

The failure of the Land Reforms Commission Report as well as the more recent Agricultural Commission Report to relate the problems of waterlogging and salinity to the institutional factors of size of holding, fragmentation and private capital rationing can be considered as one of their most serious shortcomings. In the future, more technical research is needed to ascertain what types of crop rotation and what types of mechanical equipment and irrigation facilities are needed to prevent a recurrence or further spread of waterlogging and salinity in the Indus Basin. After this technical information is in hand it will be possible to try to move towards a land tenancy and cultivation pattern which is consistent with these technical land and water-management requirements. Future agrarian-reform laws in West Pakistan must, therefore, relate the institutional and technical factors and focus more consciously on those reform measures which will contribute to a better management of the lands in the Indus Basin.

Summary and Conclusions

This paper has attempted to give a picture of ownership pattern as well as size and fragmentation of holdings in the former North West Frontier Province and to relate this information to some of the provisions of the West Pakistan Land Reforms Law of 1959.

It was shown that the number of landlords which will be affected by the ceilings on ownership (500 acres of irrigated or 1,000 acres of unirrigated land) is likely to be extremely small and only a correspondingly small number of presently landless agricultural labourers and tenants can, therefore, expect to become land owners in their own right. Our data give furthermore an indication of the approximate number of landlords that would be affected if the decision were made in future years to further limit the ceiling on individual ownership.

As regards cultivator's holdings we have shown that the majority of these holdings are already below the size of a 'subsistence holding' as defined by the Land Reforms Commission. The law restraining further subdivision and fragmentation of these holdings appears to be a very weak measure in view of the urgent need for upgrading the size of cultivator's holding to a level which will provide an adequate living to the cultivator and his family.

In the last section, we have attempted to show that there may be a need for relating future land-reform laws in West Pakistan to the waterlogging and salinity problem existing in the Indus Basin. To-date waterlogging and salinity have been considered only as a technical problem without any emphasis on the institutional factors which might be involved.

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