PREFACE

These essays report on research that was carried out over a period of several years. Essay 1 on the economics of "traditional" agriculture in the Punjab is based on research that was largely completed in 1966 and incorporated as part of the analysis of my Ph.D. thesis. Subsequently, in work done with Walter P. Falcon in the late 1960s, the model was further elaborated to incorporate coefficients simulating the new high-yielding varieties of wheat and rice. In 1970, the same basic framework was transformed into a multiperiod model by Muhammad Naseem, who used it to investigate the problems of small farmers, particularly with respect to their viability as borrowers of agricultural credit. The model was again revised in 1971 by Bashir Ahmed who used a linear programming approach in his study of the economics of mechanization. The research in Essay 5, in which various technology "packages" were forced to enter the model at integer values, was completed in 1974.

Several motives prompted the rather extensive revision and editing that were required to bring the essays together under one cover. First, despite the substantial changes that have occurred in input and output prices in the recent past, changes that invalidate some conclusions regarding comparative advantage, profitability and the like, the basic structure within which Punjabi farmers made their decisions about resource allocation has remained essentially the same. Thus, readers of these studies, be they academics or professionals working in government, will be led to deeper appreciation of the very complicated issues that irrigated farming systems in arid areas almost inevitably produce. Not only does the agro-climatic environment permit continuous cropping, but control over water permits a degree of flexibility in choosing among crops that produces a system highly sensitive to changes in various economic parameters. It is important for informed policy-making that this complexity be widely understood.

Second, by illustrating how a general equilibrium model at the enterprise level can be manipulated to provide a variety of policy insights, the studies can serve a useful pedagogical purpose. To those whose interests lead them to a direct involvement in the economics of irrigated farming systems, enough data and explanation have been presented to provide them with a running start on improving or adapting the work to their own area. (This is particularly important for students from developing countries whose access to those with programming experience may be

limited.) It is also to be hoped, however, that the essays will prove useful as background material when instructors in theoretical programming courses are searching for readings emphasizing the practical application of the technique.

Third, the essays illustrate the oft repeated but rarely followed dictum that sound research proceeds by alternating between analysis and data collection. With the exception of the last essay, each of the extensions of the basic model in Essay 1 was preceded by a field survey aimed at improving the data on which the previous study was based. Thanks are due the Ford Foundation for its wisdom in making field trips to Pakistan a part of graduate training grants, and the continuing interest of the Pakistan Agency for International Development (AID) Mission in fostering scholarly work on the economics of agriculture that made resources available for field work.

The use of such an iterative procedure to improve the data base has, however, produced certain complications with respect to the comparability of these essays. For example, the reader might well wonder whether the somewhat different results encountered in the various studies are a product of different specifications or simply the reflection of a different data base. Initially, it was hoped that all of the exercises could employ in their basic structure coefficients that reflected the same place and the same time. Unfortunately, the amount of additional work required was substantial and the plan was ultimately dropped. The matrix underlying Essays 2 and 5, as they now stand, is essentially the same. The parameters used in the tableau of the Basic Model (Essay 1) are similar, though not identical, with those used in the basic solution in Essay 2. The empirical estimates in Essay 4, obtained from the wheat-cotton area of the central Punjab, represent an intermediate stage between Essays 2 and 3.

In order to minimize duplication, the essays have been edited to remove a good deal of the redundancy that would have characterized a simple collection of the original studies. Thus only the first essay provides background on the agro-climatic environment of the Indus Basin and describes the constraints that make up the basic structure. This has, for the most part, permitted other authors to omit similar materials from their own studies and left them free to expand on the results and policy implications of the work they have done.

All of the essays give particular attention to the impact of alternative technologies on resource allocation. In Essay 1, for example, the economics of increasing the supply of irrigation water with a Persian wheel is investigated. The focus of the analysis is on the hypothesis derived from T. W. Shultz that investment in traditional agriculture has stagnated because of low rates of return. Results of the model bear out this conclusion in the Persian wheel case showing that its profitability is limited by the extent to which seasonally underutilized bullock labor exists.

The second essay examines the impact of the so-called Green Revolution technology on resource allocation. It is assumed that both additional irrigation water supplied by tubewells and the seed-fertilizer package are available to the farmer, and propositions about the shifts and shape of the normative supply response curves for various crops are derived. An attempt is also made to examine resource use when world market prices are used to value inputs and outputs. It is shown

that the allocation of resources under such conditions would be significantly different from those dictated by a profit maximizing response to domestic prices.

In the third essay, the matrix is expanded to include a duplicate set of crop activities in which tractor power is a required input. A variety of issues are then explored including the effect of mechanization on cropping patterns, cropping intensities, and employment. Also investigated is the question of the profitability of mechanization (as measured by the internal rate of return) under different assumptions about the availability of supplementary irrigation water and the price of tractors.

Essay 4 returns to the question of small farmers and investigates the relationship between land, technology, and policies involving the provision of capital (credit, interest rates, product prices) to the "minimum" holding size. It is shown that, except for the direct provision of capital in the form of credit, the model is relatively insensitive to other policy parameters. The effect of this finding is to undermine arguments that distorted product prices and subsidized inputs will contribute substantially to savings and hence to growth.

Essay 5 focuses on the distributive effects of technological indivisibilities. Using a mixed integer approach in which such items as tubewells, threshers, stationary engines, and tractors are forced to enter the optimal solution in discreet amounts, produces drastic implications for the net revenues per acre attainable at various farm sizes. Policy conclusions that flow from the essay underline the need to design profitable technology over a wide range of capacities, to consider how markets that facilitate the emergence of hire services might be promoted and to appreciate that artificially low interest rates and subsidized capital, while making "lumpy" technology available to the medium size farmer, further exacerbate the differences between him and the small operators.

Essay 6 summarizes the results presented in the previous essays and evaluates their implications for some major policy questions, notably those having to do with price and income policies, mechanization and intermediate technology, water, and management.

In all five studies, the usual, well-known limitations of the linear programming format (fixed coefficients, certainty, perfect demand elasticities, etc.) are in force. The use of a "representative farms" approach also has limitations from a policy point of view. These go beyond the questions of aggregate demand and supply effects to such issues as individual access to the common pool of groundwater that figures so prominently in the model solutions. However, in the inevitable compromises between model size, resources and available time, the authors have been guided by the belief that well-understood micro-analysis, work that deals intimately with the intricacies of the farming system, is of more use to decision-makers who formulate policy than models incorporating less detail but using aggregate regional or national parameters. It is, of course, a debatable proposition, one on which reasonable men do differ. In the final analysis, the judgment about the validity of the approach must be left to the reader.

With work that has stretched over such a long period, it is only natural that the list of an author's personal debts is lengthy. For three authors the list is even longer. However, Walter Falcon, the late Gerald Dean, and Lawrence Witt have

all, at one point or another, made unusual intellectual contributions. From a logistical point of view, special thanks go to a series of long-suffering AID Mission personnel charged with monitoring several successive research contracts on rural development in Pakistan. Most outstanding in this respect was Leon Hesser whose patience with academics was undoubtedly a source of distress to his superiors.

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