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AGRICULTURAL POLICY ANALYSIS PROJECT, PHASE II

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SOURCES OF CROP PRODUCTIVITY

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TABLE OF CONTENTS

LIST OF ACRONYMS iv
LIST OF FIGURES AND TABLES v
EXECUTIVE SUMMARY viii

1. INTRODUCTION 1
   1.1 Scope of the Study 1
   1.2 Purpose 2
   1.3 Organization of the Study 3

2. THEORETICAL CONTEXT OF THE STUDY 5
   2.1 A Theoretical Dichotomy in Explanatory Variables 5
   2.2 Examples of the Input Price School 6
   2.3 Examples of the Structural School 9
   2.4 Methodology of Study: An Exercise in Empirical Synthesis 11

3. MACRO ANALYSIS OF CROP PRODUCTIVITY CHANGES OVER TIME 12
   3.1 A Note on Area, Yield and Multiple Effects 12
   3.2 Changes at The Crop Level 13
      3.1.1 Data 13
      3.2.2 Wheat 13
      3.2.3 Rice 27
      3.2.4 Cotton 29
   3.3 Changes in High Yielding versus Low Yielding Varieties 30
      3.3.1 Introduction 30
      3.3.2 Wheat 31
      3.3.3 Rice 32
   3.4 Changes in Irrigated versus Non-irrigated Areas 36
   3.5 Changes in Favored versus Marginal Areas 39
   3.6 Summary of the Macro Analysis 42

4. MICRO-LEVEL CROSS SECTIONAL ANALYSIS
   OF THE DETERMINANTS OF CROP PRODUCTIVITY 43
   4.1 Introduction and Data Sources 43
   4.2 Structural and Input Determinants Using WAPDA 1988 Data 43
   4.3 Structural and Input Determinants Using WAPDA 1977 Data 57
   4.4 Input Determinants of Yields Using IIMI 1988 Data 67
   4.5 Main Findings 73

5. A MICRO ANALYSIS OF CHANGES IN THE CROSS SECTIONAL DETERMINANTS OF CROP PRODUCTIVITY OVER TIME 74
5.1 Hypotheses for Changes Over Time 74
5.2 Wheat 76
5.3 Cotton 76
5.4 Rice 85

6. MAJOR FINDINGS AND CONCLUSIONS 88
6.1 Introduction 88
6.2 Historical Analysis 88
6.3 Analysis for the Near Future 91
6.4 Important Issues Not Addressed by the Study 92

REFERENCES

APPENDIXES

Appendix A: Statistical Appendix
Appendix B: Summary of Data and Literature on Difference in Input Adoption and Output Indicators by Farm Size and Tenure
Appendix C: Data Sources

LIST OF ACRONYMS

HYVs	High Yield Varieties
IIMA	International Irrigation Management Institute
IRRI	International Rice Research Institute
LYVs	Low Yield Varieties
MAF	Million Acre Feet
MINFA	Ministry of Food and Agriculture
MIRR	Marginal Internal Rates of Return
NPC	Nominal Protection Coefficient
NWFP	North-West Frontier Province
PARC-CIMMYT	Pakistan Agriculture Research Council-Centro Internacional de Mejoramiento de Maiz y Trigo
RCS	Rural Credit Surveys
TFP	Total Factor Productivity
WAPDA	Water and Power Development Authority

LIST OF FIGURES AND TABLES

Page

FIGURES

Figure 1 The Yield Gap 8

Figure 2 Change in the Size Productivity Relationship Over Time 75

TABLES

Table 3.1 Wheat: Area and Yield Effects for Selected Periods and Trend Growth Rates 14

Table 3.2 Rice: Area and Yield Effects for Selected Periods and Trend Growth Rates 15

Table 3.3 Cotton: Area and Yield Effects for Selected Periods and Trend Growth Rates 16

Table 3.4 Nominal Wheat Prices in Pakistan 17

Table 3.5 Agricultures's Domestic Border Price Ratio 18

Table 3.6 Agriculture's Domestic Terms of Trade 19

Table 3.7 Crop Profitability Indices 20

Table 3.8 Agricultural Subsidy as a Percent of Domestic Value of Marketed Crop 21

Table 3.9 Area Irrigation and Water Availability 22

Table 3.10 Annual Fertilizer Offtake in Pakistan 23

Table 3.11 Use of Pesticides on Crops 24

Table 3.12 HYV Wheat: Area and Yield Effects for Selected Periods and Trend Growth Rates 33

Table 3.13 Non-HYV Wheat: Area and Yield Effects for Selected Periods and Trend Growth Rates 34

Table 3.14 HYV Rice: Area and Yield Effects for Selected Periods and Trend Growth Rates 35

Table 3.15 Non-HYV Rice: Area and Yield Effects for Selected Periods and Trend Growth Rates 35

Table 3.16 Irrigated Wheat: Area and Yield Effects for Selected Periods and Trend Growth Rates 37

Table 3.17 Unirrigated Wheat: Area and Yield Effects for Selected Periods and Trend Growth Rates 38

Table 3.18 Favored Wheat: Area & Yield Effects for Selected Periods 40

Table 3.19 Marginal Wheat: Area & Yield Effects for Selected Periods 41

Table 4.1 Crop Yields (Tons/Ha) 45

Table 4.2 Determination of Yield 47

Table 4.3 The Structural and Input Determinants of Yields 49

Table 4.4 Correlation Matrix for Wheat 50

Table 4.5 Correlation Matrix for Cotton 51

Table 4.6 Correlation Matrix for Coarse Rice 52

Table 4.7 Correlation Matrix for Fine Rice 53

Table 4.8 Correlation Matrix for Education and Commercial Inputs 56

Table 4.9 Mean Yields by Structural Categories 58

Table 4.10 Mean Yields by Inputs 59

Table 4.11 Determination of Yields by Structural and Input Variables 60

Table 4.12 Correlation Matrix (Wheat) 62

Table 4.13 Correlation Matrix (Cotton) 63

Table 4.14 Correlation Matrix (Rice) 64

Table 4.15 Total Fertilizer vs Area Productivity 68

Table 4.16 Multiple Regression on Wheat Yields 70

Table 4.17 Regression of Inputs on Wheat Yields 71

Table 5.1 Mean Yields for Wheat 77

Table 5.2 Mean Yields for Cotton 79

Table 5.3 Mean Yields for Rice 81

Table 5.4 Mean Yields for Rice HYV 83

EXECUTIVE SUMMARY

This study sets out to examine the sources of crop productivity (yield per hectare) in Pakistan, focusing on the three most important crops, namely, wheat, rice and cotton. It analyses aggregate time series data (1947 to 1990), as well as cross-sectional household data from large and small samples; desegregates the time trends into discrete epochs and the national trends into provincial ones; decomposes output changes into area, yield and multiple effects; and reviews crop-specific research reports as well as those that look more broadly at farming systems and the agriculture sector as a whole. At a heuristic level, the study systematically relates changes in crop acreage and yields to changes in profitability, policy, irrigation and technological change.

The following conclusions emerge from combining the results of aggregate, time-series and farm-level, cross-sectional analyses: (i) periods of high output growth for wheat and rice appear to be dominated by yield rather than area effects; for cotton (1960 to 1980), however, the area effect appears to have been a more important source of major production increases; (ii) there is considerable variation in the relative importance of the various sources of productivity over time, across cropping systems and between crops; (iii) however, price policy effects, input market de-regulation (especially for agro-chemicals), technological change (and the research that generates it) and water availability have had powerful and enduring influence on all crops over time; extension is not seen to have had a positive impact; and the impact of water management and soil quality on productivity has not been adequately researched at the farm level; (iv) there is reason to believe that the up-take of available technology in Pakistan has been slow, and that, in particular, small farmers have been slower than others in adopting new technology, though the difference between large and small farmers has tended to disappear over time with the development of markets and the spread of relevant knowledge; and, (v) only in the case of wheat (by virtue of the PARC-CIMMYT program) do recent field-level data exist that integrate agronomic and economic variables in analyzing the constraints on productivity, but these studies do not incorporate irrigation variables.

The historical analysis shows that the constraints on agricultural productivity do not necessarily vary in their importance in a systematic manner over time and across regions and crops. Only a synthesis of the most recent analyses for each crop may be useful for policy making on the present and near future. This can be attempted only for wheat, for which some recent analyses of agronomic and economic factors are available. For cotton and rice, only qualified statements can be made, based largely on discussions with experts. In this way, a small number of crop-specific productivity constraints for the 1990s are identified. Beyond this, however, there is a great deal of persuasion in the argument that yield increases in the future will have to come largely from improvements in better crop management such as weed control, balanced fertilizer use and improved on-farm water management.

Price policy must be counted as a primary pre-requisite for motivating farmers to undertake such improvements. In this connection, it is noted that existing price policy is

unfavorable (in terms of effective protection) towards cotton and basmati rice, as well as wheat and IRRI rice. Inefficient input markets (for seed and fertilizer) are other areas for policy reform, to which should be added the existing system of institutional credit which restricts available credit systematically in favor of a small number of influential farmers.

In addition to efficient markets and pricing, a major need for the 1990s is to pay greater attention to research on crop management and resource management. Crop management issues have been mentioned above, while resource management research is suggested by recent analyses showing the possible negative influences on yield of deteriorating soil quality.

The policy agenda for the 1990s, however, is only partly indicated by the preceding discussion. It can be better established if what this study has not addressed is stated explicitly. That is: assuming for the time being that near-term priorities can be established at a desegregated level for specific crops, resources and support systems, the paucity of public funds that is expected to persist during the 1990s would seriously constrain the effort that is needed. Moreover, as long as public funds are meager, the services provided by the systems they support will tend to be rationed in favor of large and influential farmers, and remain inaccessible to the large majority of the farming community, with the result that the uptake of available technology will continue to be slow.

These observations suggest that over the medium and long run, it is the sectoral rather than crop-specific constraints that inhibit sustained improvements in agricultural productivity. Over the longer period, the issue can be approached through policies and mechanisms that emphasize the financial sustainability of agriculture and resource transfers for investing in the systems that support it. The required framework is one that would make it worthwhile for farmers themselves to invest in the sources of productivity improvement. More specifically, it would seek to develop: (i) a more profitable agriculture that will generate and contribute the resources required to operate and maintain agricultural support systems in the private and public sectors; (ii) decentralized public institutions that are responsive to local needs and variations, and markets in which the buyers and sellers compete aggressively to respond to the farmer's demand for improvement; and, (iii) resource transfer mechanisms (including taxation for investing in public works and local organizations) within the agricultural/agro-based sector that can enable the large majority of farmers to access agricultural support services.

1. INTRODUCTION

1.1 Scope of the Study

This study attempts to establish some determinants of crop productivity in Pakistan. Three crops have been chosen for analysis, wheat, rice, and cotton. Different varieties of crops, like High Yielding Varieties (HYVs), and Low Yielding Varieties (LYVs), frequently behave differently. This makes them different crops, and increases the number of crops analyzed, often to six.

Regionally, the study begins by covering the entire country. So the macro analysis is based on the aggregate agrarian sector, which is then decomposed into the four provinces. For the micro analysis sample surveys are used. These are more regionally biased in their sampling. So the province of Balochistan is excluded. And some provinces like the Punjab, are better covered, than other provinces like Sind and NWFP.

Conceptually this study has an empirical base. We note that the literature on productivity and production behavior is split into two schools. There is an input school which explains production behavior primarily through the use of inputs. These input levels are causally determined through price and policy regimes. Then there is a structuralist school which explains production behavior primarily through supply rigidities. These input levels are causally determined through market imperfections. The schools do not deny the other's validity, but largely do not use the other's explanatory variables. The literature on Pakistan is replete with the input school.

This study does not attempt to correct the paradigmatic bias in Pakistan. That needs much more theoretical re-conceptualization, as for example indicated in section 2 here, and calls for a separate study. What the study does attempt to do, is to take both sets of explanations as given by the literature, without attempting to conceptually modify them. The given sets of explanations are tested empirically for validity. The aim is simply to establish which variables explain productivity better. If the set of variables is a mixed bag from both schools, this approach will be proved useful.

Conceptually this study is divided into four stages of analysis. At the theoretical level, producers' behavior is posited to result from the entire given production environment. This is determined both by prices, and market imperfections. This environment and its resulting production behavior can be established in three logical stages.

In the first stage, the macro environment and production behavior needs to be established. So there is a need to estimate change in productivity at a macro level. These macro changes in productivity can then be explained by changes in the macro environment. This macro environment is largely given by price and state policy changes.

In the second stage, the micro environment and production behavior needs to be established. Micro analysis gives us a chance to establish diversity in the micro environments

faced by producers. So there is a need to estimate cross sectional differentials in productivity at the micro level. These cross sectional differentials in productivity can then be explained by cross sectional differentials in the environment, both price and structure driven.

In the third stage, change in the micro environment and production behavior needs to be established. We have to see how the micro environments and resultant production behavior have changed over time given macro policy changes. So there is a need to estimate change over time in these cross sectional differentials in productivity. This time change in cross sectional productivity differentials can then be explained both by cross sectional environment differentials, and their change over time with macro policy.

Three data bases have been used for statistical analysis. The macro time series estimates are based on the Ministry of Food and Agriculture (MINFA) series. The micro cross sectional estimates are based on the Water and Power Development Authority's (WAPDA) sample surveys for 1977 and 1988, and the International Irrigation Management Institute's (IIMI) sample survey from 1988. The time change in micro cross sectional estimates are based on a comparison of WAPDA's 1977 and 1988 surveys.

1.2 Purpose

There are at least four major reasons for establishing the determinants of crop productivity in Pakistan. The first relates to perceptions of inefficiency and the second to demographic pressures. The third is the question of economic sustainability. And the fourth, found less in the price input literature, and more in the structural literature, is agrarian employment issues.

Inefficiency is the primary rationale for better establishing the determinants of crop productivity. Inefficiency implies that for a given technology, Pakistan's crop yields are below the production frontier. The difference between the frontier yield, and the actual yield, gives a yield gap. So apart from any other economic and social compulsions, the yield gap is unnecessary, and inefficient.

Cownie, Johnston and Duff's (1970) projections allow an estimation of this yield gap over time. Cownie et al. projected the gains from the new HYV technology in 1970, into the future. Against these projections, Byerlee and Siddiq (1990) have estimated realized gains to give a yield gap. Cownie et al. (1970) had projected complete proliferation of HYVs of wheat by 1979, 90% of which was realized. They projected fertilizer levels of 125 kg/ha of nutrients by 1985. The levels realized were 100 kg/ha. Given these input levels, they projected a wheat yield of 3.9 metric tons/ha. However, despite approximate realization of input levels, the realized yield was 1.9 t/ha. So there is a yield gap of 2 t/ha for the HYV technology.

The determinants of yields are known at a general level to be a set of inputs, to be used at specific times, through specific practices. These determinants give the production frontier. What is needed are better estimates of the determinants of actual yields. If some inputs and

combinations, have a stronger relationship with yields, then investment policy can focus on these sets of inputs. The literature on Pakistan, as the following section 2 shows, is heavily biased towards a school of thought that emphasizes prices determining input levels. This ignores other causal explanations of input levels, whose validity needs to be better investigated for Pakistan. So there is a need for a relatively less biased estimation of the determinants of productivity in Pakistan.

The second motivation for establishing the determinants of productivity is demographic pressure. Population growth rates in Pakistan have exceed 3% over the last decade. Growth rates in staple food output depend on area and yield increases. Area increases cannot be projected to match population increases indefinitely into the future because of relatively fixed area. Then the brunt of population pressure must fall on yield increases.

There are various estimates of yield increases. We estimate below, wheat yield growth rates have been 2.1% in the second half of the 1980s. This is 1% below the population growth rate. So there is a nutritional need to better establish the determinants of productivity.

The third reason for establishing the determinants of productivity in Pakistan is one of sustainability of existing agrarian growth patterns. The economy's single largest export is cotton and its products. The rate of growth of the volume of cotton exports has been high in the last half decade. However, international cotton prices have lowered the rate of growth of the value of cotton exports. This has led to an external current balance deficit of over $2 billion by the end of the decade.

The economic squeeze necessitates an increase in cash crop production. The nutrition squeeze necessitates an increase in food crop production. Both cannot be based on area expansion because of relatively fixed area, and partial time encroachments on each other. Therefore the economic squeeze also necessitates an increase in yields.

The fourth factor that requires attention to the determinants of productivity is the pressure of agrarian unemployment. An increase in yield will generate some employment, depending upon the employment elasticity of the technology used. At the same time, the pattern of agrarian growth over the last two decades has somewhat increased the concentration of the distribution of operated area. Reduction of sharecropped area shows this to be due to eviction of share tenants. This has increased the proportion and the numbers of the rural landless labor force (Mahmood, 1991).

1.3 Organization of the Study

The four conceptual stages of the study are the following.

The theoretical section 2 looks at the determinants of productivity posited by the literature. The dichotomy between the prices and structural schools is resolved through the positing of a production environment. This production environment is contributed to by both sets

of factors, prices and structure. The relative importance of these factors then has to be tested, by observing how well they explain differentials in yields.

The macro section 3 of the study estimates aggregate yields over time. The macro environment given by price and policy changes is then used to explain these yield changes. The aggregate estimates are decomposed regionally into provinces, HYV and non HYV areas, irrigated and non-irrigated areas, and favored and marginal zones, as the data permit.

The micro section 4 of the study estimates cross sectional differentials in yields. Differentials in the producers' micro environment are used to explain these cross sectional differentials in yields. Cross sectional differentials in yields are separately established for structural determinants, and input determinants.

The micro section 5 of the study estimates change over time in cross sectional differentials in yields. Both micro cross sectional differentials, and macro time differentials are used to explain these time changes in cross sectional differentials.

The concluding section attempts a synthesis of available evidence regarding the relative importance of the large number of determinants of productivity. It identifies the limitations of the study (including the weaknesses of the procedures used and the data constraints), and suggests some directions for further research.

2. THEORETICAL CONTEXT OF THE STUDY

2.1 A Theoretical Dichotomy in Explanatory Variables

The literature on the determinants of crop productivity in Pakistan is very diverse. Yields are reportedly constrained by biological factors (Bhatti et al. 1986); agricultural practices (Byerlee, 1990); overlapping crop timing trade offs (Sharif et al., 1988); and more complex interactions between a region's cropping systems (Byerlee and Husain, 1991). There is also said to be a persistent insufficiency of inputs (Salam, 1981). Inputs may even be sufficient, but may have a low efficiency of output, like fertilizer (Byerlee and Siddiq, 1990). Yields may be constrained by micro level producer's economic inefficiencies (Husain et al., 1990). Or they may be constrained by macro price regimes (Chaudhry and Kayani, 1991). Finally, the constraint on productivity may not be material capital, but human capital, under-investment in research and its extension to the farm (Azam and Evenson, 1990).

This is a representative list of the main discourse in the yield literature in Pakistan. This set of literature is united by a common causality. It finds that crop yields are constrained in Pakistan by the lack of a set of inputs. This set of inputs is material, like fertilizer, or water, or HYV seeds. The set also contains human capital, like research to match material inputs to local environments, and appropriate practices, dissemination of this research to the producer, and the producer's acquisition of this knowledge.

This set of material and human capital inputs is said to be constrained primarily by the macro causal mechanisms of prices and state policy. Given appropriate prices, and dissemination of knowledge of inputs and procedures, profitability will lead to increased use of this set of inputs. Yields will increase. The literature obviously grants that the micro environments of producers may be regionally diverse. But the macro causal mechanisms of price and state policy can affect the micro environments, leading to increased inputs and yields. This set of literature can be conveniently called the input price school.

Compared to this vast set of literature of the price school in Pakistan, there is another much smaller, but distinct set of literature. This literature may not be so prolific in Pakistan, but it is much larger for South Asia and for developing agriculture in general. This literature ranges over at least five debates, and its salient points are summarized as follows:

Crop productivity is constrained by the use of labor inputs per hectare which are much lower in South Asia compared to East Asia (Ishikawa, 1981). Crop yields have been found to be higher on smaller farms, than on larger farms, again based on labor use per ha. But this relationship may be changing with the increased impact of material inputs (Mahmood, 1981). Sharecropping contracts are seen to inhibit the use of inputs, because of Marshallian inefficiencies (Binswanger and Rosenzweig, 1984). Interlinked markets in land, labor, and capital, typical in South Asia, can create disincentives for the adoption of innovations, because these untie labor (Bhaduri, 1973). Finally, input use and even price, typically for labor, is often

the result of the relative bargaining power of buyers and sellers through a series of Nash-like games (Mahmood, 1991).

What this set of literature has in common is its emphasis on an alternative causal mechanism to the input price literature. Both sets of literature agree on the conception of inputs as material and human capital. Where they disagree is on the prioritization of the constraints on this set of inputs. The price school prioritizes the macro price cum policy environment as the major constraint on producers' input use.

The second set of literature prioritizes the micro (structural) environment of the producer as the major constraint on his input use. This literature argues that the micro environment of the producer is characterized by a host of market imperfections created by the prevalent agrarian structure. This micro environment is often impervious to macro price and state policy decisions, and in any case mediates their impact on the producer. Then this micro environment is the more immediate determinant of producers' decision making behavior, rather than the macro price policy environment. The only macro price cum state policy which would affect the micro environment significantly, would be policy which would affect the agrarian structure that creates these market imperfections. This second set of literature can be conveniently called the structural school.

Both the price and structure schools have an a priori validity to production conditions in Pakistan. Representatives of the two schools need to be examined to establish a conceptual methodology for this study.

2.2 Examples of the Input Price School

The input price school as seen is not only large, but diverse in the specification of determinants of yields. Four studies provide a fairly comprehensive survey of the diversity of the determinants of yields. Husain et al.'s (1990) yield gap analysis provides a conceptual approach to constraints on yields. Byerlee and Siddiq (1990) embody the macro price and policy determinants of yields. Azam and Evenson (1990) are distinctive because they emphasize the human capital element of research in productivity. Byerlee and Husain (1991) isolate important determinants of yields in marginal (rainfed) areas.

Husain et al. (1990) use the conceptual device of a yield gap, and decompose it. Diagram 1 has. yields on its vertical axis, and inputs on its horizontal axis. This gives a production frontier f(x) and a tangential cost curve. The maximal yield at Y_m t/ha is not profit maximizing. The maximal yield which is profit maximizing is Y_e. Assume that the average producer lies within the production frontier at a yield Y_a. Then the total yield gap is given by $(Y_e - Y_a)$.

The yield gap of $(Y_e - Y_a)$ is due to two sorts of inefficiencies. The producer is within the production frontier because of technical inefficiencies. The same level of inputs X_a should lead him to the frontier yield of Y_t. So one component of the yield gap is $(Y_t - Y_a)$.

The second component of the yield gap is $(Y_e - Y_t)$. This component of the yield gap is due to non profit maximizing behavior leading to lower input use. Husain et al. ascribe this non-profit maximizing behavior to producer's risk and uncertainty. So this second component is due to economic inefficiency.

Husain et al. decompose the yield gap into technical inefficiency, economic inefficiency, and a third possible physical constraint imposed by the environment. Technical inefficiency is due to human capital constraints, from research to farmers acquisition of knowledge. Economic inefficiency is due to price and state policies, plus risk aversion. And environmental constraints are geophysical constraints imposed by the locale.

Husain et al. estimate an average wheat yield gap of 1 t/ha for Pakistan. The inputs explaining this gap are specified as wheat varieties, appropriate seed, nitrogen and late wheat planting after cash crops like cotton and rice.

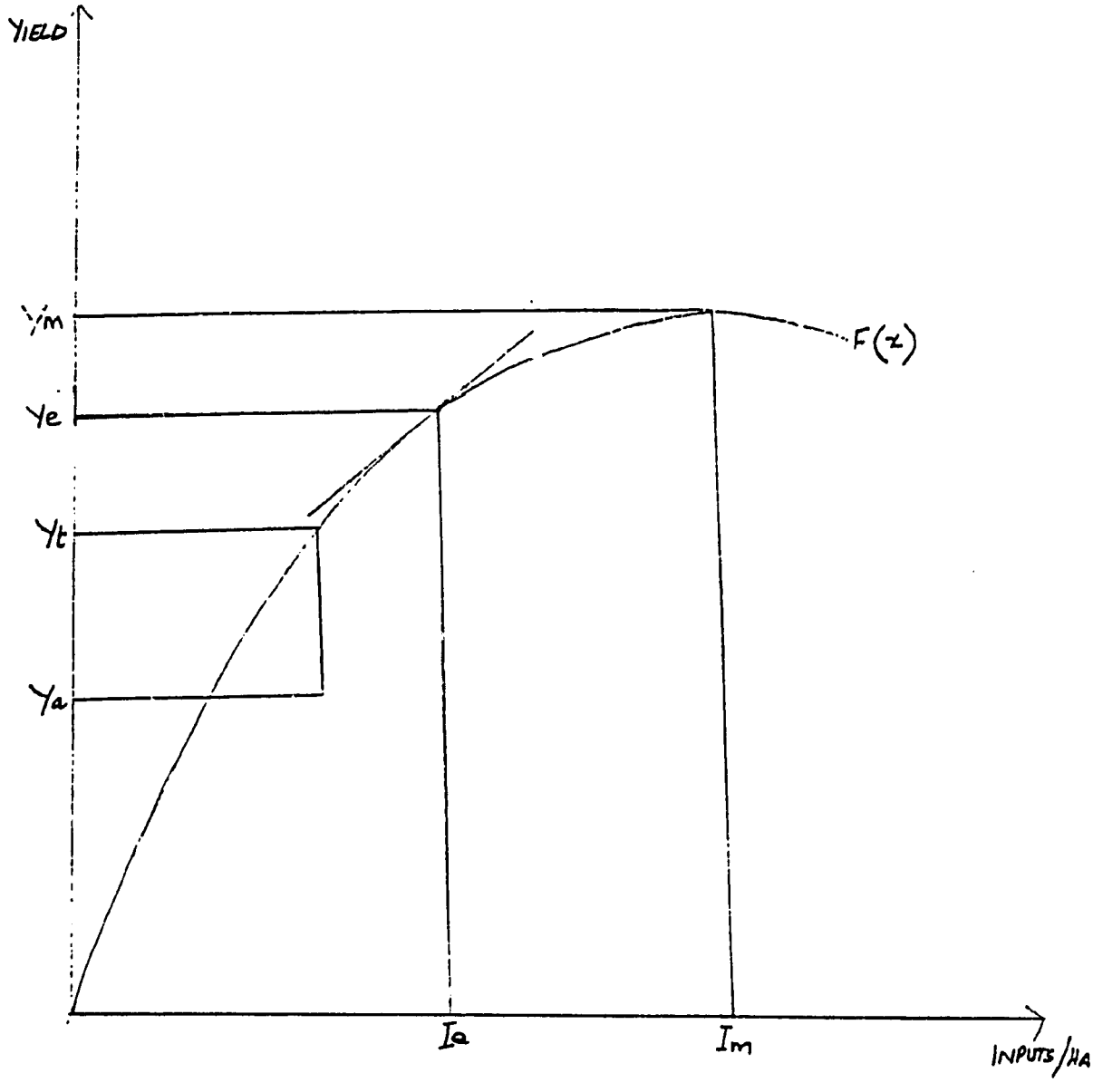
Byerlee and Siddiq (1990) conduct a macro and micro analysis of wheat yields. At the macro level they find wheat yields growing at a high rate of 4.6% between the mid-1960s and the mid-1970s. Subsequently wheat yield growth rates drop down below 2%. The high growth between the mid-1960s and the mid-1970s is largely explained by HYV adoption, and the large increase in irrigation endowments. The subsequent decline in the growth of yields is then due to the fact that conversion of irrigated areas to HYVs is almost complete, and irrigation growth slows down.

At the micro level Byerlee and Siddiq specify four constraints on yields: (i) previous crops delay wheat planting into December and decrease its yield; (ii) approximately half the subsoil water has very high sodicity levels; (iii) fertilizer efficiency is low, because of doses inappropriate to local conditions; and, (iv) weeds and pests constrain yields.

Azam and Evenson (1990) highlight human capital as a determinant of crop productivity. They estimate Marginal Internal Rates of Return (MIRR), to research in crops productivity. To do this they calculate the Total Factor Productivity (TFP) for a set of farms over time. This TFP is divided into two parts. One part is based on relating output to inputs without technical change over time. The residual second part is ascribed to technical change. These TFPs are then correlated to the flow of technology and infrastructure. The research variable used is the cumulated change in research investment.

FIGURE 1

The Yield Gap



Azam and Evenson find very high MIRRs to research in agriculture. They estimate that wheat research has an MIRR of 76%, rice 84-89%, cotton 102%, and all crops 57-65%. Given these high MIRRs, they feel that one of the primary constraints on productivity is under-investment in research in Pakistan.

Byerlee and Husain (1991) suggest three important constraints on productivity in marginal areas. One, the regional diversity of marginal areas implies that producers here need a basket of technologies to be able chose from, to suit their local needs. The one-package technology will frequently be inappropriate. Two, cropping systems interact with livestock systems far more in the marginal areas. So there is a greater need for research on the impact of these interactions. For example, the issues of crop residues and fodder trade offs between HYVs and LYVs may not be as important in favored areas as in marginal areas.

Three, there is still considerable room for input intensification in marginal areas, compared to favored areas. Irrigation, fertilizer and deep tillage are primary examples.

2.3 Examples of the Structural School

The input price school neatly categorizes constraints on yields as technically imposed, economically imposed, and environmentally imposed. Technical constraints are largely caused by lack of knowledge. Economic constraints are largely caused by prices, state policies and risk aversion. Environmental constraints are largely geophysically imposed. Theoretically these constraints can be eased through macro policies of pricing, and state provision of infrastructure, research, and its dissemination.

The structural school agrees that there are knowledge constraints, and price, infrastructural, and risk constraints. However, their removal through a macro policy will not be a sufficient condition for increasing yields. This is because there are constraints at the micro level which may not be amenable to macro price, infrastructure and research policy.

The structural school posits that a producer's behavior is based on his immediate production environment. This micro environment is contributed to by macro price, infrastructure, research, and extension policy. However, it is also contributed to by the immediate agrarian structure. The agrarian structure comprises more importantly of the distribution of owned and operated area, the distribution of other productive assets, the level of development of irrigation endowments, and the proximity of the non farm sector. This agrarian structure generates a set of market imperfections for the more critical factors like land, labor, material capital and human capital (Mahmood, 1989).

In Pakistan, the concentration of owned and operated area, and the large proportion of tenanted area has strong implications for producer's decision making behavior.

The concentration of owned and operated area implies that large farmers have two advantages over small farmers in input decision making. Large farmers have access to internal

resources, and they have access to credit, far more than smaller farmers (Ahmad and Amjad, 1986). Small farmers with insufficient land to employ family labor, and a lack of employment in the wage market, on the other hand are endowed with cheap family labor. Therefore both sets of farmers will tend to use more of the resource with which they are better endowed (Sen, 1966). Large farmers will use more material inputs per ha, and small farmers will use more family labor per ha. Small farmers will tend to do better than large farmers on labor intensive crops and processes. Large farmers will tend to do better than small farmers on material input intensive crops. As mechanization proliferates, and material input intensive crops and varieties increase, small farmers become more handicapped.

This has two implications for the input price school. In terms of Figure 1, Husain et al. (1990) attribute producers lying within the production frontier to technical inefficiency and lack of knowledge. However small producers faced with lumpy inputs may not be able to use optimal input combinations to reach the frontier. Then a macro policy of research and extension will be insufficient to increase small producers material inputs and yields.

Second, Husain et al. attribute producer's non profit maximizing low input levels to risk and uncertainty. The structural school argues that risk and uncertainty are inversely correlated to farm size. Therefore macro price and infrastructure policies will not increase small producer's material input use and yields.

These micro constraints on producers' decision making call into question not only the role of research as a sufficient condition, but the very estimate that Azam and Evenson (1990) have made. Azam and Evenson use the critical variable of cumulated change in research investment. This variable is still two stages removed from impact on production. The first stage is extension of this research to the farm. Most studies show the extension program to be very weak. Byerlee and Husain (1991) have a recent estimate that only 20% of extension work gets to the farm level. The second stage before impact is the ability to use this information. This is questioned under certain conditions for small producers. Then all Azam and Evenson have is a correlation between investment in research, and productivity. To what extent research is the causal factor has to be questioned further.

The concentration of operated area and the large proportion of share tenanted area in Pakistan has another important implication for producer's decision making. Sharecroppers face Marshallian disincentives against high use of inputs. Landlords attempting to increase inputs face the moral hazard of the tenant not applying the input. Alternatively, the landlord's monitoring and supervision of the tenant's costs increase (Sen, 1981).

The outcome of the landlord attempting to increase inputs is resolved in the literature through the device of bargaining power. Landlords able to enforce more stringent contracts will be able to increase inputs and yields. These landlords will tend to be monopsonist in regions with higher concentration of land distributions. Landlords unable to enforce contracts will be unable to increase inputs and yields. These landlords will tend to be price takers, from regions with more even land distributions.

Then, for the purpose of this study, the structural school posits four variables as important determinants of productivity. Operated area will affect production decisions. The use of family and hired labor will affect yields. And land tenure will also affect production decisions.

2.4 Methodology of Study: An Exercise in Empirical Synthesis

At an a priori level, both the input price school and the structural school offer logical explanations of productivity. What is more important, they complement each other well. What is needed then is a theoretical exercise which builds a hybrid model using macro and micro determinants to explain production behavior. Such a model would have to proceed one commodity at a time. It would have to specify for each commodity crop, the macro and micro environments. At the micro level it would need to categorize all the relevant market imperfections. Then the implications of the imperfections for each major factor's use would have to be worked out. This would allow the determination of inputs and output for the commodity.

On the input side factor use would be constrained not by market returns alone, but market returns plus transaction plus bargaining costs. On the output side factor returns would be constrained not by marginal productivity conditions but bargaining power shares.

Such a theoretical exercise would set another research agenda. This study aims at a more modest empirical synthesis of the two schools. We will assume here that a producer's behavior depends on his immediate micro production environment. This production environment is contributed to by both macro and micro conditions. Macro policies like price, infrastructure, research, and dissemination affect the micro production environment. The immediate agrarian structure generates market imperfections which also contribute to the micro production environment.

Given these assumptions, the price and structural schools offer a set of variables which explain productivity. The price school offers human and material capital, and geophysical constraints on productivity. The structural school offers farm size, tenure, family labor and hired labor as determinants of productivity. These variables can be tested with appropriate data.

This empirical testing proceeds in three stages. Yields are observed at the macro level. Changes in these yields over time are then explained through changes in macro policy variables like price, infrastructure, and research and dissemination. Then yields are observed at the micro level. To capture as much variation in the micro environment as possible, micro yields are first observed cross sectionally. Differentials in these micro level yields are then explained through differentials in the micro environment, like input use, technical knowledge, and geophysical constraints. Finally micro level yields are observed to change over time. Cross sectional differentials are also observed to change over time. Change in cross sectional differentials is then explained through differentials in the micro environment and macro policy changes.

3. MACRO ANALYSIS OF CROP PRODUCTIVITY CHANGES OVER TIME

3.1 A Note on Area, Yield and Multiple Effects

This section looks at change in crop yields over time, using aggregate data for Pakistan, and its four provinces. The three crops wheat, cotton, and rice are first examined without intra crop variation in section 3.2. In section 3.3, the data permits wheat and rice to be desegregated into HYVs and LYVs. In section 3.4, the data permits wheat to be desegregated into irrigated and non-irrigated regions. Finally in section 3.5, the data permits wheat to be desegregated into favored and marginal zones.

The macro analysis of change in yields over time uses both exponential growth rates, and decomposition of output into area, yield, and multiple effects.

Decomposition is a very useful analytical device, because it shows the relative contributions of area and yield to output. So first, it allows yields and change in yields to be isolated in growth. Second, decomposition is useful in explaining change over time, because change in the components of area and yield can be linked to specific macro policies. Area changes can be explained by price incentives for producers. Area changes are permitted by irrigation changes. Yield changes are explained by the introduction of new technology. Yield changes are also permitted largely by irrigation changes.

Given this usefulness of decomposition analysis, it has been used to explain change at the macro level. We have however used our own method for the decomposition of output into area and yield effects.

Output = Q Area = A Yield = Y

At time t: $Q_t = A_t \times Y_t$

Analytically, total increase in output is not exhausted by just two effects, an area effect, and a yield effect. Between periods t_0 and t_1, there is an area change, a yield change on the old area, and a yield change on the new area. So analytically, change in output is exhausted by three effects, an area effect, a yield effect, and a multiple effect which is the new yield on new area. This gives us the following formulation:

If in t_0: $Q_0 = A_0 \times Y_0$

and in t_1: $Q_1 = A_1 \times Y_1$

Then the change of $Q_1 - Q_0 =$

Area Effect $= [A_1 - A_0] Y_0$

$+$ Yield Effect $= A_0 [Y_1 - Y_0]$

$+$ Multiple Effect $= [A_1 - A_0] [Y_1 - Y_0]$.

3.2 Changes at The Crop Level

3.2.1 Data

MINFA data has been used to estimate a time series for output, area, and yield, from 1947/48 to 1988/89. Tables A-1.1, A-1.2 and A-1.3 in the Appendix present this series for wheat, rice, and cotton respectively. This time series has been broken up into periods distinguished by change in output, area, or yield. These periods have been decomposed into area, yield and multiple effects. Table 3.1 presents the area, yield and multiple effects, and the exponential growth rates for each period for wheat. Table 3.2 and 3.3 present these effects and growth rates for rice and cotton respectively.

3.2.2 Wheat

Table 3.1 divides wheat growth from 1947/48 to 1988/89 into 5 distinct periods. Looking first at the exponential growth rates, the first period from 1947 to 1954 is characterized by a negative growth of output. The Appendix Table A-1.1 shows that wheat output dropped below its pre independence level of 3.3 million tons in 1954/55. The decomposition in Table 3.1 shows that this negative growth in output was due entirely to a drop in yields. Wheat area actually increased over this period but the negative yield effect was greater than the area effect. Table A-1.1 shows that wheat yields dropped from pre-independence levels of 0.84 t/ha to 0.74 t/ha.

In terms of regional disaggregation, Table 3.1 shows that the negative yield effect was largely due to the Punjab and the NWFP. Yields in Sind and Balochistan (whose coverage in MINFA data is limited to the small riverain and irrigated tracts) in fact rose from their low pre independence levels. However the Punjab's share in the total wheat area which has remained largely above 70%, dragged the total yield down.

The marginal increase in area and the decline in yields is explained through Tables 3.4-3.11. These tables reflect macro state policy for the various crops over time. Tables 3.4-3.8 give the price regimes. Table 3.4 gives the state procurement prices. Table 3.5 gives the ratio of these prices to border prices, that is the Nominal Protection Coefficient (NPC). Table 3.7 gives an estimate of crop profitability. Table 3.8 gives some estimates of crop subsidy equivalents. Table 3.9 gives water availability. Table 3.10 gives fertilizer offtake. And Table 3.11 gives pesticide use. However as can be seen, data for most of these series is incomplete and some series begin in the 1960s or 1970s.

TABLE 3.1

AREA AND YIELD EFFECTS FOR SELECTED PERIODS (Indices)*

WHEAT

Year	PAKISTAN area	PAKISTAN yield	PAKISTAN multiple	NWFP area	NWFP yield	NWFP multiple	PUNJAB area	PUNJAB yield	PUNJAB multiple	SINDH area	SINDH yield	SINDH multiple	BALOCHISTAN area	BALOCHISTAN yield	BALOCHISTAN multiple
1947/48 TO 1954/55	155.6	-237.2	-18.4	-4.4	-96.8	1.1	302.6	-359.4	-43.2	-550.0	700.6	-50.6	13.5	84.2	2.3
1954/55 TO 1960/61	45.0	50.6	4.5	27.3	64.3	8.4	24.6	72.5	2.9	115.8	-11.8	-4.0			
1960/61 TO 1966/67	111.4	-9.9	-1.5	446.5	-431.3	-115.2	94.1	5.1	0.7	94.1	5.4	0.5	35.9	52.8	11.2
1966/67 TO 1975/76	13.7	75.7	10.6	16.4	68.6	15.0	15.6	73.4	11.0	6.7	85.9	7.4	-25.6	148.5	-22.9
1975/76 TO 1988/89	40.0	47.3	12.7	28.4	62.4	9.2	42.5	45.8	11.7	35.1	49.5	15.4	38.2	29.3	32.5

* Indices sum to 100 for each period

TREND GROWTH RATES (% per annum)

WHEAT

Year	PAKISTAN area	PAKISTAN product	PAKISTAN yield	NWFP area	NWFP product	NWFP yield	PUNJAB area	PUNJAB product	PUNJAB yield	SINDH area	SINDH product	SINDH yield	BALOCHISTAN area	BALOCHISTAN product	BALOCHISTAN yield
1947/48 TO 1954/55	1.1	-0.7	-1.8	-0.2	-4.5	-4.4	1.6	-0.6	-2.2	-1.1	0.2	1.3	0.4	2.6	2.2
1954/55 TO 1960/61	1.4	3.0	1.6	2.0	6.5	4.4	0.7	2.5	1.9	4.9	4.3	-0.6	3.3	0.0	-3.3
1960/61 TO 1966/67	2.4	2.1	-0.2	3.9	-1.0	-5.0	2.3	2.4	0.1	1.5	1.6	0.1	3.2	7.8	4.5
1966/67 TO 1975/76	1.5	7.8	6.4	2.2	9.4	7.2	1.6	7.5	5.9	0.9	9.1	8.2	-1.9	5.2	7.1
1975/76 TO 1989/90	1.8	4.0	2.1	1.1	3.2	2.2	1.7	3.6	1.9	2.1	4.9	2.8	5.7	10.5	4.7

TABLE 3.2

Area and Yield Effects for Selected Periods (Indices)*

RICE

Year	PAKISTAN area	PAKISTAN yield	PAKISTAN multiple	NWFP area	NWFP yield	NWFP multiple	PUNJAB area	PUNJAB yield	PUNJAB multiple	SINDH area	SINDH yield	SINDH multiple	BALOCHISTAN area	BALOCHISTAN yield	BALOCHISTAN multiple
1947/48 TO 1960/61	101.7	-1.1	-0.5	32.1	51.4	16.5	108.9	4.3	-4.6	112.6	-10.6	-2.0	4.3	94.1	1.6
1960/61 TO 1967/68	44.5	46.2	9.3	99.9	0.0	0.1	34.5	55.2	10.3	45.8	47.6	6.6	104.8	-2.5	-2.3
1967/68 TO 1974/75	18.6	73.6	7.8	30.1	52.8	17.1	46.2	43.7	10.0	6.1	90.2	3.7	-263.6	214.4	-50.7
1974/75 TO 1988/89	78.5	16.5	5.0	4.9	92.7	2.4	238.6	-95.9	-42.7	-0.6	100.9	-0.2	30.4	22.6	47.1

* Indices sum to 100 for each period

TREND GROWTH RATES (% per annum)

RICE

Year	PAKISTAN area	PAKISTAN product	PAKISTAN yield	NWFP area	NWFP product	NWFP yield	PUNJAB area	PUNJAB product	PUNJAB yield	SINDH area	SINDH product	SINDH yield	BALOCHISTAN area	BALOCHISTAN product	BALOCHISTAN yield
1947/48 TO 1960/61	3.1	3.1	0.0	2.1	5.3	3.2	5.7	5.3	-0.3	1.3	1.2	-0.1	0.1	2.6	2.5
1960/61 TO 1967/68	2.6	5.4	2.7	16.1	16.1	0.0	2.5	6.2	3.7	1.9	3.8	1.9	9.2	8.8	-0.3
1967/68 TO 1974/75	1.4	6.4	5.0	4.0	10.5	6.4	3.0	5.8	2.8	0.6	7.3	6.7	-3.9	-1.3	2.5
1974/75 TO 1988/89	1.9	2.3	0.4	0.2	3.0	2.9	2.6	1.2	-1.4	-0.0	2.2	2.3	8.0	14.7	6.7

Source: Computed from MINFA series.

TABLE 3.3

Area and Yield Effects for Selected Periods (Indices)*

COTTON

Year	PAKISTAN area	PAKISTAN yield	PAKISTAN multiple	NWFP area	NWFP yield	NWFP multiple	PUNJAB area	PUNJAB yield	PUNJAB multiple	SINDH area	SINDH yield	SINDH multiple	BALOCHISTAN area	BALOCHISTAN yield	BALOCHISTAN multiple
1947/48 TO 1954/55	6.1	91.5	2.4	200.0	-180.0	-120.0	-4.0	105.6	-1.7	26.5	64.9	8.6			
1954/55 TO 1960/61	27.6	71.1	1.3				-5.4	105.9	-0.5	351.5	-233.7	-17.8			
1960/61 TO 1969/70	45.8	39.9	14.3				53.2	30.6	16.2	-1.7	102.3	-0.6			
1969/70 TO 1978/79	1.7	91.2	7.1	-0.8	106.4	-5.6	0.8	96.1	3.1	4.1	78.2	17.6	0.0	0.0	100.0
1978/79 TO 1988/89	19.1	58.4	22.5	28.3	68.8	3.0	17.5	55.8	26.8	39.0	54.2	6.8	25.0	37.5	37.5

* Indices sum to 100 for each period

TREND GROWTH RATES (% per annum)

COTTON

Year	PAKISTAN area	PAKISTAN product	PAKISTAN yield	NWFP area	NWFP product	NWFP yield	PUNJAB area	PUNJAB product	PUNJAB yield	SINDH area	SINDH product	SINDH yield	BALOCHISTAN area	BALOCHISTAN product	BALOCHISTAN yield
1947/48 TO 1954/55	0.4	5.1	4.8	7.3	-5.8	-13.1	-0.2	4.8	5.0	1.8	5.8	4.0			
1954/55 TO 1960/61	0.3	1.1	0.8	-3.7	0.0	3.7	-0.1	1.5	1.6	1.2	0.4	-0.9			
1960/61 TO 1969/70	3.4	6.4	3.0	-3.2	0.0	3.2	4.7	7.7	3.0	-0.1	3.4	3.4			
1969/70 TO 1978/79	0.8	18.8	18.0	-0.6	22.6	23.2	0.4	18.1	17.7	2.3	20.7	18.4			
1978/79 TO 1988/89	3.3	11.0	4.8	0.4	1.4	1.0	3.9	13.2	9.3	1.2	2.8	1.6	6.9	16.1	9.2

Source: Computed from NIHFA series

TABLE 3.4

NOMINAL WHEAT PRICES IN PAKISTAN

(Rupees per 40 kgs)

	Wheat Procurement	Sugar Cane	AC-134 Seed Cotton	Paddy Fine Rice	Paddy Coarse Rice	Maize	Rice Grain Basmati
1947-48	10.18						24.2
1948-49	10.45	1.64					22.5
1949-50	10.18	1.64					29.3
1950-51	10.18	1.07					-
1951-52	10.18	0.19					-
1952-53	10.18	1.99					21.4
1953-54	13.40	1.78					21.4
1954-55	9.91	1.64					-
1955-56	9.38	1.61					-
1956-57	10.72	1.88					-
1957-58	12.32	1.88					-
1958-59	13.40	1.74					26.8
1959-60	13.40	1.61				14.6	24.7
1960-61	14.46	2.08				12.8	25.7
1961-62	14.46	2.70	37.25			14.0	26.8
1962-63	14.46	2.71	32.56			14.8	27.9
1963-64	14.46	2.14	40.0			12.2	30.0
1964-65	14.46	2.41	40.0			15.4	30.0
1965-66	14.46	2.41	39.88			15.1	30.0
1966-67	14.46	2.14	38.04			16.9	30.0
1967-68	18.21	2.59	34.94			20.4	33.2
1968-69	16.07	2.95	37.99			16.9	40.7
1969-70	18.22	2.95	41.76			17.3	37.5
1970-71	18.22	2.95	51.93	17.02	13.99	17.0	34.3
1971-72	18.22	2.70	49.96	20.20	13.99	21.0	40.7
1972-73	24.11	4.55	58.24	24.45	13.99	24.6	51.3
1973-74	27.33	4.55	66.53	32.97	18.08	24.1	66.5
1974-75	39.65	5.63	84.13	45.80	24.70	34.3	96.5
1975-76	39.65	6.16	104.92	47.80	26.79	34.30	96.5
1976-77	39.65	6.16	133.96	55.73	32.15		108.8
1977-78	39.65	6.16	147.89	59.48	32.15		108.8
1978-79	48.23	6.16	147.89	64.30	32.15		117.9
1979-80	58.00	7.50	147.89	64.30	32.15		117.9
1980-81	58.00	9.65	160.00	75.00	38.58		137.0
1981-82	58.00	9.65	170.00	85.00	45.00		150.0
1982-83	64.00	9.65	175.00	88.00	49.00	34.3	154.0
1983-84	64.00	9.65	178.00	90.00	51.00		157.0
1984-85	70.00	9.65	181.00	90.00	51.00		160.0
1985-86	80.00	9.65	185.00	93.00	53.00	34.3	175.0
1986-87	80.00	11.70	185.00	102.00	53.00		204.0
1987-88	82.50	11.70	185.00	130.00	55.00		250.0
1988-89	85.00	12.59	188.00	135.00	60.00		258.0
1989-90	96.00	13.75	203.00	143.00	66.00		276.0

Source: Government of Pakistan.

TABLE 3.5

AGRICULTURE'S DOMESTIC BORDER PRICE RATIO

	NOMINAL PROTECITON COEFFICIENT (CENTRAL PUNJAB PRICES)				
YEAR	WHEAT	BASMATI	IRRI	COTTON	SUGARCANE
60/61	0.57	0.40	-	0.50	1.30
61/62	0.61	0.42	-	0.52	1.28
62/63	0.60	0.38	-	0.51	0.87
63/64	0.61	0.41	-	0.55	0.56
64/65	0.66	0.58	-	0.58	1.60
65/66	0.74	0.43	-	0.49	1.84
66/67	0.83	0.40	-	0.50	1.74
67/68	0.65	0.35	-	0.57	2.01
68/69	0.86	0.47	-	0.46	1.42
69/70	0.83	0.46	0.38	0.49	1.25
70/71	0.76	0.40	0.42	0.58	1.03
71/72	1.06	0.36	0.36	0.33	0.63
72/73	0.83	0.53	0.55	0.64	0.61
73/74	0.50	0.38	0.22	0.57	0.24
74/75	0.66	0.34	0.35	0.62	0.40
75/76	0.84	0.50	0.75	0.68	0.68
76/77	0.88	0.76	0.85	1.02	0.84
77/78	0.72	0.99	0.97	0.82	NA
78/79	0.85	0.93	0.75	1.17	NA
79/80	0.73	0.52	1.75	1.30	NA
80/81	0.61	0.56	0.74	0.97	NA
81/82	0.64	0.65	0.70	0.87	NA
82/83	0.75	0.66	0.94	1.13	1.63
83/84	0.74	0.68	0.97	0.95	2.06
				NEW ESTIMATES	
84/85	0.58	0.33	0.75	0.63	1.73
85/86	0.73	0.30	1.13	0.78	1.19
86/87	0.58	0.30	1.18	0.74	1.53
87/88	0.60	0.39	0.88	0.48	1.85
88/89	0.60	0.38	0.61	0.50	1.43
89/90	0.52	0.40	0.50	0.48	0.58

Source: Chaudhry, G. and Kayani, N., 1991.

TABLE 3.6

AGRICULTURE'S DOMESTIC TERMS OF TRADE

YEARS	A TERMS OF TRADE	B OUTPUT INDEX	(A*B) INCOME TERMS OF TRADE
60/61	100	100	100
61/62	106	100	106
62/63	100	109	109
63/64	95	119	113
64/65	101	118	119
65/66	106	128	136
66/67	100	127	127
67/68	108	135	146
68/69	104	157	163
69/70	94	168	158
70/71	95	186	177
71/72	94	174	164
72/73 A.	94	183	172
73/74	100	188	188
74/75	100	196	196
75/76	90	187	168
76/77	87	199	173
77/78	87	203	179
78/79	93	209	194
79/80	99	219	217
80/81	93	239	222
81/82	92	249	232
82/83	100	258	258
83/84	100	-	-
84/85			
85/86			
86/87			
87/88			
88/89			
89/90			

Note A: Devaluation

Source: CHEONG, K., 1984; GOTSCH, C., AND BROWN, G., 1981; CHAUDHRY, G., 1981.

TABLE 3.7

CROP PROFITABILITY INDICES

		RATIO OF CROP PRICE INDICES TO SEED WATER FERTILIZER PRICE INDICES		
YEAR	PRICE	WHEAT	COTTON	SUGARCANE
1970	-	-	-	-
1971	0.79	0.66	0.94	0.30
1972	0.72	0.67	0.92	0.41
1973	0.86	0.70	1.04	0.47
1974	1.05	0.82	1.13	0.49
1975	0.85	1.05	0.83	0.44
1976	1.07	0.99	1.04	0.56
1977	1.13	0.95	1.34	0.57
1978	1.02	1.17	1.28	0.54
1979	1.08	1.14	1.78	0.55
1980	1.12	1.16	1.55	0.62
1981	1.07	1.00	1.43	0.66
1982	1.05	1.02	1.31	0.64
1983	-	-	-	-

Source: Cheong, K., 1984.

TABLE 3.8

AGRICULTURAL SUBSIDY AS % OF DOMESTIC VALUE OF MARKETED CROP

YEAR	WHEAT SUBSIDY FINANCIAL	WHEAT SUBSIDY ECONOMIC	WHEAT SUBSIDY EQUIVALENT	BASMATI RICE SUBSIDY FINANCIAL	BASMATI RICE SUBSIDY ECONOMIC	BASMATI RICE SUBSIDY EQUIVALENT	IRRI RICE SUBSIDY FINANCIAL	IRRI RICE SUBSIDY ECONOMIC	IRRI RICE SUBSIDY EQUIVALENT
1974	2.9	-211.0	-208.0	-31.2	-96.1	-127.3	-3[illegible].5	-339.9	377.4
1975	5.5	-58.5	-52.9	-14.5	-140.4	-150.9	-15.1	-99.7	-114.9
1976	10.2	-64.4	-54.2	-8.1	-72.7	-80.3	-3.9	-27.5	-31.4
1977	2.8	-34.3	-31.5	-1.4	8.6	7.2	0.0	-13.8	-13.8
1978	9.1	-37.9	-28.8	3.6	9.4	12.9	4.1	-68.3	-64.1
1979	17.7	-45.2	-27.6	6.0	-85.7	-79.8	8.5	-27.2	-18.7
1980	24.0	-60.8	-36.8	8.4	-71.5	-63.1	12.3	-66.9	-54.6
1981	21.8	-49.6	-27.7	10.2	-43.3	-33.1	11.7	-62.6	-50.9
1982	17.3	-60.5	-43.2	4.9	-54.2	-49.2	7.8	0.8	8.6
1983		-40			-61			-12	
1984		-56			-60			-10	
1985		-48			-67			-25	
1986		-35			-70			-13	
1987		-47			-70			-18	
1988		-46			-63			-12	
1989		-46			-62			-39	
1990		-52			-60			-50	

Source: Cheong, K., 1984.

TABLE 3.9

AREA IRRIGATION

	CANAL	TW	M ha	EXP GROWTH RATE
1950/51	7.5	-	9.3	
54/55	8.3	-	10.0	1.1%
60/61	8.6	-	10.4	2.0%
71/72	9.5	2.1	13.0	1.7%
81/82	11.4	3.0	15.4	0.2%
89/90	11.2	4.0	15.7	

WATER AVAILABILITY

(MAF)

Year	Kharif	Rabi	Total	
1960/61			58.7	As stats 75
1961/62			61.3	
1962/63			65.9	
1963/64			70.0	
1964/65			72.2	
1965/66	43.6	20.3	63.0	** Wheat Sta
1966/67	44.8	22.7	67.5	* Ag Stats 79
1967/68	42.9	25.7	68.6	
1968/69	46.9	25.9	72.8	
1969/70	49.3	26.2	75.5	
1970/71	45.3	24.7	70.0	
1971/72	45.9	25.2	71.1	
1972/73	51.5	29.6	81.1	
1973/74	49.3	30.8	80.1	
1974/75	50.3	26.7	77.0	
1975/76	50.6	34.5	85.1	* Ag Stats
1976/77	48.2	36.4	84.6	
1977/78	52.6	36.8	89.4	
1978/79	50.8	36.6	87.4	
1979/80	56.4	37.7	94.1	
1980/81	58.8	39.0	97.8	
1981/82	58.9	40.0	98.9	
1982/83	59.3	42.2	101.5	
1983/84	60.6	43.1	103.7	
1984/85	57.7	39.7	97.4	
1985/86	58.0	42.1	100.1	
1986/87	64.3	45.5	109.8	
1987/88	65.7	46.5	112.2	
1988/89	67.2	47.5	114.7	

Source: Economic Surveys.

TABLE 3.10

ANNUAL FERTILIZER OFFTAKE IN PAKISTAN

CROP YEAR	KHARIF	RABI	TOTAL
1969/70	144729	160100	304829
1970/71	123270	145820	269090
1971/72	185073	183840	368913
1972/73	183567	222713	406280
1973/74	212342	253911	466253
1974/75	163079	242880	405959
1975/76	202868	295605	498473
1976/77	277641	359690	637331
1977/78	282112	391613	673725
1978/79	339151	518367	857518
1979/80	426423	645030	1071453
1980/81	395290	630840	1026130
1981/82	329830	628000	957830
1982/83	505000	712230	1217230
1983/84	496300	737110	1233410
1984/85	485300	780090	1265390
1985/86	566510	923000	1489510
1986/87	662000	1017000	1679000
1987/88	757000	963000	1720000
1988/89	727000	994000	1721000
1989/90	776000	1058000	1834000

Source: Economic Surveys.

TABLE 3.11

USE OF PESTICIDES ON CROPS

Year	PADDY			COTTON			SUGARCANE			
	Area Sown (000 ha)	Area Ground Sprayed	%	Area Sown (000 ha)	Area Ground Sprayed	%	Area Sown (00 ha)	Area Ground Sprayed	%	
1971/72										
1972/73										
1973/74										
1974/75										
1975/76										
1976/77										
1977/78	1899.0	109.0	5.7	1843.0	377.0	20.5	823.0	96.0	11.7	* Ag Stat
1978/79	2026.0	217.0	10.7	1891.0	287.0	15.2	753.0	121.0	16.1	
1979/80										
1980/81										
1981/82										
1982/83										
1983/84										
1984/85										
1985/86	1863.0	68.0	3.7	2364.0	1295.0	54.8	780.0	101.0	12.9	* Ag Stat
1986/87	2066.0	81.0	3.9	2505.0	1369.0	54.7	762.0	93.0	12.2	
1987/88	1963.0	150.0	7.6	2568.0	1627.0	63.4	842.0	126.0	15.0	
1988/89	2042.0	196.0	9.6	2619.0	1282.0	48.9	877.0	231.0	26.3	

Source: Agriculture Statistics of Pakistan

The two important macro policy variables available for this period are prices and irrigation. Prices give the incentive for area expansion, while irrigation allows area expansion. Irrigation also allows yield increases, accompanied by other inputs. Table 3.4 shows that up to 1954/55, wheat prices certainly gave no incentive for area expansion. The procurement price remained at Rs 10 for many years an then dropped to Rs 9. Table 3.9 shows that the marginal increase in area may have been permitted by a marginal increase in irrigated area from 9.3 to 10 million has.

The second period dates from 1954/55 to 1960/61. Table 3.1 shows that this period was characterized by a positive growth of output of 3%. This growth in output was enabled by yields increasing over this period at 1.6%. In fact growth of output is contributed to equally by area and yield effects. However Table A-1.1 shows that even by 1960, yields still remained below their pre-independence levels.

Regionally, the upturn in yields is again due to the Punjab and NWFP, as Table 3.1 shows. In Sind, yields stagnated.

Again for this period, the only policy variables available are price and irrigation. Table 3.4 shows that wheat prices actually increased over this period, giving some incentive for the area expansion. Table 3.9 shows that irrigation increased by 0.5 million has. to 10.4 million has.. Over the entire 1950s, irrigation increase was very slow, at 1.1% per annum.

The third period extends from 1960/61 to 1966/67. Our Table 3.1 presents a very interesting picture of this period, not always characterized by the literature. The literature presents this period as one of rapid agricultural expansion, based on irrigation, after the neglect of the 1950s (Ahmad and Amjad, 1986). Table 3.1 shows that over this period, growth of wheat output was low at 2.1%. Moreover this growth of output was entirely due to an area effect, because yields actually stagnated. Table A-1.1 shows that wheat by 1966/67, wheat yields had still not recovered to their pre independence level of 0.8 t/ha.

Regionally, the stagnating yield effect was caused by the Punjab and Sind, as Table 3.1 shows. In NWFP yields actually dropped. The increase in area over this period was caused by an improvement in the price regime, and irrigation increases. Table 3.4 shows that wheat prices increase in nominal terms. Table 3.5 shows that this was a major increase in terms of world prices, with the NPC rising from 0.57 to 0.83. Table 3.9 shows that over this period, water increased from 59 MAF to at least 67 MAF.

The fourth period extends from 1966/67 to 1975/76. The literature portrays the period from 1967 onwards as one of high growth based on the HYV package of inputs (Ahmad and Amjad, 1986). Table 3.1 shows that growth of wheat output was very high at 7.8%. This growth of output however was entirely based on a yield effect. Table A-1.1 shows that yields shot up from 0.8 to 1.4 t/ha.

Regionally this growth in yields, and virtual stagnation of area was diffused over all four provinces, as Table 3.1 shows. Sind appears to have had the highest increase in yields, by about 1 t/ha.

The reason for the increase in wheat yields is well documented to be the proliferation of the HYV package. Byerlee and Siddiq (1990) estimate that by the mid-1970s, 80% of the wheat area was under HYVs. Table 3.10 shows that Rabi fertilizer offtake had doubled over this period.

The reason for the stagnation of area needs to be explained. Table 3.9 shows that irrigation continued expanding over this period, by almost 18 MAF for both seasons, and by 12 MAF for Rabi. So irrigation was not a major constraint for expansion of area. We feel that the answer lies in the price regime. Table 3.4 shows that nominally, wheat prices doubled over this period. However, Table 3.6 which presents the domestic terms of trade gives a contrary picture. The table shows that over much of this period the domestic terms of trade were turned against agriculture. Table 3.7 shows that the profitability ratio for wheat hovered at a low between 0.6 and 0.8 over this period. This explains why despite the HYV increase in yields, wheat area remained stagnant till the mid-1970s. The state used price policy to transfer HYV gains out of wheat. Table 3.8 shows that the high negative subsidy equivalents for wheat peak by the mid-1970s.

The final period for wheat extends from 1975/76 onwards. Table 3.1 shows that this period is characterized by a high growth of output at 4%. The area effect picks up over this period. So this growth in output has been equally due to area and yield effects. Table A-1.1 shows wheat yields to have peaked at about 1.9 t/ha. Growth in yields, however, has dropped down to 2%, one-third of the previous period.

Regionally, the pick up in the area effect has been diffused over the four provinces, as Table 3.1 shows. The decline in growth of yields has been more pronounced in the Punjab and NWFP. Sind has the highest yield of 2.3 t/ha in Table A-1.1.

The increase in wheat area is well explained by the price regime. Table 3.4 shows that nominal wheat prices have more than doubled over this period. Table 3.6 shows that domestic terms of trade have remained against agriculture till the 1980s. However against this, Table 3.7 shows that wheat profitability ratios have risen above 1. As a result, in Table 3.8, the negative subsidy equivalent for wheat drops down from half the marketed crop to a quarter, till the 1980s.

The decline in the rate of growth of wheat yields is not readily apparent. Table 3.10 shows that fertilizer offtake for Rabi has almost tripled over this period. Water, however, gives an important clue. Irrigation permits not only growth in area, but also growth in yields. And growth of water over the 1980s has declined to 0.2% pa, compared to about 2% over the 1960s and the 1970s, as Table 3.9 shows. Over the 1980s, the rate of growth of Rabi water has been particularly low, below Kharif water.

In summary, the major findings for wheat have been, that in the pre-HYV 1960s yields stagnated; during the HYV 1960s to mid-1970s, area stagnated; and subsequently, yield growth rates have dropped again.

3.2.3 Rice

Table 3.2 divides the growth of rice into four distinct periods. The first period dates from 1947/48 to 1960/61. This period is characterized by a growth rate of output of 3.1%. This growth in output is entirely due to an area effect. Table A-1.2 shows that the rice yield stagnated over this period at 0.9 t/ha.

Regionally, Table 3.2 shows that both the area expansion, and the yield stagnation are due to the Punjab and Sind which have continued to comprise about 90% of the rice area. NWFP and Balochistan actually increased their rice yields over this period, from their low pre-independence levels.

The only macro policy variables available to explain this period are prices and irrigation. Table 3.4 shows that rice prices remained about constant on trend till 1960, hovering between Rs 20 and Rs 30. So prices did not discourage area expansion. Moreover, Table 3.9 shows that irrigated area expanded slowly at 1.1% pa, permitting area expansion.

The second period for rice dates from 1960/61 to 1967/68. Here as in wheat, our results show an interesting departure from the general literature. The literature holds that rice yields were stagnating until the HYV package boosted them from 1967/68 onwards (Ahmad and Amjad, 1986). Our Table 3.2 shows that over this period growth of output was high at 5.4%. Moreover this output growth was due equally to area and yield effects. Table A-1.2 shows that the rice yield increased by 0.2 t/ha over this period.

Regionally these area and yield effects are evenly distributed over the Punjab and Sind, as Table 3.1 shows. NWFP and Balochistan had no yield increases.

The rice area increases over this period are explained by prices and irrigation. Table 3.4 shows that nominal rice prices increased. Table 3.5 shows that the NPCs for rice remained constant. So there was a price incentive for area increases. Table 3.9 shows that irrigated area increased by almost 10 MAF over this period, permitting rice area increases.

The rice yield increases over this period are not so readily explained. Table 3.9 however gives one clue from irrigation. Kharif water availability for rice has been greater than Rabi water for wheat. And up to this period the ratio of Kharif to Rabi water was the highest at about 2. So the expansion in total water availability, combined with the advantage of Kharif water enabled an increase in yields.

The third period for rice, as for wheat, extends from 1967/68 to 1974/75. Table 3.2 shows that this period is characterized by a high rate of growth of output at 6.4%. Again for

rice, as for wheat, this growth in output is largely due to a yield effect. Table A-1.2 shows that rice yields increased from 1 t/ha to 1.5 t/ha. Regionally this increase in yields is again diffused over the Punjab and Sind, as Table 3.2 shows.

The reason for the increase in yields over this period is well documented as the proliferation of the HYV IRRI rice. But what needs to be explained is the relative stagnation of rice area over this period. In the case of wheat, there was seen to be a price disincentive. This price disincentive is seen to be working for rice as well. Table 3.4 shows that nominal rice prices increased for both the basmati fine grain, and the IRRI coarse grain, over this period. However, Table 3.5 shows that the NPC for rice dropped a little over this period. Table 3.7 shows that the profitability ratio largely remained below 1 over this period. And Table 5 shows that the negative subsidy equivalents peaked before the mid-1970s, for both basmati and IRRI.

The final period for rice, as for wheat, extends from 1974/75 onwards. Table 3.2 shows that growth of output has been low over this period at 2.3%. Moreover this growth in output has been largely due to an area effect. The rate of growth of yields has dropped to 0.4%. Table A-1.2 shows that rice yields have peaked at about 1.7 t/ha.

Regionally this decline in yields has been in the Punjab, as Table 3.2 shows. In Sind rice yields have grown over this period to peak at 2.2 t/ha, as Table A-1.2 shows.

The increase in rice area is well explained by the price regime. Table 2.2 shows that nominal prices for basmati have almost tripled over this period. IRRI prices have also increased. Table 3.5 shows that the NPCs for both varieties of rice have increased well into the 1980s. Table 3.7 shows that the profitability ratio for rice has risen above 1 over this period. And as a result, Table 3.8 shows that the negative subsidy equivalents for both varieties of rice have dropped compared to earlier periods.

The slowing down of rice yields is less well explained here. The explanation offered is the same as for wheat. The rate of growth of total water availability has ground down to 0.2% pa over the 1980s. In addition, the advantage that Kharif water enjoyed over Rabi water has decreased. A third clue to this explanation lies in pesticides. Table 3.11 shows that the proportion of paddy area sprayed has been virtually constant at about 10% over the 1980s.

In summary, the major findings for rice have been, that in the pre-HYV 1960s rice yields increased, over the 1960s to mid-1970s HYV rice area stagnated, and subsequently rice yields have begun to stagnate again.

3.2.4 Cotton

Table 3.3 divides cotton growth into five periods.

The first period is characterized by a high growth of output of 5%, but from a very low base. This growth is based largely on a yield effect. Table A-1.3 shows that cotton yields increased from 0.15 t/ha to 0.2 t/ha over this period.

The second period extends from 1954/55 to 1960/61. Table 3.3 shows that this period is characterized by growth of output stagnating to 1%. This has again been largely due to a yield effect. Table A-1.3 shows that yields stagnated at 0.2 t/ha over this period. Regionally, Table 3.3 shows that the stagnation up to the 1960s is diffused over the Punjab and Sind which have over 90% of the crop area continually.

There are no price policy variables available for cotton for this period up to the 1960s. The only irrigation variable available is the slow aggregate growth for water of 1.1%, in Table 3.9. Clearly however, Kharif water constrained cotton area.

The third period for cotton extends from 1960/61 to 1969/70. Table 3.3 shows that this period is characterized by a high growth rate of output of 6.4%. This growth of output is explained more by an area effect than a yield effect. Table A-1.3 shows that the cotton yield increased marginally from 0.2 t/ha to 0.3 t/ha.

Regionally, the cotton area increase was concentrated in the Punjab, as Table 3.3 shows. The Sind cotton area remained stagnant. This area increase is explained by the price regime and irrigation. Table 3.4 shows that nominal cotton prices increased over the 1960s. Table 3.1 shows that the NPCs for cotton remained constant on trend over the 1960s. And Table 3.9 shows that Kharif water expanded to 45 MAF over the 1960s.

The fourth period for cotton extends from 1969/70 to 1978/79. Table 3.3 shows that this period is characterized by the highest growth rate of output of 19%. This output increase is entirely due to a yield effect. Table A-1.3 shows that cotton yields took a quantum jump up from 0.3 t/ha to 2 t/ha. Cotton area on the other hand remained stagnant.

For the fourth period, Table 3.3 shows that the increase in yields was diffused over the Punjab and Sind. Table A-1.3 shows that Sind yields peaked over Punjab yields.

The increase in cotton yields over this period is again well documented as the proliferation of new varieties. These new varieties were accompanied by fertilizer which helps triple the Kharif offtake over this period, as seen in Table 3.10. The puzzle here is why cotton area stagnated over the 1970s. Table 3.4 shows that nominal cotton prices tripled over this period. Table 3.1 shows that this actually increased cotton NPCs to near parity with world prices. And Table 3.7 shows that cotton profitability reached over 1.1 Some of these price incentives should have been translated into area increases rather than just yield increases. Part

of the answer can be gleaned here in the form of a water constraint. Table 3.9 shows that for most of the 1970s, Kharif water levels remained stagnant, hovering between 45 MAF and 50 MAF. So while there was a price incentive to increase cotton area over the 1970s, there was a simultaneous irrigation constraint.

The final period for cotton extends from 1978/79 onwards. Table 3.1 shows that this period is characterized by a still high growth rate of output of 11%. Unlike wheat and rice, this growth of output over the 1980s continues to be largely fuelled by an area effect. Table A-1.3 shows that cotton yields have now jumped up from 2 t/ha to 3.2 t/ha. Moreover, unlike the previous period, cotton area has also increased.

Regionally, Table 3.3 shows that the most recent yield increases have been concentrated only in the Punjab. Growth rates of output, area, and yield have been very low in Sind over the 1980s.

The increase in yields over the 1980s is well explained through the use of pesticides. Table 3.11 shows that there has been a large increase in cotton area sprayed, from 15% at the end of the 1970s to 60% at the end of the 1980s. In addition, Table 3.10 shows that cotton has contributed to Kharif fertilizer offtake almost tripling over the 1970s.

The increase in area is explained by the incentives of the price regime, and the removal of irrigation constraints over the 1980s. Table 3.4 shows that nominal cotton prices continued increasing over the 1980s. Table 3.5 shows that cotton NPCs have been high at least over the first half of the 1980s. (The new series makes it difficult to compare the two halves of the 1980s.) Table 3.7 shows that cotton profitability has peaked at 1.8. And finally, Table 3.9 shows that Kharif irrigation water increased more over the 1980s than over the 1970s, easing this constraint on area expansion.

In summary, the major findings for cotton are that yields have had two quantum jumps, in the 1970s through new varieties, and in the 1980s through pesticides. Cotton area however, like wheat and rice area, has been constrained during the period of introduction of the new varieties.

3.3 Changes in High Yielding Versus Low Yielding Varieties

3.3.1 Introduction

The growth of aggregate crops has raised questions about growth of yields and area in specific periods. The two problem crops examined have been wheat and rice. Both crops have had a large yield effect from HYV during the 1960s to the mid-1970s, while area stagnated. Subsequently, both crops have picked up in their area, while their rate of growth of yields has begun to decline.

Since HYVs have been at the cutting edge of yields for both wheat and rice, the clue to declining yields lies here. Consequently we have desegregated MINFA data into HYV and non HYV production. Like the earlier analysis, this series too has been broken into distinct periods. Table 3.12 gives the decomposition effects and growth rates for each period for HYV wheat. Similarly, Tables 3.19-3.21 give these decomposition effects and growth rates for non HYV wheat, HYV rice, and non HYV rice, respectively. The Appendix Tables A-2.1-A-2.4 give the entire series for HYV wheat, non-HYV wheat, HYV rice, and non-HYV rice, respectively.

3.3.2 Wheat

Table 3.12 shows that HYV wheat growth falls into three distinct periods.

The first period is from introduction in 1968/69 to 1974/75. This period is characterized by a high growth rate of output of 7.3%. This growth of output is entirely due to an area effect. Table A-2.1 shows that the HYV wheat yield remains stagnant at 1.6 t/ha. This result shows that the yield increase for aggregate wheat over this same period was entirely due to a conversion of non-HYV area to HYV area, increasing the aggregate yield.

The second period for HYV wheat is from 1974/75 to 1985/86. Table 3.12 shows that growth of output continues high over this period at 7.2%. This growth of output is due now largely to an area effect, but some yield effect. Table A-2.1 shows that the HYV wheat yield increase from 1.6 t/ha to 2 t/ha. One clue to this mid-life spurt i. HYV wheat yields is given by fertilizer. Table 3.10 shows that in the first HYV wheat period Rabi fertilizer offtake barely doubled. In this second period, Rabi fertilizer offtake has tripled.

The last period for HYV wheat extends from 1986/87 onwards. Table 3.12 shows a slump in growth of output, due largely to an area effect. This negative area effect may be due to the low wheat prices increases since 1985, seen in Table 3.4. Or it may be short term cycle. However, Table A-2.1 shows that HYV wheat yields have stagnated again in the last three years.

This recent stagnation of HYV wheat yields could be related to fertilizer again. Table 3.10 shows that Rabi fertilizer offtake has also stagnated. Alternatively, there may now be decreasing returns to fertilizer for HYV wheat.

It is interesting that regionally, as Table A-2.1 shows, Punjab has always had more than 90% of the HYV area. However, niches in Sind have the highest yields at 2.3 t/ha, and still creeping up. (The high Baluchistan figures are a bad sampling aberration.)

For non-HYV wheat, Table 3.13 shows that its growth has been negative through the entire period from 1968/69 onwards. This has been entirely due to an area effect, through conversion to HYV area. Table A-2.2 shows however, that non-HYV wheat yields have crept up from 0.7 t/ha to about 1 t/ha.

Regionally, the Punjab and NWFP share the non-HYV area equally.

3.3.3 Rice

Table 3.14 shows that HYV rice growth is divided into two distinct periods.

The first period dates from the introduction of HYV rice in 1968/69 to 1980/81. This period is characterized by a high growth rate of 8.6%. This growth of output is entirely due to an area effect. Table A-2.3 shows that HYV rice yields stagnate at about 2.1 t/ha over this period. So like wheat, non-HYV rice area converts to HYV rice area over this period. The high productivity favors conversion. The price regime seen in Table 3.4 is not a disincentive for IRRI either. IRRI prices increase at about 10% p.a. over this period. Basmati prices increase at a higher rate of about 15% over this period. So there is a premium on basmati still, which is why all rice area is not swamped by HYVs as in the case of wheat.

In the second period for IRRI rice, growth of output stagnates. Table 3.14 shows that this is due to a positive area effect and a negative yield effect. Table A-2.3 shows IRRI area creeping up to peak at 1 million has., before it drops down again. IRRI yields stagnate at 2.1 t/ha.

So IRRI yields have remained constant since inception. Regionally they have peaked in Sind at 2.3 t/ha, as Table A-2.3 shows. The Kharif fertilizer offtake shown in Table 3.10 has been increasing throughout and does not explain the constancy in yields. The constancy in pesticide use at about 10% of rice area, seen earlier, does correlate to constancy in yields.

TABLE 3.12

AREA AND YIELD EFFECTS FOR SELECTED PERIODS (Indices)*

HYV WHEAT

Year	PAKISTAN area	PAKISTAN yield	PAKISTAN multiple	NWFP area	NWFP yield	NWFP multiple	PUNJAB area	PUNJAB yield	PUNJAB multiple	SINDH area	SINDH yield	SINDH multiple	BALOCHISTAN area	BALOCHISTAN yield	BALOCHISTAN multiple
1968/69 TO 1974/75	104.1	-2.6	-1.5	153.2	-18.3	-34.8	103.8	-2.7	-1.2	80.3	9.3	10.4	-358.8	460.0	-201.2
1974/75 TO 1985/86	66.2	18.7	15.1	61.0	24.2	14.9	68.7	17.2	14.1	54.5	28.3	17.2	82.1	2.2	15.7
1985/86 TO 1988/89	-92.1	-9.6	1.7	63.4	34.2	2.4	342.1	-227.9	-14.2	-2.3	102.4	-0.2	31.6	63.4	5.0

* Indices sum to 100 for each period

EXPONENTIAL GROWTH RATES (% per annum)

Year	PAKISTAN area	PAKISTAN product	PAKISTAN yield	NWFP area	NWFP product	NWFP yield	PUNJAB area	PUNJAB product	PUNJAB yield	SINDH area	SINDH product	SINDH yield	BALOCHISTAN area	BALOCHISTAN product	BALOCHISTAN yield
1968/69 TO 1974/75	7.5	7.3	-0.2	17.8	13.5	-4.3	6.0	5.8	-0.2	12.5	14.6	2.0	-9.6	-2.2	7.4
1974/75 TO 1985/86	5.4	7.2	1.9	4.4	6.3	2.0	5.5	7.2	1.7	4.3	6.8	2.5	19.0	20.6	1.6
1986/86 TO 1988/89	-6.6	-7.2	-0.6	2.3	3.5	1.2	2.0	0.6	-1.4	-0.1	2.7	2.8	2.5	7.5	4.9

Source: Computed from MINFA series.

TABLE 3.13

AREA AND YIELD EFFECTS FOR SELECTED PERIODS (Indices)*

Non-HYV Wheat

	PAKISTAN			NWFP			PUNJAB			SINDH			BALOCHISTAN		
	area	yield	multiple	area	yield	multiple	area	yield	multiple	area	yield	multiple	area	yield	multiple
1968/69 TO 1988/89	-105.7	33.7	-28.0	-310.8	456.5	-245.7	-102.3	22.1	-19.9	-101.7	11.1	-10.0	-45.2	211.5	-66.3

* Indices sum to 100 for each period

EXPONENTIAL GROWTH RATES (% per annum)

	PAKISTAN			NWFP			PUNJAB			SINDH			BALOCHISTAN		
Year	area	product	yield	area	product	yield	area	product	yield	area	product	yield	area	product	yield
1968/69 TO 1988/89	-8.9	-7.7	1.2	-3.9	-1.0	2.9	-11.4	-10.5	0.9	-11.3	-10.8	0.5	-1.9	2.6	4.5

Source: Computed from MINFA series.

TABLE 3.14
HYV Rice: Area and Yield Effects for Selected Periods and Trend Growth Rates

Year	PAKISTAN area	PAKISTAN yield	PAKISTAN multiple	NWFP area	NWFP yield	NWFP multiple	PUNJAB area	PUNJAB yield	PUNJAB multiple	SINDH area	SINDH yield	SINDH multiple	BALOCHISTAN area	BALOCHISTAN yield	BALOCHISTAN multiple
1968/69 TO 1980/81	96.4	1.3	2.3	108.9	-2.1	-6.8	213.3	-42.7	-70.6	80.4	7.5	12.1			
1980/81 TO 1988/88	262.8	-162.5	-0.3	91.3	6.3	2.4	-12.0	-88.7	0.7	-96.8	-3.6	0.3	120.0	-7.5	-12.6

* Indices sum to 100 for each period

EXPONENTIAL GROWTH RATES

Year	PAKISTAN area	PAKISTAN product	PAKISTAN yield	NWFP area	NWFP product	NWFP yield	PUNJAB area	PUNJAB product	PUNJAB yield	SINDH area	SINDH product	SINDH yield	BALOCHISTAN area	BALOCHISTAN product	BALOCHISTAN yield
1968/69 TO 1980/81	8.4	8.6	0.2	12.1	11.5	-0.5	8.1	4.8	-3.4	8.0	9.1	1.2		38.1	
1980/81 TO 1989/90	0.0	0.0	0.0	3.6	3.9	0.3	-0.1	-0.8	-0.7	-1.0	-1.1	0.0	11.0	9.8	-1.2

TABLE 3.15
Non-HYV Rice: Area and Yield Effects for Selected Periods and Trend Growth Rates

Year	PAKISTAN area	PAKISTAN yield	PAKISTAN multiple	NWFP area	NWFP yield	NWFP multiple	PUNJAB area	PUNJAB yield	PUNJAB multiple	SINDH area	SINDH yield	SINDH multiple	BALOCHISTAN area	BALOCHISTAN yield	BALOCHISTAN multiple
1968/69 TO 1988/89	34.0	65.1	0.9	1.0	98.0	1.0	145.1	-31.4	-13.8	-105.4	20.3	-14.9	-111.0	354.7	-143.7

* Indices sum to 100 for each period

EXPONENTIAL GROWTH RATES (% per annum)

Year	PAKISTAN area	PAKISTAN product	PAKISTAN yield	NWFP area	NWFP product	NWFP yield	PUNJAB area	PUNJAB product	PUNJAB yield	SINDH area	SINDH product	SINDH yield	BALOCHISTAN area	BALOCHISTAN product	BALOCHISTAN yield
1968/69 TO 1989/90	0.1	0.2	0.1	0.1	3.5	3.4	1.7	1.3	-0.5	-6.3	-5.6	0.6	-2.5	1.5	4.0

Non-HYV basmati rice shows no distinct periods in Table 3.15. Its rate of growth of output has been stagnant at 0.2%. This has been due to area and yield effects. Table A-2.4 shows that basmati area has been constant over time, with about 2/3rds of the total rice area. Basmati yields have stagnated at about 1.2 t/ha.

Regionally the Punjab has a 70 % share in basmati area, as Table A-2.4 shows.

So the query that emerges from this HYV analysis is why have HYV wheat yields crept up to peak, and why have IRRI and basmati yields simply stagnated. We have a fertilizer clue for wheat, and a pesticide clue for rice.

3.4 Changes in Irrigated Versus Non-irrigated Areas

HYVs have been at the cutting edge of yields, and HYVs require controlled irrigation. Out of wheat and rice, wheat is both irrigated and non-irrigated barani. So in the case of wheat we can trace the impact of irrigation on yields.

We have desegregated MINFA district level data, available from 1970 onwards, into irrigated and non-irrigated districts. The cut off criteria used has been 50% of wheat area irrigated. The time series for wheat irrigated and non-irrigated areas has been decomposed into area and yield effects. Tables 10.1 and 10.2 give the irrigated and non-irrigated decomposition effects respectively. Appendix Tables A-3.1 and A-3.2 give the entire irrigated and non-irrigated series, respectively.

Table 3.16 gives just one period for irrigated wheat. Its growth of output has been medium at 4.2%. Area and yield effects have contributed to this growth equally. Table A-3.1 shows irrigated wheat area increasing from 4 million has. in 1970 to 6.5 million has. So non-irrigated wheat area has been converted gradually into irrigated. Yields have increased from 1.3 t/ha to about 2 t/ha.

Regionally the area and yield effects have been diffused over the Punjab and Sind, as Table 3.16 shows. The NWFP has not had much of an area effect.

Table 3.17 divides unirrigated wheat growth in two periods. The first period dates from 1970 to 1982/83. The first period is characterized by a high growth of output of 7.8%, although from a low base. This growth has been entirely due to a yield effect. Table A-3.2 shows that unirrigated wheat yields increased from 0.4 t/ha to about 0.9 t/ha over this period. This indicates that HYVs adapted for barani conditions have had some impact on yields.

The second period for unirrigated wheat extends from 1982/83 onwards. In this period growth of output has stagnated, as Table 3.17 shows. However this stagnation of output is entirely due to a negative area effect. Table A-3.2 shows unirrigated wheat area decreasing after 1982/83, as a result of conversion to irrigated area. Unirrigated wheat yields have also virtually

TABLE 3.16

Area And Yield effects for Selected Periods (Indices)*

TAB3.1: Wheat only

IRRIGATED WHEAT

Year	PAKISTAN area	PAKISTAN yield	PAKISTAN multiple	NWFP area	NWFP yield	NWFP multiple	PUNJAB area	PUNJAB yield	PUNJAB multiple	SINDH* area	SINDH* yield	SINDH* multiple	BALOCHISTAN** area	BALOCHISTAN** yield	BALOCHISTAN** multiple
1970/71 TO 1989/90	38.5	41.8	19.7	18.0	57.1	24.9	41.3	40.3	18.5	40.3	42.0	17.7	0.0	41.3	58.7

* Indices sum to 100 for each period.

EXPONENTIAL GROWTH RATES (% per annum)

Year	PAKISTAN area	PAKISTAN product	PAKISTAN yield	NWFP area	NWFP product	NWFP yield	PUNJAB area	PUNJAB product	PUNJAB yield	SINDH area	SINDH product	SINDH yield	BALOCHISTAN area	BALOCHISTAN product	BALOCHISTAN yield
1970/71 TO 1989/90	2.0	4.2	2.2	1.9	6.5	4.6	2.0	3.9	1.9	1.9	3.8	1.9	4.7		

Source: Computed from MINFA series.

TABLE 3.17

Area And Yield Effects for Selected Periods (Indices)*

TAB3.1: Wheat only

UNIRRIGATED WHEAT

Year	PAKISTAN area	PAKISTAN yield	PAKISTAN multiple	NWFP area	NWFP yield	NWFP multiple	PUNJAB area	PUNJAB yield	PUNJAB multiple	SINDH area	SINDH yield	SINDH multiple	BALOCHISTAN area	BALOCHISTAN yield	BALOCHISTAN multiple
1970/71 TO 1982/83	2.8	93.2	4.0	21.4	54.7	24.0	-2.8	107.8	-4.9	-123.0	77.9	-54.9			
1982/83 TO 1989/90	-205.8	125.0	-19.2	-39.6	143.0	-3.4	-192.6	117.5	-24.8	7.7	-105.5	-2.2	118.0	-26.0	8.0

* Indices sum to 100 for each period.

EXPONENTIAL GROWTH RATES (% per annum)

Year	PAKISTAN area	PAKISTAN product	PAKISTAN yield	NWFP area	NWFP product	NWFP yield	PUNJAB area	PUNJAB product	PUNJAB yield	SINDH area	SINDH product	SINDH yield	BALOCHISTAN area	BALOCHISTAN product	BALOCHISTAN yield
1970/71 TO 1982/83	0.4	7.8	7.5	3.0	9.3	6.3	-0.4	8.0	8.4	-10.2	-7.1	3.1	4.2		
1982/83	-2.4	-1.1	1.3	-0.3	0.8	1.2	-3.4	-1.7	1.7	0.3	-4.5	-4.8	-5.2	-4.3	0.9

Source: Computed from MINFA series.

stagnated over this period, at about 1 t/ha. Regionally, barani yields in the Punjab have been the highest, peaking at about 1.1 t/ha.

This analysis shows two things for wheat. Irrigation combined with HYVs has lead to a sustained increase in yields, with a peak not yet apparent, but which may well be just around the bend. HYVs without irrigation have increased yields to a clear peak at about 1 t/ha. Moreover barani yields are about half of irrigated yields. Ergo, irrigation continues to be a critical input for wheat yield increases.

3.5 Changes in Favored Versus Marginal Areas

Clearly irrigation is not the only geophysical factor affecting wheat growth. There are a whole host of other geophysical factors which could have an impact on wheat yields. Prominent among these geophysical factors are soil type, physiography, temperature ranges, and rainfall. To consider the possible impact of these geophysical factors on wheat yields, we have desegregated MINFA district level data into favored and marginal zones for wheat. The cutoff criteria used have been based on Mallick (1990). Broadly, the zone favorable to wheat has loamy and clayey soil, physiographically falls into the Indus plains or wet mountains, has a temperature range between 0 degree Celsius and 38 degrees Celsius in the wheat season, and rainfall below 600 mm in the wheat season.

Tables 3.18 and 3.19 present the growth and decomposition effects for the favorable and marginal zone wheat growth respectively. Appendix Tables A-4.1 and A-4.2 give the time series for the favorable and marginal zone wheat growth.

Table 3.18 shows that favored wheat has had a growth rate of output of 3% from 1970 onwards. This growth has naturally been largely a yield effect, because the zone area cannot be expected to expand very much. Table A-4.1 shows that favorable wheat yields have risen from 1.2 t/ha to about 2 t/ha.

Table 3.19 shows that marginal wheat has had a growth rate of output of 4.5% from 1970 onwards. Again this growth has been due to yields as expected. Table A-4.2 shows that marginal wheat yields have increased from 0.6 t/ha to about 1.1 t/ha.

Regionally, the Punjab comprises about 80% of the favored wheat area. This classification of area into favored and marginal zones for wheat does not really add to the explanation offered by the classification into irrigated and barani areas. The yield increases for the favorable and irrigated area similar. The yield increases for the marginal and barani areas are also similar. Table A-4.2 shows that marginal wheat yields also appears to have peaked at about 1.2 t/ha. A favored wheat peak is not yet visible. Therefore we fall back to the conclusion that irrigation is the more critical determinant of wheat yields, compared to a set of other geophysical factors.

TABLE 3.18

Area and Yield Effects for Selected Periods (Indices)*

FAVORED WHEAT

Year	PAKISTAN area	PAKISTAN yield	PAKISTAN multiple	NWFP area	NWFP yield	NWFP multiple	PUNJAB area	PUNJAB yield	PUNJAB multiple	SINDH** area	SINDH** yield	SINDH** multiple	BALOCHISTAN*** area	BALOCHISTAN*** yield	BALOCHISTAN*** multiple
1970/71 TO 1986/87	25.7	63.5	9.9	15.5	65.8	18.7	38.8	46.7	14.4	25.9	58.7	15.4	4.3	49.5	46.1

* Indices sum to100 for each
** Computed over 15 years 1970/71-1985/86
*** Computed over 15 years 1971/72-1986/87

EXPONENTIAL GROWTH RATES (% per annum)

Year	PAKISTAN area	PAKISTAN product	PAKISTAN yield	NWFP area	NWFP product	NWFP yield	PUNJAB area	PUNJAB product	PUNJAB yield	SINDH* area	SINDH* product	SINDH* yield	BALOCHISTAN** area	BALOCHISTAN** product	BALOCHISTAN** yield
1970/71 TO 1986/87	0.9	3.0	2.0	1.6	6.5	5.0	1.7	3.7	2.0	1.5	4.7	3.1	4.4	20.7	16.3

Source: Computed from MINFA series.

TABLE 3.19

Area and Yield Effects for Selected Periods (Indices)*
Marginal

Year	PAKISTAN area	PAKISTAN yield	PAKISTAN multiple	NWFP area	NWFP yield	NWFP multiple	PUNJAB area	PUNJAB yield	PUNJAB multiple	SINDH area	SINDH yield	SINDH multiple	BALOCHISTAN area	BALOCHISTAN yield	BALOCHISTAN multiple
1970/71 TO 1986/87	-0.3	100.4	-0.3	21.5	55.3	23.3	5.1	87.0	7.9	21.5	67.8		13.4	66.5	20.1

* Indices sum to 100 for each period
** Computed over 15 years 1970/71-1985/86
*** Computed over 15 years 1971/72-1986/87

EXPONENTIAL GROWTH RATES (% per annum)

Year	PAKISTAN area	PAKISTAN product	PAKISTAN yield	NWFP area	NWFP product	NWFP yield	PUNJAB area	PUNJAB product	PUNJAB yield	SINDH area	SINDH product	SINDH yield	BALOCHISTAN area	BALOCHISTAN product	BALOCHISTAN yield
1970/71 TO 1986/87	0.0	4.5	4.6	2.2	6.8	4.6	0.5	6.4	5.8	1.0	3.7	2.7	1.8	7.9	6.1

Source: Computed from MINFA series.

3.6 Summary of the Macro Analysis

This macro analysis has brought out a few important findings. There are two aspects of macro policy. Macro price policy has a major impact on crop area. It obviously can become a disincentive for crop yields, but this has not really been observed.

Macro infrastructure has an impact on both area an yields. Typically, irrigation expansion permits area expansion. However irrigation expansion has been seen to permit yield expansion for rice prior to the HYV package introduction. Irrigation expansion has allowed the introduction of HYVs of wheat, increasing yields. Moreover in irrigated wheat areas, yields have still not peaked.

Macro infrastructure in terms of provision of fertilizer and pesticides also has a major impact on yields. Cotton yields are the best example of the boost given by pesticides to yields. Rice yields may be constrained by the low levels of pesticide use. Fertilizer has been a necessary complement to HYV seeds in increasing yields, although there may now be decreasing returns for fertilizer use on HYV wheat.

So macro analysis points to input decision making as the major determinant of yields. Input decision making depends upon the micro environment of the producer. Macro price policies are seen to have a looser relationship with this micro environment with respect to yields. Macro infrastructure and research policies are seen to have a stronger relationship with this micro environment with respect to yields. This micro environment can now be examined for its impact on crop yields.

4. MICRO-LEVEL CROSS SECTIONAL ANALYSIS OF THE DETERMINANTS OF CROP PRODUCTIVITY

4.1 Introduction and Data Sources

Producers' decision making about input use determines crop yields. Producers decisions have been argued in the literature above, to depend at least in part on the agrarian structure that generates the producers environment. Therefore crop yields have two levels of determinants. In the first instance, observed input levels determine yields. In the second instance, these input levels themselves are not determined by abstractly generalizable algorithms like profit maximization. The immediate agrarian structure generates market imperfections. This can create categories of producers distinguished by differentials in their production decisions. The major categories thrown up by the literature above have been farm size, tenure, family labor reliance, and wage labor reliance.

The macro analysis has thrown up a few more geophysical categories that may distinguish producers in their decision making, like regions. The macro analysis has also thrown up irrigation as an important determinant of yields. So all these structural categories may differentiate producers in their input decision making, and therefore differentiate yields.

So yields can be determined by simple input levels. And yields can by determined by different categories of producers choosing different input levels. At the micro level therefore we need to correlate differentials in yields to differentials in inputs, and to differentials in producers.

We have used three sets of data to carry out this exercise. There is a WAPDA sample survey for 1988. There is another WAPDA sample survey for 1977. And there is an IIMI sample survey for 1988. The IIMI data contains no structural variables, only input variables. The WAPDA data allows the construction of some structural variables, although it has been designed primarily for the use of its input variables. Therefore as a data caveat, these WAPDA data sets are not well suited for testing structural variables. In this section, we first test the WAPDA 1988 data set for structural and input variables. We then similarly test the WAPDA 1977 data set. Finally we test the IIMI data set for input variables.

4.2 Structural and Input Determinants Using WAPDA 1988 Data

Structural and input determinants are tested first in tabular form, then the more significant variables are tested using regression estimations.

We have been able to construct 9 possible structural determinants of yields using WAPDA 1988 data. Table 4.1 presents the tabular results. The table estimates yields for wheat, cotton, fine grain basmati rice, and coarse IRRI rice. The structural determinants of yields are farm size, tenure, family size, producer's education, crop zones, irrigation source, water course position, depth of the water table, and the proportion of cultivated area which is saline. Each

structural determinant has been divided into a few discrete categories, for which mean yields have been estimated. For instance there are five farm sizes. A difference in yields between the farm sizes would justify farm size as a determinant of yield.

Since this table is based on category means, this tells us nothing about the standard deviation within each category, or across categories. Consequently differences between two categories means may hide more significant differences within each categories observations. So there is a need to determine the significance of differences between two categories means. This is done by calculating the pair wise t values and their significance, for the differences between each pair of means in a determinant, where possible.

For example farm size has 5 categories of size. Each size has a different mean yield for wheat. However only two pairs of means are significantly different from each other, the first and fourth, and the first and fifth. The pairs of means significantly different from each other are indicated in the table by a common character. So the means 1.72 and 1.99 are significantly different from each other, and this is indicated by an 'a' in front of each. 1.72 is also significantly different from 2.03, and this is indicated by a 'b' in front of each mean. This implies that 1.72 has both an 'a' and a 'b' in front of it, indicating that it is significantly different from both 1.99 and 2.03. This significance is at the 10% level, indicating of course that there is a 90% probability that the differences between pairs of observations forms a distinct t distribution. In some cases not can be calculated because of a lack of variance.

Table 4.1 shows that only a few structural determinants showed a consistent relationship with crop yields.

Farm size is one such variable. For wheat, mean yields increase consistently across farm size. And the tails of the size distribution are significantly different from each other. Cotton also shows a positive relationship with farm size, with the tails of the distribution significantly different from each other. For coarse and fine rice, large farms again have higher yields than small farms, but with no significance.

For tenure, owners' yields are significantly above tenants yields for wheat and cotton. However for fine and coarse rice, this relationship is reversed though with no significance. So no consistent relationship emerges here. Family size shows no consistent relationship with yields for any of the crops.

TABLE 4.1

WAPDA 1988
CROP YIELDS (TONS/HA)

VARIABLES	WHEAT VALUE	WHEAT SIG	COTTON VALUE	COTTON SIG	FINE RICE VALUE	FINE RICE SIG	COARSE RICE VALUE	COARSE RICE SIG
STRUCTURAL								
ZONES								
PUNJAB COTTON WHEAT	1.86	(NOT)	1.48	(NOT)	2.04	(NOT)	1.97	(NOT)
PUNJAB MIXED WHEAT	1.65		1.01		1.87		2.21	
PUNJAB RICE WHEAT	2.0		1.00		2.26		2.84	
" SUGARCANE WHEAT	1.73		1.10		1.53		-	
SIND COTTON WHEAT	1.73		0.95		-		2.07	
SIND RICE WHEAT	1.59		0.73		1.98		2.20	
NWFP	1.60		0.10		-		-	
TOTAL	1.84		1023		1.96		2.19	
TENURE								
OWNERS	1.90	AB	1.24	AB	1.93		2.08	A
OWNER RENTIERS	1.94	C	1.81	ACD	2.47	A	1.00	
OWNERS TENANTS	1.76	D	1.00	CE	1.88	A	2.82	A
RENTIERS	2.29	ADE	1.72	BEF	2.26		2.30	
TENANTS	1.61	BCF	1.09	DF	2.22		2.32	
TENANT RENTIERS	1.85		1.05	1.48	1.25			
TOTAL	1.84		1.24		1.98		2.20	
IRRIGATION SOURCE								
CANAL & PUBLIC TW								
PRIVATE TW	1.69		1.19		1.96		-	
CANAL	1.71	0.98	1.84		1.84		2.19	
CANAL & PUBLIC TW	1.92		0.80		1.88		2.24	
CANAL & PRIVATE TW	2.00		1.56		1.97		2.25	
PRIVATE TW	2.15		0.79		2.68		-	
OTHER	1.59		0.79		1.57		1.57	
TOTAL	1.84		1.24		1.96		2.20	
WATER COURSE POSITION								
HEAD	1.85		1.17		1.87		2.30	
MIDDLE	1.77		1.27		2.11		1.99	
TAIL	1.92		1.27		1.92		2.27	
TOTAL	1.84		1.23		1.96		2.19	
DEPTH OF WATER TABLE (FT)								
< 6	1.49		0.94		1.02		1.89	
6 - < 12	1.94		1.19		1.82		2.51	
12 - < 18	1.94		1.22		1.86		2.79	
18 - < 25	2.07		1.19		2.28		2.56	
25 - < 30	1.80		1.32		2.16		3.46	
30 - < 60	1.91		1.72		2.34		2.44	
TOTAL	1.86		1.24		1.96		2.21	
SALINE AREA % OF CULTIVATED								
0	1.67		1.06		1.45		2.98	
0 - < 10	1.95		1.50		2.26		2.34	
10 - (25	1.30		1.18		1.94		2.38	
5 - < 100	1.73		0.76		1.38		1.59	
TOTAL	1.67		1.14		1.73		2.27	

FAMILY SIZE (NO)				
< 8	1.88	1.27	1.88	2.14
8 - < 15	1.80	1.20	2.70	2.28
> 15	1.85	1.24	1.69	2.19
TOTAL	1.84	1.24	1.96	2.20
YEARSA OF EDUCATION				
0	1.56	0.87	-	2.64
0 < 4	2.03	1.43	-	2.34
4 - < 8	1.96	1.26	-	2.37
> 8	2.21	1.59	-	1.94
TOTAL	1.88	1.23		2.42
FARM SIZE (CULTIVATED AREA) (ACRES)				
< 5	1.72	1.20	1.73	2.16
5 - < 12.5	1.82	1.17	2.04	2.06
12.5 - < 25	1.83	1.10	1.83	2.26
25 - < 50	1.99	1.58	1.90	2.29
> 50	2.03	1.49	2.30	2.40

Source: Computed from WAPDA 1988.

Producer's education shows a generally positive relationship with yields for wheat and cotton, but with no significance available.

In the irrigation variables, canals plus private tubewells, or private tubewells alone, consistently had the highest yields for all four crops, but with no significance available. Surprisingly, the head of the water course did not have the highest yields. Nor was depth of the water table consistently related to yields for any of the crops.

Salinity is generally inversely related to yields for all the crops, but not very consistently, and with no significance available.

Finally the crop zones variable also does not pick up any cross crop consistent relationships. Each crop simply has the highest yield in its relevant crop zone. So wheat has the highest yield in the rice wheat zone. Cotton has the highest yield in the cotton wheat zone. And the two rices have the highest yields in the rice wheat zone.

The impact of inputs on yields is tested in the same way as the impact of the structural variables has been tested. Table 4.2 splits each input into discrete categories, and presents the mean yield and significance for the category. The input variables give better results than the structural variables tested.

Table 4.2 begins with the fertilizer variables. Nitrogenous fertilizer increases on trend with crop yields for all the crops, and with significance. Phosphatic fertilizer also increases with crop yields for all the crops, and with significance. Traditional manure however no longer has a consistently increasing impact on yields for any of the crops. Nor is there any significance available.

The seed rate does not have a systematically increasing relationship with the two crop yields it was available for, wheat and IRRI.

TABLE 4.2

WAPDA 88: DEPENDENT VARIABLE = YIELD (TONS/HA

INDEPENDENT	R^2	WHEAT X	SIG	R^2	COTTON X	SIG	R^2	FINE RICE X	SIG	R^2	COARSE RICE X	SIG
EQUATION	.11 B	1.8	(.00) SIG	.07 B	0.7	(.00) SIG	.62 B	0.8	(.00) SIG	.28 B	3.0	(.00) SIG
SALINE %	-0.01		(.00)				0.02		(.11)	-0.02		(.00)
YEARS OF EDUCATION	0.02		(.18)	0.04		(.03)						
NO DEPENDENTS	-0.01		(.18)									
DEPTH WATER TABLE POSITION	-0.01		(.28)				0.03		(.05)			
WATER COURSE	-0.05		(.48)									
FARM SIZE							0.02		(.02)			

Source: Computed from WAPDA 1988.

The number of irrigations consistently increase with crop yields, for all the crops, although no significance is available here.

The variable "tractor plowing" consistently increase with yields for all the crops, although again with no significance available. The traditional variable of bullock plowing however no longer consistently increases with yields for any of the crops. The number of planking does not consistently increase with yields for any of the crops.

The labor variables are as interesting as the labor displacing variables, so they have been left to the last. The number of family laborers is not consistently positively correlated to yields for any of the crops. However we have no significance for this variable. The number of permanently hired laborers does not consistently increase with the yield for any crop. However, the addition of at least one permanent laborer raises the crop yield for wheat, cotton, and basmati rice, significantly.

The two labor results and the tractor and bullock results are very important. The family labor and bullock results shows the weakening of the traditionally posited, strong positive relationship between cheap family labor and yields. The permanent labor and tractor results show the emergence of a new positive relationship between hired labor plus labor augmenting mechanization, and yields. This result supports the erosion of the yield advantage of the small family labor based farm, and the emergence of the positive relationship between farm size and yields seen above.

The more consistent relationships from Tables 12.1 and 13.1 were tested using Ordinary Least Squares (OLS) regression estimates. Table 4.3 presents the parametric results of the multi variate equations. The table tests the structural and input determinants of yields. Table 4.4 presents the correlation matrix for all the variables. Given that the tabular and regression results seem to show that some structural variables determine yields, Table 4.8 then investigates the implication that these structural variables in the first instance determine inputs, which in the second instance determine yields.

In Table 4.3, 4 structural variables and 9 input variables were regressed on crop yields. Wheat, cotton and coarse rice have a similar fit, with R^2s ranging between 0.43 and 0.48. Basmati rice has a much higher fit with an R^2 of 0.99.

The first important result for the structural variables is a negative one. Farm size is insignificantly correlated to three out of four crop yields, and so is system dropped from the equations. To test whether this insignificance of farm size may be due to multicollinearity, given the large number of determinants in the equation, Table 4.4 presents a correlation matrix for each variable. Farm size is seen to have a weak correlation with yield, for wheat, cotton, and coarse rice. Only for basmati rice does farm size have a strong positive correlation of 0.38 with yield.

TABLE 4.3

WAPDA 1988: DEPENDENT VARIABLE = YIELD (TONS/HA)

	WHEAT		COTTON		COARSE RICE		FINE RICE	
	VALUE	(SIG)	VALUE	(SIG)	VALUE	(SIG)	VALUE	(SIG)
R SQUARE	0.45		0.43		0.48		0.99	
ALPHA	1.49	(0.00)	0.20	(0.58)	3.94	(0.00)	0.32	(0.17)
Independent Variables	BETA		BETA		BETA		BETA	
Years of Education			0.07	(0.00)	-0.09	(0.07)	0.07	(0.02)
Farm Size			-0.03	(0.06)				
Depth Water Table	-0.02	(0.00)	-0.007	(0.40)	-0.01	(0.39)	0.09	(0.04)
No Irrigations	0.07	(0.19)	0.10	(0.11)			0.002	(0.17)
Nitrogen/ha	0.01	(0.01)	0.004	(0.13)	0.01	(0.01)	0.01	(0.13)
No Bullock Ploughing	-0.03	(0.02)	-0.06	(0.10)				
No Planting	0.10	(0.06)	0.19	(0.01)	-0.16	(0.15)		
% Salinity	-0.01	(0.00)			-0.04	(0.01)	0.04	
Seed/ha	-0.003	(0.13)			-0.01	(0.13)		
No Family Labor	-0.02	(0.25)			-0.03	(0.15)	0.11	(0.02)
Manure/ha	0.06	(0.00)						
No Wage Labor	0.01	(0.24)						
No Tractor Ploughing							0.15	(0.16)

Source: Computed from WAPDA 1988.

TABLE 4.4

WAPDA '88: CORRELATION MATRIX FOR WHEAT

Yield	Nitr ha	Phos ha	Seed ha	Manure ha	No Farm Labor	No Irrig	No Trac Plow	No Bull Plow	No Plants	No Wage Labor	Farm Size	Depth Water		% Salinity	Years Educ
Yield	1.00	0.12	0.11	-0.01	0.37**	-0.13	0.31*	0.13	-0.07	0.21	0.09	-0.03	-0.19	-0.26*	0.14
Nitrogen/ha		1.00	0.64**	0.56**	-0.11	-0.02	0.09	0.05	-0.15	-0.09	-0.07	-0.31*	0.17	-0.02	0.07
Phosphate/ha			1.00	0.21	-0.04	-0.07	0.25*	0.09	-0.14	0.05	-0.06	-0.31*	0.25*	0.09	0.06
Seed/ha				1.00	0.07	-0.06	-0.30*	-0.02	-0.17	-0.34**	-0.11	-0.42**	-0.08	0.04	-0.08
Manure/ha					1.00	-0.09	0.12	0.06	-0.10	-0.08	-0.01	-0.17	0.02	0.02	-0.03
No Farm Labor						1.00	-0.04	-0.12	0.06	-0.12	-0.07	0.33**	0.04	-0.18	-0.10
No Irrigation							1.00	0.10	-0.04	0.23	0.10	0.10	0.08	-0.12	0.10
No Tractor Plow								1.00	-0.54**	0.20	0.06	0.14	0.01	0.05	0.32*
No Bull Plow									1.00	0.35**	-0.11	0.07	-0.07	-0.13	-0.24
No Planting										1.00	-0.09	0.06	-0.05	-0.10	0.03
No Wage labor											1.00	0.32*	0.13	-0.09	0.35**
Farm Size												1.00	-0.04	-0.12	0.21
Depth Water													1.00	-0.23	-0.01
% Salinity														1.00	-0.01
Years Education															1.00

NOTE: * = Significance 0.01
** = Significance 0.001

Source: Computed from WAPDA 1988.

TABLE 4.5

WAPDA '88: CORRELATION MATRIX FOR COTTON

	Yield	Nitr ha	Phos ha	Seed ha	Manure ha	No Farm Labor	No Irrig	No Trac Plough	No Bull Plough	No Plants	No Wage Labor	Farm Size	Depth Water	% Salinity	Years Educ
Yield	1.00	0.25	0.11	0.15	0.07**	-0.06	0.22	0.25	-0.30	0.17	0.09	-0.06	0.04	-0.09	0.45**
Nitrogen/ha		1.00	0.43*	0.81**	0.28	-0.07	0.10	0.31	-0.25	-0.32	0.23	-0.08	0.28	0.22	0.19
Phosphate/ha			1.00	0.26	0.03	0.01	0.17	0.16	-0.11	-0.12	0.07	-0.11	0.58**	0.01	0.08
Seed/ha				1.00	0.37*	-0.15	0.06	0.28	-0.32	-0.42*	0.08	-0.24	0.16	0.32	0.04
Manure/ha					1.00	-0.13	0.16	0.10	-0.21	-0.14	-0.10	-0.29	0.05	0.04	-0.08
No Farm Labor						1.00	0.15	-0.08	0.13	0.19	-0.25	0.07	-0.12	-0.01	-0.10
No Irrigation							1.00	0.00	-0.09	0.05	-0.07	-0.05	0.25	-0.08	-0.05
No Tractor Plow								1.00	-0.56**	0.03	0.31	0.27	0.00	0.08	0.26
No Bull Plow									1.00	0.23	0.14	-0.05	0.00	-0.13	-0.23
No Planting										1.00	0.10	0.25	-0.07	-0.33	0.01
No Wage labor											1.00	0.62**	0.13	-0.09	0.38*
Farm Size												1.00	-0.03	0.00	0.26
Depth Water													1.00	-0.25	0.12
% Salinity														1.00	-0.24
Years Education															1.00

NOTE: * = Significance 0.01
** = Significance 0.001

Source: Computed from WAPDA 1988.

TABLE 4.6

WAPDA '88: CORRELATION MATRIX FOR COARSE RICE

	Yield	Nitr ha	Phos ha	Seed ha	Manure ha	No Farm Labor	No Irrig	No Trac Plow	No Bull Plow	No Plants	No Wage Labor	Farm Size	Depth Water	% Salinity	Years Educ
Yield	1.00	0.33	0.15	0.07	0.25	0.03	0.15	-0.04	-0.16	-0.39*	-0.03	-0.01	0.05	-0.46*	-0.29
Nitrogen/ha		1.00	0.59**	0.55**	0.33	0.23	0.52**	-0.09	0.00	-0.16	-0.13	-0.14	0.15	0.03	-0.30
Phosphate/ha			1.00	0.77**	-0.16	0.06	0.32	-0.03	0.03	-0.15	-0.23	-0.32	0.06	0.01	-0.35
Seed/ha				1.00	0.04	-0.01	0.57**	-0.26	0.08	-0.22	-0.37	-0.56**	0.14	0.11	-0.44*
Manure/ha					1.00	-0.07	0.17	-0.31	-0.01	-0.17	-0.09	-0.20	0.00	-0.19	-0.15
No Farm Labor						1.00	0.04	0.42*	-0.06	-0.07	-0.06	0.22	-0.03	-0.23	-0.09
No Irrigation							1.00	-0.31	0.11	-0.07	-0.38*	-0.45*	0.14	0.14	-0.41*
No Tractor Plow								1.00	-0.45*	-0.04	0.37	0.59**	0.22	-0.29	0.35
No Bull Plow									1.00	0.28	-0.11	-0.03	0.02	0.16	-0.19
No Planting										1.00	-0.01	0.14	-0.08	0.39*	0.04
No Wage labor											1.00	0.57**	0.05	-0.07	0.59**
Farm Size												1.00	0.00	-0.14	0.39*
Depth Water													1.00	-0.24	-0.05
% Salinity														1.00	0.04
Years Education															1.00

NOTE: * = Significance 0.01
** = Significance 0.001

Source: Computed from WAPDA 1988

TABLE 4.7

WAPDA '88: CORRELATION MATRIX FOR FINE RICE

	Yield	Nitr ha	Phos ha	Seed ha	Manure ha	No Farm Labor	No Irrig	No Trac Plough	No Bull Plough	No Plants	No Wage Labor	Farm Size	Depth Water	% Salinity	Years Educ
Yield	1.00	0.27	0.31	-0.02	0.07	0.43	0.48	0.53	-0.26	0.04	-0.42	0.38	0.32	0.47	0.35
Nitrogen/ha		1.00	0.96**	0.92**	0.89*	0.11	0.54	0.35	-0.25	-0.30	-0.23	-0.30	0.49	0.54	-0.27
Phosphate/ha			1.00	0.89*	0.90*	0.10	0.63	0.37	-0.39	-0.41	-0.16	-0.27	0.49	0.63	-0.25
Seed/ha				1.00	0.97**	-0.18	0.52	0.28	-0.34	-0.52	-0.19	-0.46	0.42	0.45	-0.32
Manure/ha					1.00	0.24	0.67	0.32	-0.46	-0.62	-0.21	-0.44	0.50	0.55	-0.28
No Farm Labor						1.00	-0.17	-0.02	0.30	0.23	-0.45	0.22	-0.27	0.04	0.02
No Irrigation							1.00	0.11	-0.29	-0.43	-0.25	-0.43	0.80	0.47	-0.32
No Tractor Plow								1.00	-0.82*	-0.39	-0.29	0.60	-0.16	0.57	0.77
No Bull Plow									1.00	0.75	0.18	-0.38	0.14	-0.63	-0.62
No Planting										1.00	0.47	0.17	0.11	-0.42	-0.16
No Wage labor											1.00	0.00	0.15	-0.25	-0.22
Farm Size												1.00	-0.54	0.37	0.90*
Depth Water													1.00	0.17	-0.57
% Salinity														1.00	0.34
Years Education															1.00

NOTE: * = Significance 0.01
** = Significance 0.001

Source: Computed from WAPDA 1988.

The second structural variable tested, farmer's years of education, emerges as an important determinant of yield for three crops. Table 4.3 shows that education is significantly positively correlated to cotton and basmati rice yields. The correlation matrix in Table 4.4further shows that for wheat education is also positively though weakly correlated to yields. It is important to note that this education variable is one of schooling, and not for extension information.

The third structural variable tested, the depth of the water table gave no consistently significant results across the four crops, in Table 4.3. The correlation matrix in Table 4.4 confirms that this insignificance is not due to multicollinearity.

The fourth structural variable, the percentage of salinity is significantly negatively correlated to yields for wheat, coarse rice, and basmati, in Table 4.3. The correlation matrix in Table 4.4 adds to this result however. For wheat and cotton salinity has low negative correlation with yield. For coarse rice salinity has a strong negative correlation with yield. For basmati, salinity has a strong positive correlation with yield. Clearly what is happening is that the salinity effect is being affected by the basmati rice area effect. Basmati rice yields are higher in the basmati rice zone, which is also more saline. This data however will not permit a regional disaggregation by rice varieties to test this explanation further.

Tables 4.3 and 4.4 also present the input variable results. The first input variable tested, the number of irrigations, gives a strong positive result. Table 4.3 shows that irrigation is positively correlated to yields, for wheat, cotton, and basmati, with marginal significance. The correlation matrix further strengthens this result by showing strong VK correlations between irrigation and yield, for wheat, and basmati, and weaker though VK correlations for cotton and coarse rice.

The second input variable tested, fertilizer per ha. also gives a positive result. Table 4.3 shows that Nitrogen per ha. is significantly positively correlated to yields for wheat, cotton, and coarse rice. The correlation matrix in Table 4.4 picks up the variables system dropped in Table 4.3. Basmati is also shown to have a strong positive correlation between nitrogen and yield. And all four crops have a positive correlation between Phosphate per ha. and yield.

Needless to say, fertilizer and irrigation are positively correlated, for all four crops, in Table 4.4.

Manure per ha also has a significant positive correlation to yield for at least two crops. Table 4.3 shows that manure is significantly positively correlated to yield for wheat. For the other crops manure has been system dropped in Table 4.3. The correlation matrix in Table 4.4 however shows that manure is also significantly positively correlated to yield for coarse rice.

Seed per ha is neither consistently nor significantly correlated to yields for any of the four crops, in Tables 4.3 and 4.4.

This leaves the two labor variables, and the two farm power variables. Tables 4.3 and 4.4 show that the number of family laborers are only significantly positively correlated to yield for only one crop, basmati. This is an important result because it shows the decline of a major traditional, non commercial input, in contributing to high yields. The second non commercial input whose importance is seen to decline is bullocks. The number of bullock plowing is not positively correlated to yields for any of the four crops, in Tables 4.3 and 4.4.

If neither of the non commercial labor and power inputs contribute to high yields, then the remaining commercial inputs should. The number of wage laborers is not significantly positively correlated to yields for any of the four crops, in Tables 4.3 and 4.4. The number of tractor plowing is however significantly and positively correlated to yields for wheat, cotton, and especially strongly for basmati. So clearly, tractors are substituting for labor, both family and hired, and are associated with high yields.

In summary, from the structural variables, human capital in the form of schooling is associated with high yields for wheat, cotton, and basmati. Farm size is associated with high yields for only basmati. And of course salinity lowers yields for wheat cotton and rice. From the input variables, commercial inputs like irrigation, fertilizer, and tractors increase yields for all four crops. Non commercial inputs like family labor and bullocks are associated with lower yields for all four crops.

Now if structural variables like human capital, and farm size, do affect yields positively for some crops, then they must affect them through inputs. The advantages of human capital and farm size must lead to the higher adoption of some inputs, particularly commercial inputs since these are positively correlated to yields, which produces higher yields. This hypothesis can be tested using Table 4.8. Table 4.8 tests whether the various input levels are determined by the two structural variables, human capital, and farm size.

Table 4.8 shows that farmer's education is significantly and positively correlated mostly to commercial inputs. And from amongst commercial inputs, farmers education is more significantly positively correlated to more complex inputs like fertilizer and tractors, rather than more traditional commercial inputs like irrigation.

So on the one hand, Table 4.8 shows that farmer's education is significantly and positively correlated to commercial inputs like nitrogen and phosphate for wheat and cotton. Education is positively correlated to irrigation for wheat. Education is positively correlated to tractor plowing for wheat, cotton, and rice. And education is significantly and positively correlated to wage labor for wheat cotton and rice. On the other hand, Table 4.8 shows that education is not positively correlated to non commercial inputs like manure, family labor, and bullock plowing for any of the crops.

TABLE 4.8
Correlation Matrix for Education and Commercial Inputs

WAPDA '88

DEPENDENT VARIABLES		WHEAT Independent Variables Yrs. Education Coeff (sig) Value	WHEAT Farm Size Coeff (sig) Value	COTTON Yrs. Education Coeff (sig) Value	COTTON Farm Size Coeff (sig) Value	COARSE RICE Yrs. Education Coeff (sig) Value	COARSE RICE Farm Size Coeff (sig) Value	FINE RICE Yrs. Education Coeff (sig) Value	FINE RICE Farm Size Coeff (sig) Value
	R-Square	0.02		0.23		0.06		0.17	
Yield	Alpha	146 (0.00)		0.93 (0.00)		3.04 (0.00)		1.26 (0.00)	
	Beta	0.03 (0.12)		0.08 (0.00)	-0.02 (0.15)	-0.08 (0.11)			0.03 (0.26)
	R-Square	0.12		0.06		0.08		0.08	
Nitrogen/ha	Alpha	48.1 (0.00)		36.1 (0.00)		76.7 (0.00)		24.4 (0.11)	
	Beta	1.42 (0.08)	-1.86 (0.00)	1.81 (0.11)	-0.91 (0.30)	-3.3 (0.07)			-1.06 (0.45)
	R-Square	0.10		0.03		0.16		0.07	
Phosphate/ha	Alpha	25 (0.00)		18.38 (0.00)		48.1 (0.00)		13.8 (0.23)	
	Beta	1.00 (0.11)	-1.34 (0.00)	0.81 (0.44)	-0.83 (0.31)	-1.77 (0.14)	-0.98 (0.13)		-0.76 (0.50)
	R-Square	0.13		0.07		0.36			
Seed/ha	Alpha	70.8 (0.00)		9.89 (0.00)		91.7 (0.00)			
	Beta		-2.11 (0.00)	0.25 (0.34)	-0.37 (0.07)	-2.3 (0.10)	-2.6 (0.00)		
	R-Square	0.03		0.08		0.04			
Manure/ha	Alpha	2.27 (0.00)		1.92 (0.00)		6.79 (0.02)			
	Beta		-0.13 (0.08)		-0.12 (0.04)		-0.39 (0.22)		
	R-Square	0.13		0.01		0.07			
No Family Labor	Alpha	4.68 (0.00)		5.83 (0.00)		6.76 (0.00)			
	Beta	-0.20 (0.09)	0.28 (0.00)	-0.10 (0.49)		-0.33 (0.33)	0.30 (0.10)		
	R-Square	0.02				0.25			
No Irrigation	Alpha	3.51 (0.00)				99.2 (0.00)			
	Beta	0.03 (0.44)	0.03 (0.26)			-2.23 (0.18)	-2.24 (0.02)		
	R-Square	0.11		0.10		0.32			
No Tractor	Alpha	1.79 (0.00)		1.64 (0.00)		1.23 (0.00)			
Plowings	Beta	0.19 (0.00)		0.12 (0.17)	0.09 (0.18)	0.07 (0.19)	0.09 (0.00)		
	R-Square	0.08		0.06		0.03			
No Bull	Alpha	2.4 (0.00)		3.39 (0.00)		2.74 (0.01)			
Plowings	Beta	-0.19 (0.00)	0.06 (0.19)	-0.21 (0.09)		-0.26 (0.24)			
	R-Square			0.07		0.02			
No Plantings	Alpha			2.00 (0.00)		0.78 (0.02)			
	Beta			-0.03 (0.47)	0.06 (0.06)		0.03 (0.39)		
	R-Square	0.18		0.44		0.49			
No Wage Labor	Alpha	-2.3 (0.03)		-6.03 (0.00)		-5.15 (0.00)			
	Beta	0.60 (0.00)	0.32 (0.00)	0.55 (0.03)	0.98 (0.00)	1.27 (0.00)	0.61 (0.00)		

Source: Computed from WAPDA 1988.

The second distinction Table 4.8 allows is between more complex, new knowledge based commercial inputs like fertilizer and tractors, and less complex, more traditional knowledge based inputs like irrigation. Table 4.8 shows that education is positively and significantly correlated to new commercial inputs like fertilizer over a greater number of crops. Education is positively and significantly correlated to older commercial inputs like irrigation over a fewer number of crops.

The structural variable of farm size is seen to only determine farm labor and farm power. Table 4.8 shows that farm size is significantly and positively correlated to wage labor for wheat, cotton, and rice. And farm size is positively correlated to tractor plowing for cotton and rice.

So the WAPDA 1988 data set shows that commercial inputs like irrigation, fertilizer, and tractors are strongly associated with yields for wheat cotton and rice. Non commercial inputs like bullocks and family labor are weakly associated with yields for these crops. The data set also shows that human capital is strongly associated with higher use of new knowledge based inputs like fertilizer and tractors. And farm size, a proxy for internal resources is associated with the higher use of commercial farm power, like tractors.

4.3 Structural and Input Determinants Using WAPDA 1977 Data

The WAPDA 1977 data set, being a decade prior, cannot be expected to exhibit the same results as the WAPDA 1988 data. The macro analysis above has shown that agricultural growth picked up only in the decade of the 1960s, with the introduction of the new inputs, irrigation, fertilizer and pesticides, and some improvement in pricing policy. Consequently the decade of the 1970s is really the first decade of adoption, and input use was not very widespread by the time of the WAPDA 1977 survey. This changes our expectations of the relationships between structural variables and yield, and between inputs and yield. We can expect weaker relationships in 1977 compared to 1988.

For structural relationships, there is some evidence that these were just developing by 1977, and indeed even by 1988 are not yet fully developed. For inputs the 1977 data does not show the same strong associations between commercial inputs and yields.

Table 4.9 presents the mean yields by structural categories. Table 4.10 presents the mean yields by inputs. Table 4.11 tests the determination of yields by structural and input variables in a multi variate regression. Table 4.12 presents the correlation matrix for all these variables. Since by 1977, adoption of HYVs was not as universal as by 1988, so here wheat cotton and rice have Low Yielding Varieties (LYV), as well as HYVs. The number of variables in this initial WAPDA survey of 1977 is also less than those available in the 1988 WAPDA survey.

TABLE 4.9
Mean Yields by Structural Categories

WAPDA 88: DEPENDENT VARIABLE = YIELD (TONS/HA

INDEPENDENT	WHEAT			COTTON			FINE RICE			COARSE RICE		
	R^2	X	SIG	R^2	X	SIG	R^2	X	SIG	R^2	X	SIG
EQUATION 2:	.27	0.8	(.00)	.22	0.1	(.71)	.99	1.9	(.02)	.26	2.8	(.00)
	B		SIG	B		SIG	B		SIG	B		SIG
MANURE/HA	0.05		(.00)				-0.07		(.02)	0.02		(.28)
NITROGEN/HA	0.003		(.06)	0.01		(.08)	0.04		(.03)	0.003		(.53)
NO PLANTIGS	0.1		(.03)	0.17		(.04)	-0.12		(.03)	-0.23		(.04)
NO IRRIGATION	0.09		(.06)	0.09		(19)	0.01		(.01)	0.01		(.36)
NO HIRED LABOURERS	0.01		(.25)				-0.01		(.19)			
NO FAMILY LABOUR	-0.01		(.40)	-0.02		(.49)	-0.03		(.14)			
NO BULLOCK PLANTINGS				-0.03		(.21)						
NO TRACTOR PLOWINGS				0.03		(.48)	0.14		(0.02)			
SEEDS/HA										-0.01		(.12)
PHOSPHATE/HA										0.01		(.26)

Source: Computed from WAPDA 1988.

TABLE 4.10
Mean Yields by Inputs

WAPDA 88 DEPENDENT VARIABLE = YIELD (TONS/HA)

INDEPENDENT	WHEAT			COTTON			LYV RICE			HYV RICE		
VARIABLE	R^2	X (SIG)	B (SIG)	R^2	X (SIG)	B (SIG)	R^2	X (SIG)	B (SIG)	R^2	X	B
NITROGEN/HA	.01	1.7 (.06)	0.002 (.03)	.19	0.9 (.00	0.01 (.00)	.09	1.7 (.00)	0.01 (.00)	.09	1.9 (.00	0.01 (.00)
PHOSPHATE/HA	.02	1.7 (.00)	0.01 (.00)	.10	1.04 (.00	0.01 (.00)	.15	1.8 (.00)	0.02 (.00)	.05	2.2 (.00	0.01 (.04)
MANURE/HA	.01	1.7 (.00)	0.03 (.07)	.01	1.2 (.00	0.002 (.27)				.05	2.4 (.00)	0.02 (.06)
NO FAMILY LABOURERS	.01	1.7 (0.00)	-0.01 (.14)				.11	1.4 (.00)	0.06 (.20)			
NO IRRIGATIONS	.02	1.5 (.00)	0.06 (.00)	.12	0.6 (.00	0.12 (.00)				.14	1.7 (.00	0.01 (.00)
NO TRACTOR PLANTINGS	.03	1.7 (.00)	0.05 (.00)	.16	0.8 (.00	0.10 (.00)	.09	1.6 (.00)	0.08 (.01)			
NO HIRED LABOURERS	.02	1.7 (.00)	0.01 (.01)	.09	1.1 (.00	0.02 (.00)						
SEED/HA				.07	1.0 (.00)	0.03 (.00)	.05	1.8 (.00)	0.05 (.05)			
BULLOCHS/HA										.03	2.4 (0.00)	-0.05 (.10)
Table: 14												
FARM SIZE	.01	1.8 (.00)	0.001 (.04)	.03	1.1 (.00	0.001 (.00)	.03	1.8 (.00)	0.001 (.09)	.01	2.1 (.00	0.001 (.38)
O/O SALINE AREA	.05	1.8 (.00)	-0.01 (.00)	.05	1.2 (.00	-0.01 (.00)	.05	1.9 (.00)	-0.01 (.18)	.24	2.8 (.00	-0.02 (.00)
YEARS OF EDUCATION	.03	1.7 (.00)	0.04 (.00)	.08	1.1 (.00)	0.03 (.00)	.16	1.8 (.00)	0.03 (.00)			
DEPTH & WATER TABLE												

Source: Computed from WAPDA 1988 series.

TABLE 4.11
Determination of Yields by Structural and Input Variables

WAPDA '77: DEPENDENT VARIABLE = YIELD (TONS/HA)

	LYV WHEAT Value (sig)	HYV WHEAT Value (sig)	LYV COTTON Value (sig)	HYV COTTON Value (sig)	LYV RICE Value (sig)	HYV RICE Value (sig)
R-SQUARE	0.96	0.14	0.08	0.01	0.30	0.03
ALPHA	5.7 (0.31)	1.4 (0.00)	0.56 (0.32)	0.54 (0.00)	0.54 (0.11)	1.91 (0.00)
Independent Variable	Beta (sig)	Beta (sig)	Beta (sig)	Beta (sig)	Beta (sig)	Beta (sig)
Farm Size	0.11 (0.50)	-0.04 (0.04)		-0.01 (0.30)	0.08 (0.00)	-0.03 (0.09)
Nitrogen/ha			-0.01 (0.19)		0.01 (0.13)	0.00 (0.03)
Phosphate/ha		0.00 (0.03)				
Seed/ha	-0.04 (0.37)	0.00 (0.10)	0.07 (0.04)	0.01 (0.00)	0.00 (0.45)	
Manure/ha	0.00 (0.24)	0.00 (0.00)				
No Family Labor		-0.01 (0.16)				
No Wage Labor		0.14 (0.00)				0.10 (0.00)

Source: Computed from WAPDA 1977.

In Table 4.9, the two structural variables available are farm size and salinity. The salinity variable here is groundwater salinity. The table shows that salinity lowers the yields of each variety of wheat and rice. However when this variable was tested in an the regression equation in Table 4.11, it was system dropped because of low significance.

In Table 4.9, farm size is the more interesting variable. For each crop, the tails of the farm size distribution have high mean yields, with significant differences between them. So the relationship between farm size and crop yields in 1977 is that of a U-shaped curve. Naturally when we estimated a simple linear equation between farm size and crop yields for 1977 data, we did not get a fit. Table 4.11 shows no systematic relationship between farms size and yield across the six crop varieties. The correlation matrix in Table 20 confirms this.

Our tentative explanation for the 1977 and 1988 farm size yield results, and one which calls for more detailed examination in the future, is the following. The 1977 data gives one snapshot in time of the relationship between farm size and yield. Call this t_2. The 1988 data gives another snapshot in time of the relationship between farm size and yield. Call this t_3 If we could have a pre-HYV package snapshot of the relationship between farm size and yield, we could call it t_1.

The literature points to a traditional negative relationship between farm size and yield in t_1, based on the cheap family labor of the small farm. With the HYV package, material capital inputs become as important as labor. Given an imperfect credit market biased against small farms, and lumpy HYV inputs, the advantage of the small farm starts eroding vis a vis the large farm. This gives in t_2 a U-shaped curve.

The disadvantage of large farms in supervising and monitoring hired labor, and therefore using lower labor inputs compared to small farms, is further decreased with the use of tractors. The educational advantage that large farmers undoubtedly have in using technical inputs like pesticides for cotton, gives them a further advantage over small farms. This gives in t3 the beginnings of a positive relationship between farm size and yields. We predict that in the future this positive relationship will become even more statistically robust. The tracing of this somewhat acrobatic relationship between farm size and yields over time, however requires much more research. Here we can cite some secondary evidence to support this conjecture. For t1, a negative relationship between yields and farm size is reported for instance by Khan (1979) for the 1960s. For t_2, a U-shaped curve between yields and farm size is reported by Mahmood and Haq (1981), for macro data, for 1972. For t_3, a positive relationship between yields and farm size is reported by Mahmood (1992) for sample data from the Punjab for the mid-1980s.

TABLE 4.12
Correlation Matrix (Wheat)

WAPADA 1977

VARIABLES	CROP YIELDS (TONS/HA)								
INPUTS	LYV HYV WHEAT RICE		HYV WHEAT		LYV COTTON		HYV COTTOH		LYV RICE
SIG	VALE VALUE	SIG SIG	VALUE	SIG	VALUE	SIG	VALUE	SIG	VALUE
FERTILIZER: NITROGEN/HA									
0 - <40	0.99		1.24		1.29		0.56		0.86
	1.61								
40 - <70	1.12		1.50		0.56		0.64		1.00
	1.89								
70 - <100	1.27		1.78		0.62		0.69		1.01
	2.40								
>100	1.23		1.85		0.75		0.81		0.83
	2.19								
:PHOSPHORUS/HA									
0 - <20	1.09		1.58		0.40		0.59		-
		1.67							
20 -	1.84		1.51		0.51		0.61		-2.00
40 - <60	1.21		1.78		0.61		0.72		1.012.40
>60	0.62		1.77		0.92		0.72		-1.95
SEED KGS/HA									
<40	0.26		1.12		0.57		0.61		1.101.83
40 - <50	0.52		0.63		-		0.39		0.721.95
50 - <80	0.66		1.29		-		1.02		0.861.65
80 - <100	0.98		1.50		-		0.86		0.941.70
>100	1.20		1.61		-		0.05		1.541.33
NO PERMANENT LABOURERS									
0	0.89		1.41		0.59		0.62		0.961.73
0 - <4	0.81		1.65		0.45		0.63		1.512.05
4 - <11	1.33		1.93		-		0.54		0.922.52
>11	-		1.98		-		0.56		-2.26
NO FAMILY LABOURERS									
<5	0.88		1.47		0.57		0.62		0.981.80
5 - <8	1.71		1.25		0.54		0.36		-
>8	-		1.54		-		0.43		-1.67

Source: Computed from WAPDA 1977.

TABLE 4.13
Correlation Matrix (Cotton)

WAPDA '77: CORRELATION MATRIX

WHEAT LYV

	Yield	Nitr ha	Phos ha	Seed ha	Manure ha	Farm Size	No Family Labor	No Wage Labor
Yield	1.00	-0.72	-0.64	0.15	-0.86	0.86	0.59	-0.44
Nitrogen/ha		1.00	0.96*	0.11	0.37	-0.71	-0.11	-0.11
Phosphate/ha			1.00	0.21	0.25	-0.76	-0.21	-0.21
Seed/ha				1.00	-0.59	0.10	0.25	0.25
Manure/ha					1.00	-0.68	-0.64	0.40
Farm Size						1.00	0.78	-0.11
No Family Labor							1.00	-0.25
No Wage Labor								1.00

WHEAT HYV

	Yield	Nitr ha	Phos ha	Seed ha	Manure ha	Farm Size	No Family Labor	No Wage Labor
Yield	1.00	0.02	0.13	0.09	0.25**	0.00	-0.08	0.15
Nitrogen/ha		1.00	0.51	0.00	-0.17*	0.44	0.00	0.32**
Phosphate/ha			1.00	-0.01	-0.14	0.57**	0.00	0.44**
Seed/ha				1.00	-0.05	-0.06	0.00	-0.01
Manure/ha					1.00	-0.29**	-0.05	-0.14
Farm Size						1.00	-0.02	0.66**
No Family Labor							1.00	0.06
No Wage Labor								1.00

NOTE: * = Significance 0.1
** = Significance 0.01

Source: Computed from WAPDA 1977.

TABLE 4.14
Correlation Matrix (Rice)

	COTTON LYV							
	Yield	Nitr ha	Phos ha	Seed ha	Manure ha	Farm Size	No Family Labor	No Wage Labor
Yield	1.00	-0.07		0.22		-0.04		-0.06
Nitrogen/ha		1.00		0.38*		-0.28		0.02
Phosphate/ha			1.00					
Seed/ha				1.00		-0.22		-0.13
Manure/ha					1.00			
Farm Size						1.00		0.01
No Family Labor							1.00	
No Wage Labor								1.00

	COTTON HYV							
	Yield	Nitr ha	Phos ha	Seed ha	Manure ha	Farm Size	No Family Labor	No Wage Labor
Yield	1.00	0.00		0.11*		-0.04		-0.04
Nitrogen/ha		1.00		0.07		0.36**		0.32**
Phosphate/ha			1.00					
Seed/ha				1.00		-0.04		-0.08
Manure/ha					1.00			
Farm Size						1.00		0.66**
No Family Labor							1.00	
No Wage Labor								1.00

NOTE: * = Significance 0.1
** = Significance 0.01

Source: Computed from WAPDA 1977.

Here we simply note that in 1988 three structural determinants are seen to weakly constrain yields, farm size, producer's education, and salinity.

The positive relationship of commercial inputs to yields, and the weakening family labor relationship to yields, observed in the WAPDA 1988 data, are also weakly confirmed by the WAPDA 1977 data.

In Table 4.12, nitrogen has a more consistently positive and significant relationship with yields for the HYVs of wheat, cotton, and rice. In Table 4.11, nitrogen is significant and positive only for rice. This is confirmed by the correlation matrix in Table 4.12.

In Table 4.12, Phosphate generally increases with yield for all the crops, except LYV wheat. In Table 4.11, phosphate is significant and positive only for HYV wheat. In fact wheat was probably the only crop to which phosphate was applied in any great quantity in the mid-1970s, which is why it drops out of the correlation matrix for rice and cotton in Table 4.12.

In Table 4.10, the seed rate has a consistently increasing relationship with yield, for both varieties of wheat. In Table 4.11, the seed rate is significant and positive for LYV wheat, and both the cottons. It is interesting that in the early years of adoption of HYVs, the WAPDA 1977 data shows seeds to be a significant determinant of yields. In comparison, by 1988 when HYVs had become more universalized and hybrid, the WAPDA data shows seeds to be an insignificant determinant of yield.

There is only farm labor data, and no farm power data for 1977. So we only have relative reliance on family or wage labor, and no information on labor substituting variables like bullocks and tractors. Table 4.10 shows that family labor is not consistently related to yields for either wheat, or cotton. Table 4.11 shows that family labor is not positively correlated to yields for any of the crop varieties. The correlation matrix only associates family labor positively and significantly with yields for LYV wheat.

On the other hand, permanently hired labor, here in 1977, as in 1988, increases the yield when at least one laborer is added, for all the crops except LYV cotton, in Table 18. In Table 4.11 wage labor is significantly positively correlated to yields for HYVs of wheat and rice. This is confirmed by the correlation matrix in Table 4.12.

In summary, analysis of the WAPDA data sets for 1977 and 1988 show the gradual emergence of new relationships between structural variables and yield, and inputs and yield, for the three major crops, wheat, cotton, and rice.

By 1977, on the one hand, there is a weak positive relationship between commercial inputs like fertilizer and seeds and yield. On the other hand, the traditional strong positive relationship posited by the literature, between non commercial inputs like family labor and yields is weakening by 1977. Conversely, a positive relationship between wage labor and yields is emerging.

With the increasing importance of commercial inputs, large farms with a credit advantage over small farms, have raised their productivity to equal that of small farms. As a result, the traditionally posited negative relationship between yield and farm size turns into a U-shaped curve by 1977.

By 1988, there is a strong positive relationship between commercial inputs like irrigation, fertilizer, and tractors, and yield, for wheat, cotton, and rice. The relationship between non commercial inputs like bullocks and family labor has become very weak. And even wage labor has lost its significantly positive correlation with yields, while tractors have become significantly positive. So over the 1980s, the labor constraint on yields has been eased by substituting tractors.

As a partial result of these changing input yield relationships, three structural variables emerge as important determinants of yields. Two are behavioral variables, human capital, and farm size, and the third is a regional variable, salinity.

Human capital, in the form of farmer's schooling, has a strong positive association with yields. This is seen to be due in the first instance to a strong positive association between human capital and new knowledge based commercial inputs like fertilizer and tractors. This is in contrast to a weaker association between human capital and traditional knowledge based commercial inputs like irrigation.

Farm size has developed a significant and positive association with yield. This is statistically evident for only rice here. This is seen to be due to a strong positive association between farm size and tractors. So clearly it is the large farms which are easing their labor constraints on yields, by substituting tractors for labor. The explanation suggested for these results obtained here, and which needs much more detailed investigation in the future, is that the traditional inverse relationship between yield and farm size posited at the advent of the green revolution, turns into a U-shaped curve over the 1970s, and is now becoming a positive relationship. Small farms lose their relative endowment advantage in intensively using non commercial inputs, especially family labor. Large farms increase their relative endowment advantage in intensively using commercial inputs, especially labor substituting tractors.

The third structural variable is the regional one of salinity, which strongly decreases yields.

The policy corollary from an analysis of the WAPDA data sets is not a surprising one, but very important nevertheless. Human capital, and physical capital (in the form of commercial inputs), are the major behavioral determinants of yields. Access to human capital in the form of schooling, is very low. Access to physical capital is constrained by a very inadequate credit market.

An increase in schooling and credit market expansion will therefore increase yields considerably.

4.4 Input Determinants of Yields Using IIMI 1988 Data

Two inputs that have been observed to have a consistent, strong positive relationship with yields for all the crops have been irrigation and fertilizer. There are two aspects to the relationship of these inputs to yields. One, technically, irrigation and fertilizer are joint inputs, and therefore their relationship to each other has an impact on yields. Two, the timing of these two inputs has an impact on yields. So the impact of the correlation of irrigation and fertilizer, and the timing of these inputs, on yields needs to be investigated.

The International Irrigation Management Institute (IIMI) Pakistan has a sample survey for wheat for 1988, which allows us to investigate these two impacts. This data set gives a number of irrigation and fertilizer variables. Moreover it allows the estimation of yields, not only as output per ha of area, but also output per cubic meter of water. Given that irrigation is a major constraint on yields, the behavior of this index of productivity can be very important.

The analysis of the IIMI data follows the format of the WAPDA data. Table 4.15 presents the tabular results. The table splits up inputs into discrete categories, and gives the mean yields and significance for these categories. Table 4.16 runs these inputs in a multiple regression on yields. Table 4.17 regresses the inputs separately on yields. The data allows three indices of wheat productivity. These are tons/ha without late irrigation, tons/ha with late irrigation, and kg/cubic (kg/cu) meter of water without late irrigation.

Table 4.15 shows that total fertilizer behaves as expected for area productivity. Total nitrogen and phosphate increase on trend with land yields, and with significance. However nitrogen peaks the water yield at 40 kg/ha with significance. And Phosphate peaks the water yield at 20 kg/ha, but without significance. This result is clarified in Table 4.17 and 4.18. In the single regressions, Table 4.17 shows that total nitrogen and total phosphate are positively correlated to land yields with some significance. Total phosphate however is alone related to the water yield with significance, both in the single regression in Table 4.17, and in the multiple regression in Table 4.16. (Note that the multiple regressions again have much higher R^2s and therefore explanatory power than the single regressions).

TABLE 4.15
Total Fertilizer vs Area Productivity

VARIABLE INPUTS IRRIGATION	MEAN YIELDS (TONS/HA) WITHOUT LATE IRRIGATION		MEAN YIELDS (TONS/HA) WITH LATE IRRIGATION		MEAN YIELDS (KGS/CU) WITHOUT LATE	
	VALUE	SIG	VALUE	SIG	VALUE	SIG
FERTILIZER:						
TOTAL NITROGEN: 0 KG/HA	2.80	ABC	3.05	AB	0.61	ABC
0 - <40	3.30	A	3.50	A	0.92	AEF
40 - <70	3.03	D	3.37		0.77	BE
70 - <100	3.21	B	3.39		0.78	CF
>100	3.45	CD	3.61	B	0.83	D
TOTAL PHOSPHATE: 0 KG/HA	2.80	AB	3.0	AB	0.63	AB
0 - <20	3.30		3.25		1.21	
20 - <40	2.99		3.24		0.65	C
40 - <60	3.27	A	3.49	A	0.84	AC
>60	3.30	B	3.46	B	0.77	B
TOTAL POTASSIUM: 0 KG/HA	3.19	(NO SIG)	3.42	(NO SIG)	0.78	A
>0	3.24		3.20		0.97	A
NITROGEN AT SOWING:						
0 KG/HA	3.23	A	3.43	A	0.82	A
5 - <10	3.42	B	3.65	B	0.83	B
>10	2.93		3.14		0.73	
PHOSPHATE AT SOWING: 0 KG/HA	2.80	AB	3.0	AB	0.64	ABC
0 - <5	3.07		3.40		0.68	AD
5 - <10	3.27	A	3.47	A	0.84	BD
>10	3.30	B	3.48	B	0.75	C
POTASSIUM AT SOWING: 0 KG/HA	3.19		3.42	(NO SIG)	0.78	A
>0	3.24		3.20		0.97	A
NITROGEN AT IRRIGATION 0 KGS/HA	3.15		3.38	(NO SIG)	0.81	(NO SIG)
0 - <9	3.08		3.55		0.80	
>9	3.24		3.38		0.78	
POTASSIUM AT IRRIGATION: 0 KG/HA	3.21		3.42	A	0.79	(NO SIG)
>	2.53		2.36	A	0.83	
IRRIGATION: TIME 1= 0 - <20 HRS	-		-		-	
20 - <40	3.32	A	3.49	A	0.80	(NO SIG)
>40	2.68	A	2.87	A	0.76	
" TIME: 2 = 0-<60 HRS	2.08	ABC	2.32	AB	0.69	
60 - <80	3.16	A	3.31	ABC	0.78	
80 - <100	3.26	B	-		-	
>100	3.26	C	3.54	BC	0.83	
" TIME 3 = 0 HRS	3.00	AB	3.24	A	0.83	(NO SIG)
0 - <95	3.22	A	3.42		0.77	
>95	3.38	B	3.56	A	0.78	
" TIME: 4 = 0 HRS	3.20	(NO SIG)	3.41	(NO SIG)	0.81	A
>0	3.19		3.36		0.74	A
" TIME 5 = 0 HRS	3.19	(NO SIG)	3.41	(NO SIG)	0.80	(NO SIG)
>0	3.27		3.19		0.73	

TABLE 4.15 (cont)

* TIME 6 =	3.19	(NOT)	3.40	(NOT)	0.79	(NO SIG)
>0	4.30		4.53		0.99	
APPLICATION 1:						
0-<100 MMS	-		-		-	
100 - <120	3.23	(NOT)	3.54	(NOT)	0.73	A
>120	3.09		3.36		0.64	A
APPLICATION 2						
= 0-<80 MM	2.08	AB	2.32	AB	0.69	
80 - <100	3.17	A	3.25	A	0.77	A
>100	3.17	B	3.48	B	0.66	A
APPLICATION 3 = 0 MM	3.00	A	3.24	A	0.84	A
0 - <70	3.12	B	3.41		0.84	B
70 - <100	3.50	ABC	3.68	AB	0.82	
>100	3.08	C	3.20	B	0.39	AB
APPLICAITON 4 = 0 MM	3.18	A	3.41	(NO SIG)	0.81	AB
0 - <60	3.59	AB	3.64		0.95	AC
> 60	3.09	B	3.27		0.66	BC
APPLICAITON 5 = 0 MM	3.19	(NO SIG)	3.41	(NO SIG)	0.80	(NO SIG)
>0	3.27		3.19		0.73	
APPLICATION 6 = OM	3.19	(NO SIG)	3.40	(NOT)	0.80	(NOT)
>0	4.30		4.53		0.99	
TIME LATE SINCE SOWING						
= 90 - 120 DAYS	-		-		-	
120 - ,140	3.14	A	3.37	A	0.79	(NO SIG)
>140	3.50	A	3.77	A	0.84	
LATE IRRIGATED AREA=						
0.15 - <0.38 HA	-		-		-	
0.38 - <0.86	3.12		3.33	(NO SIG)	0.78	
0.86 - <1.25	3.13	A	3.35		0.76	A
>1.25	3.40	A	3.60		0.85	A
: RAIN IN RABI >10MM	3.19		3.40		-	
<10MM	-		-		-	

Source: Computed from IIMI 1988.

TABLE 4.16
Multiple Regression of Inputs on Wheat Yields

IIMI — DEPENDENT VARIABLE - WHEAT YIELDS

INDEPENDENT	R^2	X	SIG	R^2	X	SIG	R^2	X	SIG
EQUAITON 1:	0.28	1.8	(0.01)	0.21	0.7	(0.41)	0.45	0.9	
(0.00)		b	(SIG)		B	(SIG)		B	
(SIG)									
AREA LATE IRRIGATED		0.41	(0.00)		0.31	(0.01)		0.10	
(0.00)									
PHOSPHATE AT SOWING		0.05	(0.00)		0.05	(0.00)			
TIME LATE IRRIGATION		0.007	(0.22)		0.02	(0.00)		0.002	
(.19)									
TIME IRRIGATION 1		-0.02	(0.00)		-0.02	(0.00)		-	
0.004 (.00)									
RAIN IN RABI		0.006	(0.00)		0.004	(0.10)		-	
0.004 (.45)									
TIME IRRIGATION 2		0.006	(0.08)					0.003	
(.01)									
TIME IRRIGATION 3		0.003	(0.06)						
APPLICATION IRRIGATION 6		0.02	(0.14)						
NITROGEN AT IRRIGATION		-0.01	(0.27)		-0.02	(0.25)		-	
0.007 (.11)									
POTASSIUM AT SOWING		0.02	(0.33)					0.007	
(.22)									
NITROGEN LATE		-0.07	(0.32)					-	
0.02 (.30)									
VARIETY		0.14	(0.40)					0.05	
(.29)									
SOWING METHOD		-0.12	(0.47)					0.06	
(.23)									
APPLICAITON IRRIGATION 4					-0.005	(0.11)		-	
0.002 (.00)									
TIME IRRIGATION 5					-0.06	(0.04)		-	
0.008 (.25)									
APPLICATION IRRIGATION 5					0.12	(0.06)		0.02	
(.32)									
NUMBER IRRIGATIONS					0.23	(0.13)		-	
APPLICATION IRRIGATION 1									
0.003 (.00)									
TOTAL PHOSPHATE								0.001	
(.10)									
APPLICATION IRRIGATION 3								-	
0.001 (.13)									
APPLICATION IRRIGATION 2								-	
0.002 (.03)									
NO PLOUGHINGS AT SOWING								-	
0.02 (.19)									
NITROGEN AT SOWING								0.005	
(.00)									

Source: Computed from IIMI 1988.

TABLE 4.17

Regression Estimates of Impact of Irrigation and Fertilizers on Output/ha and Output/cubic meter of Water

IIMI — DEPENDENT VARIABLE - WHEAT YIELDS

INDEPENDENT VARIABLE	(TONS/HA) WITHOUT LATE IRRIGATION			(TONS/HA) WITH LATE IRRIGATION			PER CUBIC METER OF WATER WITHOUT LATE IRRIGATION		
	R^2 (SIG)	X (SIG)	B (SIG)	R^2 (SIG)	X (SIG)	B (SIG)	R^2 (SIG)	X (SIG)	B
NO. PRE-SOW PLOUGHINGS	.04	2.9 (.00)	0.08 (.00)	.02	3.2 (.13)	0.05 (.07)	DROPPED		
NITROGEN AT SOWING (KGS/HA)	.02	2.9 (.00)	0.05 (.06)	.02	3.2 (.00)	0.05 (.04)	DROPPED		
PHOSPHATE AT SOWING (KGS/HA)	.04	2.8 (.00)	0.05 (.00)	.04	3.0 (.00)	0.05 (.00)	.04	0.67 (.00)	0.02 (.00)
POTASSIUM AT SOWING (KGS/HA)	DROPPED			DROPPED			DROPPED		
NITROGEN AT IRRIGATION	DROPPED			DROPPED			DROPPED		
TOTAL NITROGEN	.01	3.0 (.00)	0.003 (.16)	DROPPED			DROPPED		
TOTAL PHOSPHATE	.04	2.8 (.00)	0.01 (.00)	.04	3.0 (.00)	0.007 (.00)	.04	0.67 (.00)	0.003 (.00)
TOTAL POTASSIUM	DROPPED			DROPPED			DROPPED		
TIME: IRRIGATION 1(HRS)	DROPPED			DROPPED			DROPPED		
" IRRIGATION 2	.01	2.9 (.00)	0.004 (.27)	DROPPED			DROPPED		
" IRRIGATION 3	.03	2.9 (.00)	0.004 (.01)	.02	3.2 (.00)	0.003 (.05)	DROPPED		
" IRRIGATION 4	DROPPED			DROPPED			DROPPED		
" IRRIGATION 5	DROPPED			DROPPED			DROPPED		
APPLICATION IRRIGATION 1 (MM)	DROPPED			DROPPED			DROPPED		
" IRRIGATION 2	DROPPED			DROPPED			DROPPED		
" IRRIGATION 3	.02	3.1 (.00)	0.003 (.08)						
" IRRIGATION 4	DROPPED			DROPPED			DROPPED		
" IRRIGATION 5	DROPPED			DROPPED			DROPPED		
" IRRIGATION 6	DROPPED			DROPPED			DROPPED		
NO. IRRIGATIONS	.02	2.8 (.00)	0.13 (.09)	DROPPED			DROPPED		
TIME LATE IRRIGATION (DAYS)	.02	1.9 (.00)	0.01 (.07)	.03	1.5 (.04)	0.01 (.01)	DROPPED		
AREA LATE IRRIGATED	.02	3.0 (.00)	0.21 (.07)	DROPPED			DROPPED		

Source: Computed from IIMI.

Table 4.15 shows that fertilizer at sowing is positively correlated to land and water yields. Nitrogen, phosphate, and potassium, increase on trend with land and water yields, with some significance. In Table 4.16 in the multiple regression, phosphate at sowing is significantly positively correlated to the land yields. And nitrogen at sowing is significantly positively correlated to the water yield. Potassium at sowing is significantly positively correlated to both land and water yields.

Table 4.15 shows that fertilizer at irrigation is not consistently related to either land or water yields.

Thus, in total, and at sowing, fertilizer emerges as important for both land and water yields, in total, and at sowing.

There are basically three irrigation variables. One is the number and duration of irrigations. The second is the depth of the irrigations. The third is the area irrigated late.

For the first irrigation variable, what Table 4.15 shows is that the early and last irrigations increase both land and water yields. The second and third irrigations increase the land yields significantly. And the sixth irrigation increases the land and the water yields, but with no significance available. The multiple regression in Table 4.16 bears this out. Irrigations 2, 3, and 6 are significant and positive for the land yield. However it is irrigation 2 which is significant and positive for the water yield.

The depth of application of the 6 irrigations however show no consistent relationship with yield, except for the last irrigation. Table 4.15 shows that the sixth irrigation increases both the land and the water yields, but with no significance available. The multiple regression in Table 4.16 partly bears this out. The depth of the sixth irrigation is positively correlated to the land yield, but with marginal significance. It is interesting that the irrigation application variables turn the water yield negative. This may be an estimation error. But if not, then the irrigation efficiency is very low.

The third irrigation variable emerges as the most significant irrigation variable. Table 4.15 shows that the area irrigated late consistently increase both the land and the water yields, with some significance. The multiple regression in Table 4.16 bears this out fully. The area irrigated late has a significant positive correlation to both the land and water yields. Moreover, the table shows that the later the late irrigation, the higher are both the land and the water yields, but with marginal significance.

In conclusion, this IIMI data has allowed us to hone down our input findings. The general input finding was that commercial inputs like fertilizer and irrigation increase yields for all the crops. For wheat, the IIMI data has allowed further qualifications to these relationships. Total nitrogen, phosphate and potassium have strong positive correlations to land and water yields. Moreover fertilizer at sowing has a significant positive relationship to the land and water yields.

For irrigation, the early and late irrigations have a strong positive correlation to both land and water yields. But the strongest positive relationship is between the late irrigation and land and water yields.

4.5 Main Findings

The general findings of this section show that yields are influenced by three structural variables. Farm size and producer's education have a positive relationship with yields. Salinity has a strong negative relationship with yields.

On the input side, yields are strongly influenced by commercial inputs. So irrigation and fertilizer have a strong positive correlation to yields. Moreover hired labor and labor augmenting tractors now have a positive correlation to yields. Conversely, the positive relationship between family labor and yields has weakened. Similarly the relationship between cheap family labor inputs like bullocks and manure on the one hand, and yields on the other, has also weakened. This has eroded the traditional advantage of the small family labor based farms and has resulted in the emergence of the positive relationship between farm size and yields.

5. A MICRO ANALYSIS OF CHANGES IN THE CROSS-SECTIONAL DETERMINANTS OF CROP PRODUCTIVITY OVER TIME

5.1 Hypotheses for Changes Over Time

The previous section has given two major results. It has shown that there are significant structural determinants of crop yields. Farm size is seen to have an emerging positive relationship with yield. Producers' education also has a positive correlation with yield. Salinity has a negative correlation with yield.

On the input side, commercial inputs are seen to have a positive correlation with yield. Fertilizer, seed, and irrigation have a positive correlation to yield. Hired labor and labor augmenting tractorization has a positive correlation to yield. Conversely, family labor, and cheap family labor inputs like bullocks and manure have a weakening relationship to yield. This input result argues that the traditional advantage of the small family farm over the large farm, in yields is being eroded. The input result supports the structural result.

These findings and hypotheses are based on static analyses at one point in time. They imply the following hypotheses for change over time:

(a) **For structural determinants:**

- Assume there is a traditional negative relationship between farm size and productivity in time period t_1. Assume it turns into a U-shaped curve in t_2. Assume it further turns into a positive relationship in t_3. This implies that the smallest farms will have the lowest increase in yields over time. The middle farms will have medium increases in yields over time. And the large farms will have the highest increase in yields over time. This can be seen in Diagram 2.

- If the initial position of the curve is not negative, but U-shaped, then the smallest and largest farms will have the lowest increases in yields over time. And the middle farms will have the highest increase in yields over time.

(b) **For input determinants:**

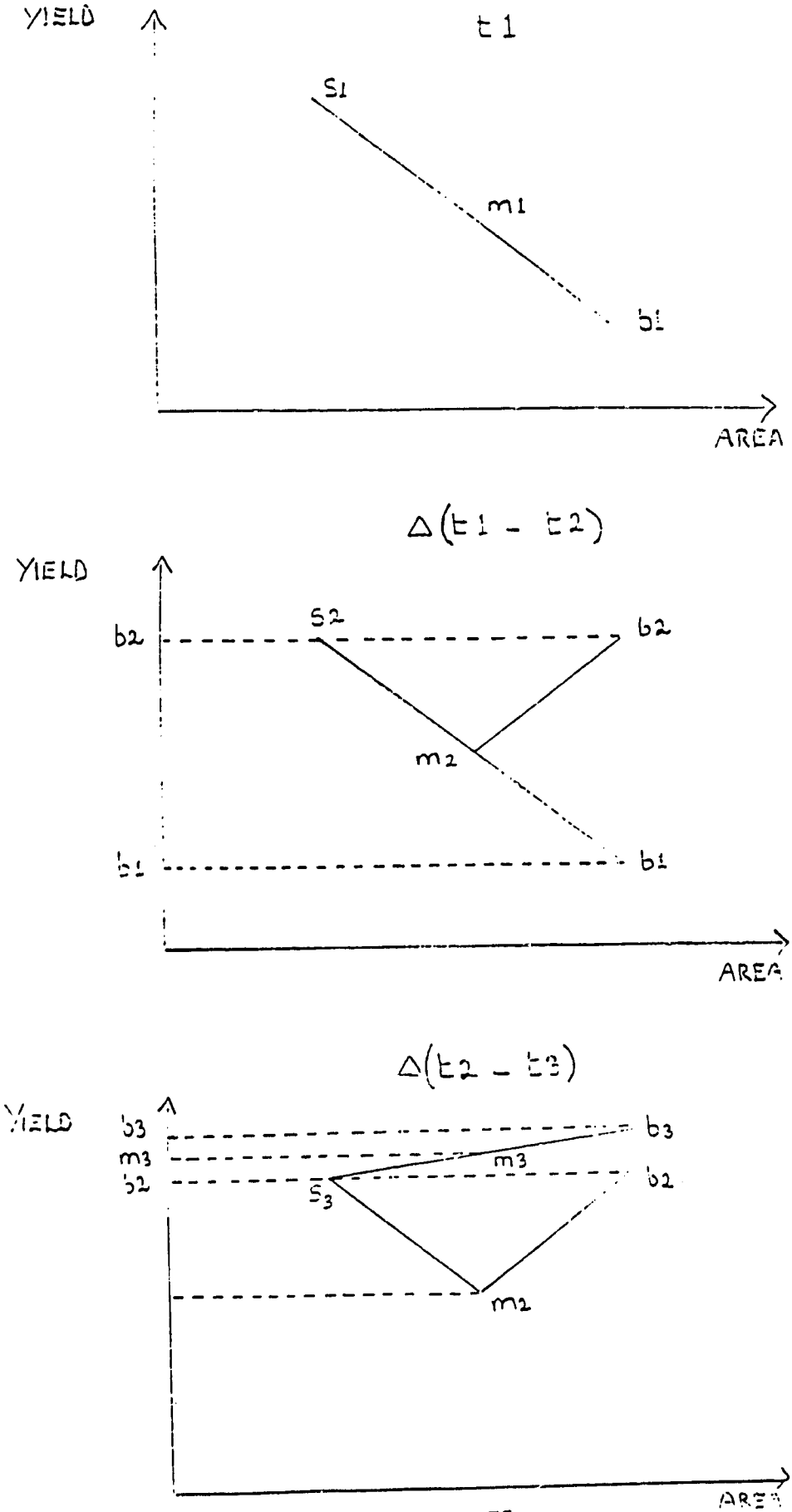
- Producers with **high material input use** will have the highest yield increases over time.

- Producers using **wage labor** will have the highest yield increases over time.

- High **family labor use** will not result in the highest yield increases over time.

FIGURE 2

Change in the size productivity Relationship over time



These hypotheses can be tested by comparing the WAPDA sample surveys for 1977 and 1988. Tables 5.1-5.4 split the structural and input determinants into discrete categories for 1977 and 1988. Where the categories are comparable the increase in mean yields is given. The t ratios now give the significance of the change over time for each category. Note that it has not been possible to do any parametric tests for change over time, because the number of common observations giving panel data is negligible. Therefore only means can be compared over time.

5.2 Wheat

Table 5.1 shows that the mean yield for HYV wheat has increased by 25% over the decade from 1977 to 1988. Traditional rice yields have increased by 104%. Regionally the highest increases have been in the rice wheat zones of Punjab and Sind. The NWFP shows no increase in this data.

(a) The structural hypothesis is supported by the results. Wheat yields formed a U across farm size in 1977. Therefore smallest farms have had the lowest increase in yields, with no significance. The largest farms have had the medium increases, but again with no significance. The middle farms have had the highest increases, with significance.

For tenure, it is interesting to note that between owners and tenants, owners have had the higher increases in yields.

(b) The **material input** hypothesis is not well supported by Table 5.1. In nitrogen, the highest increases in yields have come at the bottom end of nitrogen use, with significance. For seeds again, the highest increase in yields have come at the bottom end of the seed rate, with significance.

The **wage labor** hypothesis is supported by Table 5.1. For wage labor, the highest increase in yields have been by producers using some wage labor, with significance.

The **family labor** hypothesis is also supported by Table 5.1. Farms with the highest family labor have not had the highest increase in yields. Farms with the lowest family labor have had the highest increase in yields, although with no significance.

5.3 Cotton

Table 5.2 shows that the mean yield for HYV cotton has increased by 102% between 1977 and 1988. Regionally the highest increase in yields has been in the Sind rice wheat zone, and the Punjab sugar wheat zone, with significance, although from low bases.

TABLE 5.1

MEAN YIELDS FOR WHEAT

Comparison of WAPDA 77 and WAPDA 88
Structural Variables

	1977			1988			Increase 88-77	% Increase (88-77)/77
	Yield	No. Obs	St. Dev	Yield	No. Obs	St Dev.		
WHEAT (TV)	0.89	202	0.55	1.84	444	0.99	0.37	25.17*
WHEAT (HYV)	1.47	1458	0.85	1.96	81	0.85	1.00	104.17*
RICE (TV)	0.96	76	0.86	2.19	122	1.12	0.38	20.99*
RICE (HYV)	1.81	714	1.14					
COTTON (TV)	0.57	127	1.09	1.23	254	0.72	0.62	101.64*
COTTON (HYV)	0.61	772	0.54					

YIELDS BY ZONE

ZONE_CD		1977			1988			Increase 88-77	% Increase (88-77)/77
		Yield	No Obs	St Dev	Yield	No Obs	St Dev		
NWFP	1	1.66	47	0.71	1.6	15	0.76	-0.06	-3.61
PUNJAB MIXED/WHEAT	2	1.24	84	0.67	1.65	34	0.65	0.41	33.06*
PUNJAB COTTON/WHEAT	3	1.61	546	0.76	1.86	152	0.67	0.25	15.53*
PUNJAB SUGAR/WHEAT	4	1.66	252	1.01	2.18	66	0.84	0.52	31.33*
PUNJAB RICE/WHEAT	5	1.33	155	0.6	2.03	40	0.55	0.70	52.63*
SINDH COTTON/WHEAT	6	1.35	293	1	1.73	84	0.68	0.38	28.15*
SINDH RICE/WHEAT	7	0.67	81	0.59	1.59	53	2.1	0.92	137.31*

		1977			1988			88-77	(88-77)/77
		Yield	No Obs	St Dev	Yield	No Obs	St Dev		
< 5 ACRES	1	1.58	185	0.82	1.72	59	0.73	0.14	8.86
5 - 12.4 ACRES	2	1.47	[illegible]	0.86	1.82	[illegible]	1.3	0.35	23.81*
12.4 - 25 ACRES	3	1.42	445	0.94	1.83	126	0.75	0.41	28.87*
25 - 50 ACRES	4	1.34	196	0.7	1.99	62	0.75	0.65	48.51*
> 50 ACRES	5	1.72	100	0.85	2.03	27	0.74	0.31	18.02

YIELDS BY TENURE

	1977			1988			Increase 88-77	% Increase (88-77)/77
	Yield	No. Obs	St. Dev	Yield	No. Obs	St Dev.		
OWNERS	1.4	849	0.78	1.9	266	1.14	0.42	28.38*
TENANTS	1.39	376	1.01	1.61	90	0.62	0.22	15.83*
RENTERS				2.29	17	0.74		
OWNER CUM TENANT	1.57	179	0.96	1.76	40	0.77	0.19	12.10
OWNER CUM RENTER				1.94	18	0.66		
TENANTS CUM RENTER				1.85	3	0.9		
MIXED CON	1.84	2	0					
OWNERS/LL	1.48	52	0.66					

WC_REACH	1977			1988			Increase 88-77	% Increase (88-77)/77
	Yield	No. Obs	St. Dev	Yield	No. Obs	St Dev.		
HEAD	1.44	538	0.75	1.85	163	0.7	0.41	28.47*
MIDDLE	1.51	436	0.8	1.77	147	0.71	0.26	17.22*
TAIL	1.45	476	1.03	1.92	134	1.44	0.47	32.41*

TABLE 5.1 (cont)

FAMILY-SIZE	1977 Yield	1977 No. Obs	1977 St. Dev	1988 Yield	1988 No. Obs	1988 St Dev.	Increase 88-77	% Increase (88-77)/77
0 - 8 MEMBERS	NOT AVAILABLE			1.88	173	0.73		
- 15 MEMBERS				1.8	181	0.74		
GREATER THAN 15				1.85	83	1.7		

FAMILY-LABOR	1977 Yield	1977 No. Obs	1977 St. Dev	1988 Yield	1988 No. Obs	1988 St Dev.	Increase 88-77	% Increase (88-77)/77
FAM LABOR <5	0.88	198	155	1.65	73	0.66	0.77	87.5*
FAM LABOR> = 5 AND < = 8	1.71	1	0	1.61	58	0.66	-0.10	-5.85
FAM LABOR > 8				1.45	24	0.84		

NITROGEN PER HECTARE	1977 Yield	1977 No. Obs	1977 St. Dev	1988 Yield	1988 No. Obs	1988 St Dev.	Increase 88-77	% Increase (88-77)/77
NITROGEN 0				1.87	8	1.02		
>0 AND < 40 KGS/HA	1.24	248	0.72	1.72	206	0.75	0.48	38.71*
> 40 AND < = 70 KGS/HA	1.5	460	0.94	1.94	139	0.72	0.44	29.33*
> 70 AND < = 100 KGS/HA	1.78	306	0.77	1.92	44	0.65	0.14	7.87
> 100 KGS/HA	1.85	120	0.83	1.8	37	0.61	-0.05	-2.70

PHOSPHATE PER HECTARE	1977 Yield	1977 No. Obs	1977 St. Dev	1988 Yield	1988 No. Obs	1988 St Dev.	Increase 88-77	% Increase (88-77)/77
PHOSPHATE 0				1.35	55	0.67		
> 0 AND < = 20 KGS/HA								
> 20 AND < = 40 KGS/HA								
> 40 AND < = 60 KGS/HA	1.7	505	0.81	1.94	306	0.69	0.24	14.12*
> 60 KGS/HA	1.77	62	0.78	1.93	16	0.81	0.16	9.04*

SEED PER HECTARE	1977 Yield	1977 No. Obs	1977 St. Dev	1988 Yield	1988 No. Obs	1988 St Dev.	Increase 88-77	% Increase (88-77)/77
< = 40 KGS/HA	1.13	12	0.88	1.78	137	0.77	0.65	57.52*
> 40 AND < = 50 KGS/HA	0.63	19	0.42	2.22	76	1.77	1.59	252.38*
> 50 AND < = 80	1.29	192	0.85	1.82	143	0.69	0.53	41.09*
> 80 AND < = 100	1.5	1069	0.88	1.62	53	0.66	0.12	8.00
> 100	1.61	162	0.75	1.73	29	0.52	0.12	7.45

PERMANENT WORKERS	1977 Yield	1977 No. Obs	1977 St. Dev	1988 Yield	1988 No. Obs	1988 St Dev.	Increase 88-77	% Increase (88-77)/77
= 0	1.41	1190	0.88	1.56	152	0.67	0.15	10.64*
1 - 3	1.64	192	0.66	2.12	38	0.71	0.48	29.27*
4 - 11	1.92	40	1	2	22	0.66	0.08	4.17
> 11	1.98	3	1.03	1.94	23	0.51	-0.04	-2.02

Source: Computed from WAPDA 1977 and WAPDA 1988.

TABLE 5.2

MEAN YIELDS FOR COTTON
Comparison of WAPDA 77 and WAPDA 88
Structural Variables

	1977			1988			Increase 88-77	% Increase (88-77)/77
	Yield	No. Obs	St. Dev	Yield	No. Obs	St Dev.		
)TTON (TV)	0.57	127	1.09					
)TTON (HYV)	0.61	772	0.54	1.23	254	0.72	0.62	101.64*

IELDS BY ZONE

ZONE_CD		1977			1988			Increase 88-77	% Increase (88-77)/77
		Yield	No Obs	St Dev	Yield	No Obs	St Dev		
IFP	1				0.1	1	0		
INJAB MIXED/WHEAT	2	0.55	22	0.26	1.01	19	47	0.46	83.64
INJAB COTTON/WHEAT	3	0.56	427	0.5	1.47	129	0.76	0.92	164.29*
INJAB SUGAR/WHEAT	4	0.3	70	0.21	1.1	27	0.74	0.80	266.67*
INJAB RICE/WHEAT	5	0.37	1	0	0.98	4	0.37	0.61	164.86*
NDH COTTON/WHEAT	6	0.8	250	0.63	0.95	69	0.53	0.15	18.75*
NDH RICE/WHEAT	7	0.11	2	0.03	0.73	5	0.55	0.62	563.64*

ELD BY FARMSIZE		1977			1988			Increase 88-77	% Increase (88-77)/77
		Yield	No Obs	St Dev	Yield	No Obs	St Dev		
5 ACRES	1	0.64	66	0.37	1.2	31	0.76	0.56	87.5*
- 12.4 ACRES	2	0.66	285	0.65	1.17	98	0.71	0.51	77.27*
.4 - 25 ACRES	3	0.61	255	0.53	1.1	69	0.63	0.49	80.33
- 50 ACRES	4	0.54	100	0.39	1.58	39	0.72	1.04	192.59
50 ACRES	5	0.54	66	0.36	1.49	16	0.84	0.95	175.93

ELDS BY TENURE	1977			1988			Increase 88-77	% Increase (88-77)/77
	Yield	No. Obs	St. Dev	Yield	No. Obs	St Dev.		
NERS	0.57	422	0.51	1.24	147	0.72	0.67	117.54*
NANTS	0.72	231	0.65	1.09	51	0.65	0.37	51.39*
NTERS				1.72	9	0.63		
NER CUM TENANT	0.56	86	0.41	1	23	0.73	0.44	78.57*
NER CUM RENTER				1.81	15	0.76		
NANTS CUM RENTER				1.05	2	0.69		
XED CON	0.92	1	0					
NERS/LL	0.6	32	0.39					

_REACH	1977			1988			Increase 88-77	% Increase (88-77)/77
	Yield	No. Obs	St. Dev	Yield	No. Obs	St Dev.		
AD	0.62	280	0.5	1.17	94	0.62	0.55	88.71*
DDLE	0.62	232	0.42	1.27	85	0.82	0.65	104.87*
IL	0.6	258	0.67	1.27	75	0.72	0.67	111.67

TABLE 5.2 (cont)

FAMILY-SIZE	1977 Yield	1977 No. Obs	1977 St. Dev	1988 Yield	1988 No. Obs	1988 St Dev.	Increase 88-77	% Increase (88-77)/77
0 - 8 MEMBERS				1.27	97	0.72		
8 - 15 MEMBERS	NOT AVAILABLE			1.2	102	0.76		
GREATER THAN 15				1.24	49	0.65		

FAMILY-LABOR	1977 Yield	1977 No. Obs	1977 St. Dev	1988 Yield	1988 No. Obs	1988 St Dev.	Increase 88-77	% Increase (88-77)/77
FAM LABOR <5	0.62	763	0.55	1.03	34	0.57	0.41	66.13*
FAM LABOR> = 5 AND < = 8	0.36	3	0.23	1.09	36	0.69	0.73	202.78*
FAM LABOR > 8	0.43	1	0	0.87	13	0.38	0.44	102.33*

NITROGEN PER HECTARE	1977 Yield	1977 No. Obs	1977 St. Dev	1988 Yield	1988 No. Obs	1988 St Dev.	Increase 88-77	% Increase (88-77)/77
NITROGEN 0				0.76	11	0.66		
>0 AND < 40 KGS/HA	0.56	101	0.79	1.02	121	0.58	0.46	82.14*
> 40 AND < = 70 KGS/HA	0.64	225	0.55	1.24	58	0.69	0.60	93.75*
> 70 AND < = 100 KGS/HA	0.68	167	0.53	1.68	37	0.79	1.00	147.06*
> 100 KGS/HA	0.81	73	0.48	1.84	25	0.67	1.03	127.16

PHOSPHATE PER HECTARE	1977 Yield	1977 No. Obs	1977 St. Dev	1988 Yield	1988 No. Obs	1988 St Dev.	Increase 88-77	% Increase (88-77)/77
PHOSPHATE 0				0.86	40	0.57		
> 0 AND < = 20 KGS/HA								
> 20 AND < = 40 KGS/HA								
> 40 AND < = 60 KGS/HA	0.7	239	0.45	1.34	161	0.73	0.64	91.43*
> 60 KGS/HA	1.72	24	0.38	1.78	8	0.49	0.06	3.49

SEED PER HECTARE	1977 Yield	1977 No. Obs	1977 St. Dev	1988 Yield	1988 No. Obs	1988 St Dev.	Increase 88-77	% Increase (88-77)/77
< = 40 KGS/HA	0.61	758	0.54	1.24	253	0.72	0.63	103.28
> 40 AND < = 50 KGS/HA	0.39	7	0.22					
> 50 AND < = 80	1.02	3	0.84					
> 80 AND < = 100	0.86	2	0.41					
> 100	0.05	1	0					

PERMANENT WORKERS	1977 Yield	1977 No. Obs	1977 St. Dev	1988 Yield	1988 No. Obs	1988 St Dev.	Increase 88-77	% Increase (88-77)/77
= 0	0.62	64	0.5	0.97	82	0.56	0.35	56.45*
1 - 3	0.63	91	0.82	1.62	20	0.92	0.99	157.14*
4 - 11	0.54	25	0.69	1.57	12	0.63	1.03	190.74*
> 11	0.56	3	0.23	1.59	12	0.85	1.03	183.93*

Source: Computed from WAPDA 1977 and WAPDA 1988.

TABLE 5.3
Mean Yields for Rice

Comparison of WAPDA 77 and WAPDA 88
Structural Variables

	1977 Yield	1977 No. Obs	1977 St. Dev	1988 Yield	1988 No. Obs	1988 St Dev.	Increase 88-77	% Increase (88-77)/77
RICE (FINE)	0.96	76	0.86	1.96	81	0.85	1	104.17*
ROCE (HYV)	1.81	714	1.14	2.19	122	1.12	0.38	20.99

YIELDS BY ZONE

	ZONE_CD	1977 Yield	1977 No Obs	1977 St Dev	1988 Yield	1988 No Obs	1988 St Dev	Increase 88-77	% Increase (88-77)/77
NWFP	1	1.15	1	0					
PUNJAB MIXED/WHEAT	2				1.87	2	0.06	0.89	77.39*
PUNJAB COTTON/WHEAT	3	1.15	9	0.59	2.04	28	0.84	0.71	86.59*
PUNJAB SUGAR/WHEAT	4	0.82	5	0.19	1.53	24	0.8	1.43	172.29*
PUNJAB RICE/WHEAT	5	0.83	1	0	2.26	28	0.82		
SINDH COTTON/WHEAT	6	0.82	7	0.57					
SINDH RICE/WHEAT	7	0.96	53	0.98	1.98	1	0	1.02	106.25

	1977 Yield	1977 No Obs	1977 St Dev	1988 Yield	1988 No Obs	1988 St Dev	Increase 88-77	%Increase (88-77)/77
< 5 ACRES	1.56	8	2.07	1.73	4	1	0.17	10.90
5 - 12.4 ACRES	0.95	26	0.67	2.04	29	0.93	1.09	114.74*
12.4 - 25 ACRES	0.72	31	0.42	1.83	26	0.85	1.11	154.17*
25 - 50 ACRES	1.12	9	0.44	1.9	13	0.7	0.78	69.64
> 50 ACRES	1.8	2	1.24	2.3	9	0.75	0.50	27.78

YIELDS BY TENURE	1977 Yield	1977 No. Obs	1977 St. Dev	1988 Yield	1988 No. Obs	1988 St Dev.	Increase 88-77	% Increase (88-77)/77
OWNERS	0.82	31	0.45	1.93	53	0.9	1.11	135.37*
TENANTS	1.04	30	1.19	2.22	8	0.96	1.18	113.46*
RENTERS				2.26	0.77	5		
OWNER CUM TENANT				1.88	11	0.47		
OWNER CUM RENTER				2.247	2	0.7		
TENANTS CUM RENTER				1.48	1	0		
MIXED CON	1.2	2	0.49					
OWNERS/LL	0.58	13	0.75					

WC_REACH	1977 Yield	1977 No. Obs	1977 St. Dev	1988 Yield	1988 No. Obs	1988 St Dev.	Increase 88-77	% Increase (88-77)/77
HEAD	0.81	26	0.45	1.87	27	0.9	1.06	130.86*
MIDDLE	1.03	25	0.78	2.11	25	0.78	1.08	104.85*
TAIL	1.03	23	1.26	1.92	29	0.86	0.89	86.41*

TABLE 5.3 (cont)

FAMILY-SIZE	1977 Yield	1977 No. Obs	1977 St. Dev	1988 Yield	1988 No. Obs	1988 St Dev.	Increase 88-77	% Increase (88-77)/77
0 - 8 MEMBERS	NOT AVAILABLE			1.88	30	1		
8 - 15 MEMBERS				2.2	32	0.83		
GREATER THAN 15				1.69	19	0.46		

FAMILY-LABOR	1977 Yield	1977 No. Obs	1977 St. Dev	1988 Yield	1988 No. Obs	1988 St Dev.	Increase 88-77	% Increase (88-77)/77
FAM LABOR <5	0.98	71	0.88	1.52	9	0.51	0.54	55.10*
FAM LABOR> = 5 AND < = 8				2.09	4	0.61		
FAM LABOR > 8				1.76	3	0.25		

NITROGEN PER HECTARE	1977 Yield	1977 No. Obs	1977 St. Dev	1988 Yield	1988 No. Obs	1988 St Dev.	Increase 88-77	% Increase (88-77)/77
NITROGEN 0				1.98	1	0		
>0 AND < 40 KGS/HA	0.86	17	0.68	1.85	59	0.81	0.99	115.12*
> 40 AND < = 70 KGS/HA	1	10	0.57	2.38	15	0.83	1.38	138.00*
> 70 AND < = 100 KGS/HA	1.01	3	0.44	2.62	4	0.93	1.61	159.41*
> 100 KGS/HA	0.83	2	0.13					

PHOSPHATE PER HECTARE	1977 Yield	1977 No. Obs	1977 St. Dev	1988 Yield	1988 No. Obs	1988 St Dev.	Increase 88-77	% Increase (88-77)/77
PHOSPHATE 0				1.45	12	0.79		
> 0 AND < = 20 KGS/HA								
> 20 AND < = 40 KGS/HA								
> 40 AND < = 60 KGS/HA	1.01	3	0.44	2.27	36	0.78	1.26	124.75
> 60 KGS/HA								

SEED PER HECTARE	1977 Yield	1977 No. Obs	1977 St. Dev	1988 Yield	1988 No. Obs	1988 St Dev.	Increase 88-77	% Increase (88-77)/77
< = 40 KGS/HA	1.1	20	0.59	1.97	73	0.84	0.87	79.09*
> 40 AND < = 50 KGS/HA	0.72	14	0.16					
> 50 AND < = 80	0.86	0.3	[illegible]					
> 80 AND < = 100	0.94	28	1.21					
> 100	1.54	4	1.39					

PERMANENT WORKERS	1977 Yield	1977 No. Obs	1977 St. Dev	1988 Yield	1988 No. Obs	1988 St Dev.	Increase 88-77	% Increase (88-77)/77
= 0	0.96	67	0.9	1.67	13	0.65	0.71	73.96*
1 - 3	1.51	1	0	2.2	11	0.97	0.69	45.70*
4 - 11	0.92	1	0	2.36	5	1.03	1.44	156.52*
> 11								

Source: Computed from WAPDA 1977 and WAPDA 1988 series.

TABLE 5.4

MEAN YIELDS FOR RICE HYV
Comparison of WAPDA 77 and WAPDA 88
Structural Variables

	1977			1988			Increase 88-77	% Increas (88-77)/7
	Yield	No. Obs	St Dev.	Yield	No. Obs	St Dev.		
RICE (FINE)	0.96	76	0.86	1.96	81	0.85	1	104.17
ROCE (HYV)	1.81	714	1.14	2.19	122	1.12	0.38	20.99

YIELDS BY ZONE

	ZONE_CD	1977			1988			Increase 88-77	% Increas (88-77)/7
		Yield	No Obs	St Dev	Yield	No Obs	St Dev		
NWFP	1	0.84	4	0.41					
PUNJAB MIXED/WHEAT	2	1.6	8	0.83	2.21	2	0.89	0.61	38.12
PUNJAB COTTON/WHEAT	3	2.12	214	1.08	1.97	21	1.1	-0.15	-7.08
PUNJAB SUGAR/WHEAT	4	1.77	103	0.94					
PUNJAB RICE/WHEAT	5	1.55	136	0.71	2.84	9	0.65	1.29	83.23
SINDH COTTON/WHEAT	6	1.76	30	0.74	2.07	15	1.02	0.31	17.61
SINDH RICE/WHEAT	7	1.71	219	1.45	2.2	75	1.18	0.49	28.65

		1977			1988			Increase 88-77	% Increas (88-77)/7
		Yield	No Obs	St Dev	Yield	No Obs	St Dev		
< 5 ACRES	1	1.89	83	0.91	2.16	15	1.06	0.27	14.29
5 - 12.4 ACRES	2	1.75	263	1.06	2.06	46	1.16	0.31	17.71
12.4 - 25 ACRES	3	1.78	221	1.28	2.26	35	0.48	0.48	26.97
25 - 50 ACRES	4	1.79	85	1.19	2.29	16	1.05	0.50	27.93
> 50 ACRES	5	2.2	42	1.07	2.4	9	0.8	0.20	9.09

YIELDS BY TENURE	1977			1988			Increase 88-77	% Increas (88-77)/7
	Yield	No. Obs	St. Dev	Yield	No. Obs	St Dev.		
OWNERS	1.74	382	0.94	2.08	62	1.15	0.34	19.5
TENANTS	1.83	218	1.22	2.32	42	0.99	0.49	26.7
RENTERS				2.3	1	0.0		
OWNER CUM TENANT	2.04	84	1.62	2.82	11	1.35	0.78	38.2
OWNER CUM RENTER				0.99	1	0		
TENANTS CUM RENTER				1.25	3	0.63		
MIXED CON								
OWNERS/LL	1.82	30	1.1					

WC_REACH	1977			1988			Increase 88-77	% Increas (88-77)/7
	Yield	No. Obs	St. Dev	Yield	No. Obs	St Dev.		
HEAD	1.83	276	1.26	1.3	45	1.18	0.47	25.6
MIDDLE	1.86	219	1.07	1.99	39	1	0.13	6.9
TAIL	1.73	217	1.03	2.27	38	1.15	0.54	31.2

TABLE 5.4 (cont)

FAMILY-SIZE	1977 Yield	1977 No. Obs	1977 St. Dev	1988 Yield	1988 No. Obs	1988 St Dev.	Increase 88-77	% Increase (88-77)/77
0 - 8 MEMBERS				2.14	47	0.99		
8 - 15 MEMBERS	NOT AVAILABLE			2.28	48	1.16		
GREATER THAN 15				2.19	25	1.31		

FAMILY-LABOR	1977 Yield	1977 No. Obs	1977 St. Dev	1988 Yield	1988 No. Obs	1988 St Dev.	Increase 88-77	% Increase (88-77)/77
FAM LABOR <5	1.8	700	1.05	2.49	18	0.89	0.69	38.33*
FAM LABOR> = 5 AND < = 8				2.88	21	1.03		
FAM LABOR > 8	1.67	6	1.21	2.62	14	1.39	0.95	56.89

NITROGEN PER HECTARE	1977 Yield	1977 No. Obs	1977 St. Dev	1988 Yield	1988 No. Obs	1988 St Dev.	Increase 88-77	% Increase (88-77)/77
NITROGEN 0				3.08	2	0.24		
>0 AND < 40 KGS/HA	1.61	135	0.93	2.06	54	1.06	0.45	27.95*
> 40 AND < = 70 KGS/HA	1.89	216	1.26	1.88	24	0.91	-0.01	0.53
> 70 AND < = 100 KGS/HA	2.4	90	1.27	2.76	23	0.86	0.36	15.00
> 100 KGS/HA	2.19	51	1.03	3.11	10	1.4	0.92	42.01*

PHOSPHATE PER HECTARE	1977 Yield	1977 No. Obs	1977 St. Dev	1988 Yield	1988 No. Obs	1988 St Dev.	Increase 88-77	% Increase (88-77)/77
PHOSPHATE 0				2.27	12	1.06		
> 0 AND < = 20 KGS/HA	1.67	21	1.1					
> 20 AND < = 40 KGS/HA	2	39	1.22					
> 40 AND < = 60 KGS/HA	2.4	84	1.23	2.55	62	1.1	0.15	6.25
> 60 KGS/HA	1.95	16	0.83	2.97	2	0	1.02	52.31*

SEED PER HECTARE	1977 Yield	1977 No. Obs	1977 St. Dev	1988 Yield	1988 No. Obs	1988 St Dev.	Increase 88-77	% Increase (88-77)/77
< = 40 KGS/HA	1.83	476	0.97	2.17	59	1.08	0.34	18.58*
> 40 AND < = 50 KGS/HA	1.95	84	1.76	2.26	9	1.45	0.31	15.90*
> 50 AND < = 80	1.65	87	1.18	1.78	24	1	0.13	7.88
> 80 AND < = 100	1.7	61	1.22	2.56	28	1.13	0.86	50.59*
> 100	1.33	5	1.01					

PERMANENT WORKERS	1977 Yield	1977 No. Obs	1977 St. Dev	1988 Yield	1988 No. Obs	1988 St Dev.	Increase 88-77	% Increase (88-77)/77
= 0	1.72	585	1.03	2.64	50	1.06	0.92	53.49*
1 - 3	2.05	97	1	2.27	4	1.04	0.22	10.73
4 - 11	2.52	16	1.34	2.64	6	0.94	0.12	4.76
> 11	2.26	2	0.72	2.32	6	1.07	0.06	2.65

Source: Computed from WAPDA 1977 and WAPDA 1988 series.

(a) The **structural hypothesis** is supported by Table 5.2. Cotton yields had a negative relationship with farm size in 1977. Therefore the two largest farm sizes have had the highest increases in yields, with significance. The middle and small farm sizes have had approximately equal increases in yields, with significance. What this implies is the turning of the negative curve in 1977 to a U-shaped curve in 1988.

In terms of tenure, again owners have had the higher increases in yields compared to tenants, with significance.

(b) The **material input** hypothesis is supported by Table 5.2. For nitrogen, the highest increase in yields has been by the two highest users, with significance.

The **hired labor** hypothesis is supported in its strong form by Table 5.2. The highest increase in yields has been by farms using the highest labor, with significance.

The **family labor** hypothesis is not well supported by Table 5.2. The highest increase in yields has been on farms with higher family labor, with significance. Farms with the lowest family labor have had the lowest yield increases, with significance.

5.4 Rice

Table 5.3 shows that fine rice has had a yield increase of 104% between 1977 and 1988, with significance. Table 5.4 shows that HYV rice has had a yield increase of 21% over this period, although from a much higher base. Regionally the yield increases have been the highest in the rice wheat zones of the Punjab and Sind.

(a) The structural hypothesis is supported by Table 5.3 for fine rice, and by Table 5.4 for HYV rice. Fine rice yields had U-shaped curve in 1977. Consequently increase in yields has been the highest for the middle farm sizes, with significance. Increase in yields for the two largest farm sizes have been medium, with some significance. Increase in yields for the smallest farm sizes have been the lowest, and with no significance.

HYV rice yields similarly had a U-shaped curve in 1977. Consequently the middle farm sizes have had the highest increase in yields with some significance. The two largest farm sizes have had an average of medium increases in yields, with some significance. The smallest farm size has had the lowest yield increase with no significance.

In terms of tenure, for fine rice, owners have had the highest yield increases with significance. For HYV rice, tenants have had higher increases in yields than owners, with significance.

(b) The **material input** hypothesis is supported for fine rice by Table 5.4. For nitrogen, the highest increase in yields has been for the highest users, with significance. For seed again, the highest increase in yields has been for the highest seed rate, with significance.

This hypothesis is also supported for HYV rice by Table 5.3. For nitrogen, the highest increase in yields has been by the highest users, with significance.

The **hired labor** hypothesis is supported for fine rice by Table 5.3. Farms with the highest hired labor have had the highest increase in yields with significance. Although farms with no hired labor have had the next highest increase in yields, with significance.

This hypothesis is not supported by HYV rice in Table 5.4. Here the highest increase in yields has been on farms with no hired labor, with significance.

The **family labor** hypothesis can only be tested for HYV rice. Given the failure of the hired labor hypothesis for HYV rice, this family labor hypothesis is also overturned. Table 5.4 shows that the farms with the highest family labor had the highest increases in yields, although with no significance.

In summary, the hypotheses posited about change of yields over time have been supported, except for a material input hypothesis for wheat, and the hired and family labor hypotheses for HYV rice. In terms of structural farm size determinants of yield, wheat yields have gone from a U-shaped curve across farm size to positive slope across farm size. Cotton yields have gone from a negative slope across farm size to a U-shaped curve. Fine and HYV rice yields have gone from a U-shaped curve across to farm size to a positive slope across farm size. Therefore for each crop, the smallest farms have had the lowest increases in yields.

This structure-led pattern of the change in yields over time has resulted through a pattern of change in input use. The highest material input use has resulted in the highest increase in yields, as illustrated by nitrogen, for cotton, fine rice, and HYV rice. Hired labor use, frequently high, has resulted in the highest increase in yields over time, for wheat, cotton, and fine rice. High family labor use has not resulted in the highest increase in yields, for wheat, cotton, and fine rice.

These results help to hone down the larger hypothesis emerging from section 4. High commercial input use, like fertilizer, has increased yields the most. This has increased or created a yield increasing advantage for medium and large farms, in wheat, cotton, and rice, because of their internal resources. Hired labor farms have increased their yields the most, except for

HYV rice. High family labor farms have not increased their yields the most, except for HYV rice. These two results imply a decreased advantage of small family labor based farms in increasing yields, in wheat, cotton, and fine rice, through their cheap family labor. As a result of this changing advantage across farm size, the negative slope of yields across farm size in cotton, and the U-shaped curve of yields across farm size in wheat, fine rice, and HYV rice, are turning positive.

6. MAJOR FINDINGS AND CONCLUSIONS

6.1 Introduction

This study sets out to examine the sources of crop productivity (Yield per hectare) in Pakistan in a historical context, so that inferences can be drawn about desirable directions for the future. The study focuses on the three most important crops, namely, wheat, rice and cotton. It analyzes aggregate time series data from 1947 to 1990, as well as cross-sectional household data from large and small samples. It desegregates the time trends into discrete epochs and the national trends into provincial ones; decomposes output changes into area, yield and multiple effects; and reviews crop-specific research reports as well as those that look more broadly at farming systems and the agriculture sector as a whole. It examines the influence on productivity of several variables in categories that distinguish structural variables from agricultural inputs, and purchased inputs from others. At a heuristic level, the study systematically relates changes in crop acreage and yields to changes in profitability, policy, irrigation and technological change.

From a practical point of view, three questions arise in interpreting and using the results of a study such as this one; namely:

- What does the analysis (including a review of recent literature) tell us about the past?
- What does it tell us about the future?
- What does the analysis of this study not tell us?

Evidence bearing of these questions is taken up in sequence in the next three sections of this chapter.

6.2 Historical Analysis

The historical trends for the three major crops are summarized in Table 6.1 on the next page. The output trends and decomposition shown therein are based on published MINFA time series from 1971 and unpublished MINFA data from 1947 to 1970. Inferences about "probable causal factors" were drawn by "eyeballing" the trends in the few explanatory variables for which time series data are available.

Period	Output Growth	Major Effect	Probable Causal Factors
		Crop: Wheat	
1947-1954	Negative	Yield Effect	Stagnant Irrigation Declining price
1955-1960	Low	Similar Area and Yield Effects	Small irrig. increase Small price increase
1961-1966	Low	Area Effect	Large irrig increase Price increase
1967-1975	Very High	Yield Effect	HYV inputs Small Price increase
1976-1989	High	Similar Area and Yield Effects	Price increases Small irrig increase
		Crop: Rice	
1947-1960	Low	Area Effect	Small price increase Some irrig. increase
1961-1967	High	Similar Area and yield Effects	Large irrig increase Price increase
1968-1975	Very High	Yield Effect	HYV Inputs Small price increase
1976-1989	Low	Area Effect	Small price increase Small irrig increase
		Crop: Cotton	
1947-1954	High	Yield Effect	From low base
1955-1960	Very Low	Yield Effect	Kharif irrig. low
1961-1970	Very High	Area Effect	Large irrig increase Price increase
1971-1979	Very High	Yield Effect	Modern inputs Kharif irrig. low
1980-1989	Very High	Area Effect	Large price increase Greater pesticide use

The real complexity of the issue, however, and the variety of possible explanations for productivity variations is met not in the time series data but in cross-sectional analysis. In this connection, the study attempted to understand the influence of irrigation; the impact of research, extension and education; the importance of inputs such as seed, fertilizer, pesticide and credit; and the role of socio-economic factors such as farm size and land tenure. Statistical analysis was undertaken on two large-sample WAPDA data sets from 1977 and 1988 (for Punjab and Sind), and a smaller sample from IIMI (for Punjab, 1988). Several recent research reports were also reviewed, particularly those originating in the PARC-CIMMYT collaborative research program.

The following conclusions emerge from combining the results of this exercise with those of the aggregate-level analysis:

- Periods of high output growth for wheat and rice appear to be dominated by yield rather than area effects; for cotton, however, the area effect appears to have been a more important source of major production increases;[1]

- There is considerable variation in the relative importance of the various sources of productivity over time, across cropping systems and between crops;

- However, price policy effects, input market de-regulation (especially for agro-chemicals), technological change (and the research that generates it) and water availability have had powerful and enduring influence on all crops over time; extension is not seen to have had a positive impact; and the impact of water management and soil quality on productivity has not been adequately researched at the farm (or field) level;

- There is reason to believe that the up-take of available technology in Pakistan has been slow, and that, in particular, small farmers have been slower than others in adopting new technology, though the difference between large adopting new technology, though the difference between large and small farmers has tended to disappear over time with the development of markets and the spread of relevant knowledge.[2]

- Only in the case of wheat (by virtue of the PARC-CIMMYT program) do recent field-level data exist that integrate agronomic and economic variables in analyzing

[1]Chaudhry and Chaudhry (1990) report that one third of the agricultural output growth rate of 3.5% (per annum) since 1960 has been due to area increase.

[2]Appendix B summarizes what census data and available studies have to show on the differences across farm size and tenure in the adoption of new inputs.

the constraints on productivity;[3] these studies, however, do not incorporate irrigation variables.

6.3 Analysis for the Near Future

The historical analysis of this study shows that the constraints on agricultural productivity do not necessarily vary in their importance in systematic manner over time and across regions and crops. Only the most recent analyses for each crop may be useful for policy making in the present and near future, and that only if their results can be combined and synthesized. Such an approach can be attempted only for wheat, for which some recent analyses of agronomic and economic factors are available. For cotton and rice, only qualified statements can be made, based largely on discussions with experts.

A major concern for cereal crops as a whole, articulated by Byerlee, Harrington and Sharif (1990), is that of the declining growth rates, since 1960, of increases in area and yield, trends that make it difficult for Pakistan to feed its growing population in the 1990s. These researchers also reports that total factor productivity in agriculture has changed little since 1970 despite the adoption of newer improved varieties and a tripling of the fertilizer doze. Past increase in average wheat yields have come about due to increases in the percentage of total area planted to modern varieties.

For the future, Byerlee, Harrington and Sharif anticipate a scenario in which:

- Wheat consumption is projected to grow at 3.3% per year;
- Wheat area may grow at about 1% annually (the authors describe this as an optimistic projection); and,
- The 2.3% rate of growth in yield that is required for self-sufficiency will be met only when a number of obstacles are overcome in helping realized the potential of further genetic gains, increased fertilizer use and improved management practices.

Several studies (including Byerlee, Harrington and Sharif, 1990; Husain et al., 1990; and Heisey, 1990) identify the present systems of seed supply and distribution of new varieties as major obstacles to wheat yield increases in almost all parts of the country. These have been important factors in pakistan's slow adoption of improved varieties relative to other countries. Discussions with economists and extension officers in Sind suggest that the availability of appropriate varieties and seed for cotton are also serious problems in that province. For basmati

[3]Household-level (as opposed to field-level) data do not yield much insight beyond confirming the obvious importance of factors such as irrigation, salinity, education, etc., and throwing some light on the effect of farm size and tenure on productivity.

rice (which has not shown yield increases in recent years), experts emphasize better pest and disease control as the most important priority at this stages.

Beyond the identification of these crop-specific constraints on productivity, there is a great deal of persuasion in the argument that yield increases in the future will have to come largely from that yield increases in the future will have to come largely from improvements in better crop management such as weed control, balanced fertilizer use and improved on-farm water management.

Price policy must be counted as a primary pre-requisite for motivating farmers to undertake such improvements. In this connection, a recent report commissioned by the World Bank (Longmire and Debord, 1993) suggests that existing price policy is unfavorable (in terms of effective protection) towards cotton and basmati rice, as well as wheat and IRRI rice. Inefficient input markets (for seed and fertilizer) are other areas for policy reform identified by Longmire and Debord (1993) and Husain et al. (1990), to which should be added the existing system of institutional credit which restricts available credit systematically in favor of a small number of influential farmers.

In addition to efficient markets and pricing, a major need for the 1990s is to pay greater attention to research on crop management and resource management. Crop management issues have been mentioned above, while resource management research in suggested by analyses (Byerlee, Harrington, and Sharif, 1990) showing the possible negative influences on yield of deteriorating soil quality.

The policy agenda for the 1990s, however, is only partly indicated by the preceding discussion. It can be better established if what this study has not addressed is brought explicitly.

6.4 Important Issues Not Addressed by the Study

Assuming for the time being that near-term priorities can be established at a desegregated level for specific crops, resources and support systems, the paucity of public funds that is expected to persist during the 1990s would seriously constrain the effort that is needed. Moreover, as long as public funds are meager, the services provided by the systems they support will tend to be retained in favor of large and influential farmers, and remain inaccessible to the large majority of the farming community, with the result that the uptake of available technology will continue to be slow.

These observations suggest that over the medium and long run, it is the sectoral rather than crop-specific constraints that inhibit sustained improvements in agricultural productivity. Over the longer period, therefore, the issue can be approached through policies and mechanisms that can enable the sector to:

- Address the constraints on productivity as and when they arise;

- Generate the resources from agriculture to sustain agricultural support systems that are responsive to farmer demand; and,

- Distribute the resources available for agricultural development widely, so that the gains from productivity increases are widespread and rapid.

The framework within which these goals can be approached would emphasize the financial sustainability of agriculture and resource transfers for investing in the systems that support it. It would need to make it worthwhile for farmers themselves to invest in the sources of productivity improvement. More specifically, it would seek to develop:

- A more profitable that will generate and willingly contribute[4] the resources required to operate and maintain agricultural support systems in the private and public sectors;

- Decentralized public institutions that are responsive to local needs and variations, and markets in which the buyers and sellers compete aggressively to respond to the farmer's demand for improvement; and,

- Resource transfer mechanisms (including taxation for investing in public works and local organizations) within the agricultural/agro-based sector that can enable the large majority of farmers to access agricultural support services.

[4]That is, willingly in the context of political economy.

REFERENCES

Ahmad V. and R. Amjad. 1986. *The Management of Pakistan's Economy*. Oxford.

Akhter, Ramzam., D. Byerlee, A. Qayyum, A. Majid and Peter Hobbs. 1986. *Wheat in the Cotton Wheat Farming Systems of the Punjab: Implications for Research and Extension.* Islamabad: PARC/CIMMYT Collaborative Program (Agricultural Economic Research Unit PARC Islamabad, Ayub Agricultural Research Institute Faisalabad, PARC/CIMMYT Collaborative Program, Wheat Program NARC). Paper No. 86-8.

Azam, Q.T. and R.E. Evenson. 1990. "Agricultural Research Productivity in Pakistan." (mimeo). New Haven: Economic Growth Center, Yale University.

Bhaduri, A. 1973. "Agricultural Backwardness Under Semi-Feudalism." *Economic Journal.* 1973.

Bhatti I.M. et al. 1986. "Technological Options to Increase On-Farm Rice Yields and Profits in Larkana District." *Pakistan Journal of Agricultural Sciences.* 1(1).

Binswanger, H.P. and M.R. Rosenzweig. 1984. *Contractual Arrangements Employment and Wages in Rural Labor Markets in Asia.* New Haven: Yale University Press.

Byerlee, D. 1990. "Monitoring Farmers' Practices and Fields as a Continuing Activity in On-Farm Research for Evaluating Cropping Systems." Paper Presented at the 1990 Asian Farming Systems Research and Extension Symposium, Bangkok.

Byerlee, Derek., A.D. Sheikh, Kirnnat Khan, and Munir Ahmad (1987) *Diagnosing Research and Extension Priorities for Small Farmers: Maize in the Swat Valley.* Islamabad: PARC/CIMMYT Collaborative Program (International Maize and Wheat Improvement Center CIMMYT, Cereal Crop Research Institute Pirsabak, Agricultural Economic Research Unit Tarnab Peshawer, National Coordinated Maize Program PARC). Program Paper No. 87-19.

Byerlee, D., and A.Siddiq. 1990. *Sources of Growth in Wheat Yields in Pakistan's Punjab, 1965-2000: Is There a Sustainability Issue?* CIMMYT Economics Working Paper No. 90/04.

Byerlee, D., L. Harrington and M. Sharif. 1990. "Irrigated Cropping Systems of South Asia: Technological Changes and Sustainability to the Year 200 and Beyond." *Pakistan Journal of Agricultural Social Sciences.* 5(1).

Byerlee, D. and T. Husain. 1991. "Agricultural Research Strategies for Favored and Marginal Areas: The Experience of Farming Systems Research in Pakistan." Forthcoming in *Experimental Agriculture.*

Byerlee, Derek., and T. Husain. 1992. *Farming Systems of Pakistan: Diagnosing Priorities for Agricultural Research*. Lahore: Vanguard Press.

Byerlee, Derek., Peter R. Hobbs, Khan, Roidar Bakht, Abdul Majid, M. Ramzan Akkhter and Naeem I. Hashmi. 1986. *Increasing Wheat Productivity in the Context of Pakistan's Irrigated Cropping Systems: A View from the Farmers' Field.* Islamabad: PARC/CIMMYT Collaborative Program (Agricultural Economic Research Unit PARC Islamabad, Ayub Agricultural Research Institute Faisalabad, PARC/CIMMYT Collaborative Program, Wheat Program NARC) Paper No. 86-7.

Chaudhry, M. G. and G. M. Chaudhry. 1990. "Productivity of Small and Large Farms in Pakistan An Intertemporal Analysis." *Pakistan Journal of Agricultural Social Sciences.* 5(1).

Chaudhry, G. and N. Kayani. 1991. "Nominal Protection Coefficients for Pakistan's Agriculture." Paper presented at the 7th Annual General Meeting of the Pakistan Society for Development Economists. Islamabad.

Cownie, J., B.F. Johnston, and B. Duff. 1970. "The Quantitative Impact of the Seed and Fertilizer Revolution in West Pakistan: An Exploratory Study." *Food Research Institute Studies.*

Heisey, P. W., ed. 1990. *Accelerating the Transfer of Wheat Breeding Gains to Farmers: A Study of the Dynamics of Varietal Replacement in Pakistan.* CIMMYT Research Report No. 1.

Heisey, Paul, M. Ahmad, John. E.Stevens, Kiramat Khan, Jahan Zeb; and Habib Iqbal Javed. 1990. *Diagnosing Research Priorities for Higher Altitude Maize Based Farming Systems in Swat.* Islamabad: PARC/CIMMYT Collaborative Program (Agricultural Economics Research Unit PARC Tarnab Peshawar, PARC/CIMMYT Collaborative Program, Cereal Crops Research Institute Pirsabak, National Coordinated Maize Program NARC). Paper No. 90-3.

Hobbs, Peter R, A. Razzaq, Naeem I. Hashmi, Bakht R. Khan, Bakht and B.M. Khan 1989. *Wheat Production and Yields in Rawalpindi District of the Punjab from 1983-1986.* Islamabad: PARC/CIMMYT Collaborative Program (International Maize and wheat Improvement Center CIMMYT, Coordinated Wheat Program NARC Islamabad, Arid Zone Research Institute PARC Quetta), Paper No. 89-2.

Husain, S. S., J. Longmire, M. M. Ali and G. Traxler. 1990. "The Yield Gap for Wheat in Pakistan." *Pakistan Journal of Agricultural Social Sciences.* 5(1).

Husain S.S., J.Longmire, A. M. Manzoor, and J. Traxler. 1990. "The Yield Gap for Pakistan." (mimeo).

Husain, Tariq. 1986. *Wheat in the High Mountain Valleys of Gilgit*. Peshawar: AKRSP Rural Sciences Research Program. Report No. 2.

Irfan, M., and R. Amjad. 1984. "Poverty in Rural Pakistan." in Khan A.R., and Lee, E., eds. *Poverty in Rural Asia*. Bangkok: International Labor Organization.

Ishikawa S. 1981. "Labor Absorption in Asian Agriculture." *Poverty in Rural Asia*. Bangkok: International Labor Organization.

Khan, M.H. 1979. "Farm Size and Productivity." *Pakistan Development Review*. 18(4).

Khan, Mahmood Hasan. 1975. *The Economics of the Green Revolution in Pakistan*. Praeger.

Khan, Mahmood Hasan. 1987. *Underdevelopment and Agrarian Structure in Pakistan*. Lahore: Vanguard.

Longmire, J. and P. Debord. January 1993. "Agricultural Pricing and Comparative Advantage in Pakistan: An Update to 1991-92." Report Prepared for the South Asia Agricultural Division, World Bank. Washington D.C.

Mahmood M. 1992. "Profitability Productivity and Contractual Choice in Agriculture." Forthcoming in *The Pakistan Development Review*.

Mahmood, M. 1991. "Structural Change in Pakistan's Agrarian Sector over Time." Paper presented for the Planning Commission's Conference on the 8th Five Year Plan, January 1992, forthcoming in Papers and Proceedings.

Mahmood M. 1989. "An Exogenous-Endogenous Model for Agrarian Sector Analysis." Papers and Proceedings of the Fifth Annual General Meeting of the Pakistan Society of Development Economists.

Mahmood M. and Haq N. 1981. "Farm Size and Productivity Revisited." *Pakistan Development Review*. 21(3).

Mallick A.A. 1990. *Classification of Pakistan's Districts into Favored and Marginal Zones*. (mimeo). Islamabad: Development Research and Management Services.

Nabi, Ijaz; Naved Hamid, and Shahid Zahid. 1986. *The Agrarian Economy of Pakistan: Issues and Policies*. Oxford: Oxford University Press.

Salam A. 1981. "Farm Tractorization, Fertilizer Use and Productivity of Mexican Wheat in Pakistan." *Pakistan Development Review*. 20(3).

Sen, A.K. 1981. "Market Failure and Control of Labor Power." *Cambridge Journal of Economics*. Vol. 5.

Sen, A.K. 1966. "Peasants and Dualism With or Without Surplus Labor." *Journal of Political Economy*. 76(5).

Sharif M., J. Longmire, M. Shafiq, and Z. Ahmad. 1988. "Adoption of basmati-385: Implications for Time Conflicts in the Rice-Wheat Cropping System of Pakistan's Punjab." *Pakistan Journal of Agricultural Social Sciences*. 2(2).

Tetlay, Khaleel, Derek Byerlee and Zulfiqar Ahmad. 1990. *Role of Tractors, Tubewells and Plant Breeding in Increased Cropping Intensity in Pakistan*. Elsevier Science Publishers.

TABLE A-1.1

Area And Yield Effects for Selected Periods (Indices)*

WHEAT

Year	PAKISTAN area '000 ha.	PAKISTAN product '000 tons	PAKISTAN yield tons/ha	NWFP area '000 ha.	NWFP product '000 tons	NWFP yield tons/ha	PUNJAB area '000 ha.	PUNJAB product '000 tons	PUNJAB yield tons/ha	SINDH area '000 ha.	SINDH product '000 tons	SINDH yield tons/ha	BALOCHISTAN area '000ha	BALOCHISTAN product '000tons	BALOCHISTAN yield tons/ha
1947-48	3953.7	3301.0	0.835	409.9	280.0	0.68	2900.7	2595.0	0.89	538.2	381.0	0.71	104.8	45.0	0.43
1948-49	4285.9	3974.0	0.93	439.9	268.0	0.61	3132.6	3232.0	1.03	609.0	425.0	0.70	104.4	49.0	0.47
1949-50	4183.2	2862.0	0.92	446.0	295.0	0.66	3063.4	3131.0	1.02	554.0	368.0	0.66	119.8	68.0	0.57
1950-51	4370.1	3930.0	0.90	438.7	261.0	0.59	3316.3	3299.0	0.99	508.3	322.0	0.63	106.8	48.0	0.45
1951-52	4106.7	2962.0	0.72	442.7	189.0	0.43	3105.9	2436.0	0.78	454.5	284.0	0.62	103.6	53.0	0.51
1952-53	3816.9	2367.0	0.62	32.7	160.0	0.43	2787.0	1777.0	0.64	541.9	390.0	0.72	115.3	40.0	0.35
1953-54	4215.1	3587.0	0.85	421.3	213.0	0.51	3064.2	2910.0	0.95	615.1	404.0	0.66	114.5	60.0	0.52
1954-55	4261.3	3136.0	0.74	405.1	204.0	0.50	3249.2	2492.0	0.77	499.4	386.0	0.77	107.6	54.0	0.50
1955-56	4521.1	3317.0	0.734	425.3	255.0	0.60	3405.8	2612.0	0.77	571.0	392.0	0.69	119.0	58.0	0.49
1956-57	4689.0	3581.0	0.76	455.7	270.0	0.59	3538.1	2846.0	0.80	568.6	415.0	0.73	126.7	50.0	0.39
1957-58	4608.5	3508.0	0.76	467.4	279.0	0.60	3483.1	2750.0	0.79	529.7	422.0	0.80	128.3	57.0	0.44
1958-59	4829.0	3845.0	0.80	471.4	301.0	0.64	3599.2	3042.0	0.85	630.9	453.0	0.72	127.5	49.0	0.38
1959-60	4878.4	3847.0	0.79	552.8	353.0	0.64	3555.1	2977.0	0.84	639.4	463.0	0.72	131.1	54.0	0.41
1960-61	4638.8	3754.0	0.81	457.7	301.0	0.66	3379.9	2899.0	0.86	670.1	500.0	0.75	131.1	54.0	0.41
1961-62	4922.9	3963.0	0.81	498.6	304.0	0.61	3630.4	3109.0	0.86	674.6	495.0	0.73	119.4	55.0	0.46
1962-63	5022.1	4104.0	0.82	524.5	301.0	0.57	3729.5	3309.0	0.89	612.7	425.0	0.69	155.4	69.0	0.44
1963-64	5018.8	4096.0	0.82	596.9	343.0	0.57	3624.7	3209.0	0.89	625.2	464.0	0.74	172.0	80.0	0.47
1964-65	5317.5	4518.0	0.85	624.8	361.0	0.58	3788.6	3514.0	0.93	722.4	544.0	0.75	181.7	99.0	0.54
1965-66	5154.8	3854.0	0.75	585.6	304.0	0.52	3684.6	2931.0	0.80	683.1	533.0	0.78	201.5	86.0	0.43
1966.67	5343.8	4266.0	0.80	579.9	283.0	0.49	3870.3	3346.0	0.86	734.5	551.0	0.75	159.0	86.0	0.54
1967-68	5983.2	6317.0	1.06	611.9	389.0	0.64	4292.4	4966.0	1.16	845.8	832.0	0.98	233.1	130.0	0.56
1968-69	6159.6	6513.0	1.06	607.4	381.0	0.63	4551.8	5185.0	1.14	826.4	845.0	1.02	174.0	102.0	0.59
1969-70	6229.2	7179.0	1.15	625.6	375.0	0.60	4476.5	5552.2	1.24	939.3	1121.0	1.19	187.8	131.0	0.70
1970-71	5963.6	6475.5	1.09	589.9	330.6	0.56	4375.6	4948.4	1.13	837.0	1120.3	1.34	161.1	76.2	0.47
1971-72	5781.3	6890.1	1.19	592.8	439.4	0.74	4213.7	5291.0	1.26	779.5	1081.1	1.39	195.3	78.6	0.40
1972-73	5953.6	7442.0	1.25	684.0	584.1	0.85	4349.4	5693.6	1.31	770.7	1095.7	1.42	149.5	68.6	0.46
1973-74	6093.4	7628.4	1.25	691.7	606.3	0.88	4394.1	5665.0	1.29	840.2	1245.9	1.48	167.4	111.2	0.66
1974-75	5795.2	7673.0	1.32	694.7	613.0	0.88	4200.5	5785.4	1.38	754.4	1143.5	1.52	145.6	131.1	0.90
1975-76	6090.9	8620.8	1.42	706.6	659.9	0.93	4452.4	6571.6	1.48	797.4	1251.5	1.57	134.5	137.8	1.02
1976-77	6373.4	9142.8	1.43	716.7	711.2	0.99	4581.2	6807.0	1.49	927.4	1478.6	1.59	148.1	146.0	0.99
1977-78	6359.2	8384.6	1.32	695.2	705.9	1.02	4601.1	6090.2	1.32	906.0	1427.1	1.58	156.9	161.4	1.03
1978-79	6687.1	9949.9	1.49	704.6	737.5	1.05	4806.1	7323.5	1.52	1008.6	1680.1	1.67	167.8	208.8	1.24
1979-80	6923.9	10856.7	1.57	757.6	862.6	1.14	4952.0	7913.6	1.60	1026.2	1849.4	1.80	188.1	231.1	1.23
1980-81	6981.6	11473.0	1.64	788.6	938.9	1.19	4978.0	8350.3	1.68	1029.7	1945.8	1.89	185.3	238.3	1.28
1981-82	7222.9	11916.0	1.65	813.2	962.1	1.18	5167.6	8574.0	1.66	1026.0	2061.7	2.01	216.1	318.2	1.47
1982-83	7396.9	12414.9	1.68	824.3	998.3	1.21	5284.5	8935.7	1.69	1008.4	2066.7	2.05	279.7	414.2	1.48
1983-84	7342.9	10881.9	1.48	793.3	859.9	1.08	5248.5	7622.7	1.45	1010.4	1945.8	1.93	290.7	453.5	1.56
1984-85	7258.7	11703.3	1.61	785.5	872.1	1.11	5166.3	5315.4	1.61	1029.5	2078.7	2.02	277.4	437.1	1.58
1985-86	7403.3	13923.8	1.88	782.0	906.4	1.16	5343.2	10432.[illegible]	1.95	1030.5	2172.2	2.11	247.6	412.7	1.67
1986-87	7706.0	12882.1	1.67	802.7	960.2	1.20	5573.6	9199.7	1.65	1036.0	2211.5	2.1	293.7	510.7	1.74
1987-88	7308.4	12603.1	1.72	756.5	899.2	1.19	5343.8	9203.8	1.72	1024.8	2180.4	2.1	183.3	319.7	1.74
1988-89	7729.6	14419.2	1.87	811.2	1003.7	1.24	5589.4	10517.0	1.88	1045.2	2360.6	2.3	283.8	537.9	1.90

* Indices sum to 100 for each period.

Source: Computed from MINFA series.

TABLE A-1.2

Area And Yield Effects for Selected Periods (Indices)*

RICE

Unit: Area ('000 hectares) Produciton ('000 tons) (tons/ha.)

Year	PAKISTAN area '000 ha.	PAKISTAN product '000 tons	PAKISTAN yield tons/ha	NWFP area '000 ha.	NWFP product '000 tons	NWFP yield tons/ha	PUNJAB area '000 ha.	PUNJAB product '000 tons	PUNJAB yield tons/ha	SINDH area '000 ha.	SINDH product '000 tons	SINDH yield tons/ha	BALOCHISTAN area '000 ha.	BALOCHISTAN product '000 tons	BALOCHISTAN yield tons/ha
1947-48	789.9	682.0	0.86	11.3	6.0	0.53	268.7	249.0	0.93	486.4	412.0	0.85	23.5	15.0	0.64
1948-49	939.7	736.0	0.88	13.8	10.0	0.73	297.8	311.0	1.04	507.5	401.0	0.79	20.6	14.0	0.68
1949-50	932.8	792.0	0.85	15.4	11.0	0.72	348.8	342.0	0.98	542.3	419.0	0.77	26.3	20.0	0.76
1950-51	968.0	851.0	0.88	15.4	9.0	0.59	352.9	307.0	0.87	572.6	519.0	0.91	27.1	16.0	0.59
1951-52	883.8	719.0	0.81	15.4	11.0	0.72	308.4	285.0	0.92	531.7	405.0	0.76	28.3	18.0	0.64
1952-53	907.7	818.0	0.90	13.8	8.0	0.58	311.6	302.0	0.97	554.0	491.0	0.89	28.3	18.0	0.64
1953-54	1015.7	906.0	0.89	12.9	7.0	0.54	372.3	370.0	0.99	600.9	503.0	0.84	29.5	26.0	0.88
1954-55	958.7	825.0	0.86	17.0	10.0	0.59	355.7	282.0	0.79	565.3	514.0	0.91	20.6	19.0	0.92
1955-56	969.2	828.0	0.85	13.4	11.0	0.82	354.1	275.0	0.78	576.7	517.0	0.90	25.1	25.0	1.00
1956-57	971.6	831.0	0.86	12.9	11.0	0.85	382.4	313.0	0.82	552.8	487.0	0.88	23.5	20.0	0.85
1957-58	1073.2	862.0	0.80	13.8	12.0	0.87	406.3	303.0	0.75	626.4	524.0	0.84	26.7	23.0	0.86
1958-59	1150.9	976.0	0.85	15.4	14.0	0.91	463.0	404.0	0.87	644.7	532.0	0.83	27.9	26.0	0.93
1959-60	1203.5	979.0	0.81	15.8	14.0	0.89	501.8	410.0	0.82	663.3	535.0	0.81	22.7	20.0	0.88
1960-61	1180.9	1014.0	0.86	15.0	12.0	0.80	562.5	499.0	0.89	579.5	482.0	0.83	23.9	21.0	0.88
1961-62	1214.4	1109.0	0.91	15.8	12.0	0.76	548.3	508.0	0.93	617.9	574.0	0.93	32.4	15.0	0.46
1962-63	1185.7	1078.0	0.91	15.0	12.0	0.80	543.5	521.0	0.96	593.3	514.0	0.87	34.0	31.0	0.91
1963-64	1286.1	1173.0	0.91	17.0	013.0	0.76	551.2	531.0	0.96	677.4	594.0	0.88	40.5	35.0	0.86
1964-65	1355.7	1329.0	0.98	17.0	14.0	0.82	596.9	649.0	1.09	700.1	629.0	0.90	41.7	37.0	0.89
1965-66	1393.3	1296.0	0.93	43.7	33.0	0.76	572.2	568.0	0.99	734.1	676.0	0.92	43.3	19.0	0.44
1966-67	1409.5	1343.0	0.95	44.5	34.0	0.76	588.4	618.0	1.05	729.6	651.0	0.39	46.9	40.0	0.85
1967-68	1419.6	1475.0	1.04	46.1	37.0	0.80	667.8	770.0	1.15	660.4	629.0	0.95	45.3	39.0	0.86
1968-69	1554.8	2000.0	1.29	47.8	45.0	0.94	828.4	1078.0	1.30	634.9	839.0	1.32	43.7	38.0	0.87
1969-70	1621.9	2363.0	1.46	52.6	49.0	0.93	819.5	1175.0	1.43	703.3	1097.0	1.56	46.5	42.0	0.90
1970-71	1463.2	2199.5	1.50	53.8	66.0	1.23	738.1	982.3	1.33	671.3	112.7	1.67	40.1	28.5	0.71
1971-72	1414.7	2261.7	1.60	54.2	59.3	1.09	688.0	991.7	1.44	672.5	1168.1	1.74	41.5	42.6	1.03
1972-73	1441.2	2329.7	1.62	52.4	66.0	1.26	686.7	1000.9	1.46	702.1	1221.9	1.74	38.4	40.9	1.07
1973-74	1476.3	2455.0	1.66	57.2	72.2	1.26	713.0	1114.5	1.56	706.1	1234.9	1.75	35.6	33.4	0.94
1974-75	1569.6	2313.8	1.47	61.1	76.9	1.26	821.1	1152.4	1.40	687.4	1049.0	1.53	34.6	35.5	1.03
1975-76	1709.7	2617.5	1.53	63.0	84.6	1.34	877.3	1207.2	1.38	731.1	1286.1	1.76	38.3	39.6	1.03
1976-77	1749.3	2737.4	1.56	63.1	85.4	1.35	919.8	1332.0	1.45	747.5	1292.0	1.73	18.9	28.0	1.48
1977-78	1899.1	2949.6	1.55	65.7	87.6	1.33	1047.7	1507.8	1.44	747.6	1315.3	1.76	38.1	38.9	1.02
1978-79	2025.6	3212.6	1.59	67.9	104.0	1.53	1181.7	1706.5	1.44	734.7	1340.9	1.83	41.3	61.2	1.48
1979-80	2034.5	3215.8	1.58	67.2	104.7	1.56	1179.6	1518.4	1.29	745.6	1499.1	2.11	42.1	93.6	2.22
1980-81	1933.1	3123.2	1.62	66.2	105.1	1.59	1061.9	1361.7	1.28	763.8	1549.9	2.03	41.2	106.5	2.58
1981-82	1976.0	3429.7	1.74	69.3	110.7	1.60	1088.6	1450.9	1.33	727.6	1584.2	2.18	90.5	283.9	3.14
1982-83	1978.1	3444.5	1.74	70.5	112.5	1.60	1072.9	1407.0	1.31	718.6	1560.1	2.17	116.1	364.9	3.14
1983-84	1998.5	3339.5	1.67	72.2	115.8	1.60	1096.3	1409.4	1.29	722.0	1478.8	2.05	108.0	335.5	3.11
1984-85	198.5	3315.2	1.66	72.4	115.5	1.60	1120.6	1534.9	1.37	689.7	1345.0	1.95	115.8	319.8	2.76
1985-86	1863.2	2918.9	1.57	70.1	113.8	1.62	1113.3	1478.2	1.33	585.7	1071.7	1.83	94.1	255.2	2.71
1986-87	2065.6	3486.3	1.69	70.7	118.3	1.67	1174.8	1534.8	1.31	721.0	1548.5	2.15	99.1	284.7	2.87
1987-88	1963.0	3240.9	1.65	60.9	107.5	1.77	1085.4	1352.3	1.25	721.8	1537.5	2.13	94.9	243.6	2.57
1988-89	2041.7	3200.2	1.57	62.7	117.8	1.88	1186.5	1367.3	1.15	685.8	1435.9	2.09	106.7	279.2	2.62

* Indices sum to 100 for each period.

Source: Computed from MINFA series.

TABLE A-1.3

Area And Yield Effects for Selected Periods (Indices)*

COTTON

Year	PAKISTAN area '000 ha.	PAKISTAN product '000 tons	PAKISTAN yield tons/ha	NWFP area '000 ha.	NWFP product '000 tons	NWFP yield tons/ha	PUNJAB area '000 ha.	PUNJAB product '000 tons	PUNJAB yield tons/ha	SINDH area '000 ha.	SINDH product '000 tons	SINDH yield tons/ha	BALOCHISTAN area '000 ha.	BALOCHISTAN product '000 tons	BALOCHISTAN yield tons/ha
1947-48	1236.7	188.1	0.15	2.4	0.5	0.21	897.2	125.0	0.14	337.1	62.6	0.19			
1948-49	1051.4	164.0	0.16	2.4	0.2	0.07	743.0	109.2	0.15	305.9	54.6	0.18			
1949-50	1110.4	210.8	0.19	2.0	0.2	0.08	755.5	148.8	0.20	352.9	61.7	0.17			
1950-51	1220.5	239.2	0.20	2.8	0.2	0.06	853.9	154.6	0.18	363.8	84.4	0.23			
1951-52	1342.7	237.6	0.18	6.1	0.9	0.14	959.1	162.8	0.17	377.2	74.0	0.20			
1952-53	1384.8	303.5	0.22	4.9	0.9	0.18	959.1	203.1	0.21	419.7	99.5	0.24			
1953-54	1161.4	242.4	0.21	4.5	0.5	0.11	773.3	144.1	0.19	383.6	97.8	0.25			
1954-55	1269.1	269.3	0.21	4.0	0.3	0.08	883.0	174.9	0.20	382.0	94.1	0.25			
1955-56	1407.1	285.4	0.20	4.0	0.5	0.13	978.9	190.5	0.19	423.7	94.4	0.22			
1956-57	1438.6	291.0	0.20	4.0	0.3	0.08	982.6	193.4	0.20	451.2	97.3	0.22			
1957-58	1452.8	290.5	0.20	3.6	0.3	0.09	1006.8	192.2	0.19	442.3	98.0	0.22			
1958-59	1324.5	269.9	0.20	3.6	0.3	0.09	906.9	172.6	0.19	414.0	97.0	0.23			
1959-60	1342.7	278.8	0.21	5.3	0.5	0.10	930.0	191.5	0.21	407.5	86.7	0.21			
1960-61	1292.9	287.6	0.22	3.2	0.3	0.11	878.6	191.2	0.22	411.2	96.1	0.23			
1961-62	1395.7	310.1	0.22	3.2	0.5	0.16	972.0	220.8	0.23	420.5	88.8	0.21			
1962-63	1373.9	350.4	0.26	3.2	0.5	0.16	973.3	254.3	0.26	397.4	95.6	0.24			
1963-64	1470.6	400.4	0.27	2.8	0.3	0.12	1060.3	298.2	0.28	407.5	101.9	0.25			
1964-65	1466.6	361.3	0.25	2.8	0.3	0.12	1125.4	285.1	0.25	338.3	75.9	0.22			
1965-66	1561.2	396.5	0.25	2.4	0.5	0.21	1161.4	271.0	0.23	397.4	125.0	0.31			
1966-67	1619.9	443.1	0.27	2.4	0.5	0.21	1199.9	322.2	0.27	417.6	120.4	0.29			
1967-68	1765.0	495.2	0.28	3.2	0.7	0.21	1329.8	368.4	0.28	452.0	126.0	0.28			
1968-69	1745.4	504.7	0.29	2.0	0.5	0.25	1307.9	369.8	0.28	435.4	134.4	0.31			
1969-70	1755.5	512.3	0.29	2.4	0.3	0.14	1344.3	381.7	0.28	408.7	130.3	0.32			
1970-71	1733.6	3189.1	1.84	2.2	2.3	1.05	1300.4	2330.0	1.78	422.9	856.4	2.03	0.1	0.4	4.00
1971-72	1957.4	4158.0	2.12	1.9	2.1	1.11	1496.0	3110.0	2.08	459.1	1045.2	2.28	0.4	0.7	1.75
1972-73	2010.7	4126.3	2.05	2.7	3.1	1.15	1578.7	2954.2	1.87	429.0	1168.3	2.72	0.3	0.7	2.33
1973-74	1844.8	3871.3	2.10	2.7	3.3	1.22	1369.0	2639.3	1.93	472.6	1228.0	2.60	0.5	0.7	1.40
1974-75	2030.9	3728.3	1.84	3.0	3.7	1.23	1546.5	2587.6	1.67	481.1	1136.5	2.36	0.3	0.5	1.67
1975-76	1851.3	3020.5	1.63	2.4	3.0	1.25	1383.8	2024.6	1.46	464.9	992.5	2.13	0.2	0.4	2.00
1976-77	1864.8	2556.9	1.37	2.8	3.4	1.21	1330.2	1627.6	1.22	531.3	925.4	1.74	0.5	0.5	1.00
1977-78	1843.2	3379.4	1.83	2.5	2.9	1.16	1304.3	2113.5	1.62	536.3	1262.9	2.35	0.1	0.1	1.00
1978-79	1891.2	2782.3	1.47	2.3	2.6	1.13	1388.0	1941.8	1.40	500.8	837.8	1.67	0.1	0.1	1.00
1979-80	2081.0	4281.8	2.06	2.2	2.6	1.18	1481.1	2831.6	1.91	597.5	1447.3	2.42	0.2	0.3	1.50
1980-81	2108.5	4201.7	1.99	2.3	2.8	1.22	1506.2	2789.3	1.85	599.0	1406.9	2.35	1.0	2.7	2.70
1981-82	2214.1	4399.0	1.99	2.8	3.4	1.21	1573.1	2844.2	1.81	637.9	1550.2	2.43	0.3	1.2	4.00
1982-83	2262.9	4844.4	2.14	2.7	3.3	1.22	1612.7	3255.2	2.02	647.0	1584.5	2.45	0.5	1.4	2.80
1983-84	2220.7	2908.6	1.31	2.5	3.0	1.20	1562.5	1694.2	1.08	655.5	1210.0	1.85	0.2	1.4	7.00
1984-85	2241.5	5931.5	2.65	2.3	2.9	1.26	1567.7	4450.9	2.84	671.1	1475.6	2.20	0.4	2.1	5.25
1985-86	2364.0	7155.7	3.03	2.2	2.8	1.27	1745.8	5701.2	3.27	615.4	1449.2	2.35	0.6	2.5	4.17
1986-87	2505.1	7760.7	3.10	2.1	2.7	1.29	1864.0	6451.0	3.46	638.3	1304.6	2.04	0.7	2.4	3.43
1987-88	2567.1	8632.5	3.36	1.4	1.8	1.29	1935.6	7255.4	3.75	629.6	1373.7	2.18	0.5	1.6	3.20
1988-89	2620.4	8387.6	3.20	2.4	3.0	1.25	2053.8	7275.2	3.54	564.0	1108.9	1.97	0.2	0.5	2.50

* Indices sum to 100 for each period.

Source: Computed from MINFA series.

TABLE A-2.1

Area And Yield Effects for Selected Periods (Indices)*

HYV PROD. WHEAT

Unit: Area ('000 acres) Production ('000 tons) Yield (tons/acre)

Year	Pakistan area	Pakistan product	Pakistan yield	NWFP area	NWFP product	NWFP yield	Punjab area	Punjab product	Punjab yield	Sindh area	Sindh product	Sindh yield	Balochistan area	Balochistan product	Balochistan yield
1967-68			No breakdown given												
1968-69	2367.4	3875.0	1.6	116.5	165.0	1.4	1921.0	3248.0	1.7	291.0	421.0	1.4	38.8	41.0	1.1
1969-70	2681.4	4678.0	1.7	136.8	142.0	1.0	2101.9	3820.0	1.8	429.4	695.0	1.6	13.4	21.0	1.6
1970-71	3128.6	4708.0	1.5	213.7	171.0	0.8	2343.5	3633.0	1.6	545.9	883.0	1.6	25.5	21.0	0.8
1971-72	3286.4	5180.0	1.6	279.6	308.0	1.1	2452.3	3970.0	1.6	527.3	869.0	1.6	27.1	33.0	1.2
1972-73	3375.8	5471.0	1.6	309.2	338.0	1.1	2525.2	4234.0	1.7	526.5	877.0	1.7	15.0	22.0	1.5
1973-74	3475.4	5638.0	1.6	305.5	367.0	1.2	2591.6	4264.0	1.6	562.5	984.0	1.7	15.8	23.0	1.5
1974-75	3723.0	6006.0	1.6	338.3	370.0	1.1	2745.7	4591.0	1.7	617.1	1009.0	1.6	21.9	36.0	1.6
1975-76	4015.6	6965.8	1.7	434.1	474.3	1.1	2982.5	5400.0	1.8	568.6	1033.8	1.8	30.4	57.7	1.9
1976-77	4599.3	7905.4	1.7	419.4	503.5	1.2	3434.5	6031.9	1.8	718.3	1308.8	1.8	27.1	61.2	2.3
1977-78	4684.5	7106.5	1.5	432.3	508.3	1.2	3450.3	5210.3	1.5	773.7	1327.5	1.7	28.2	60.4	2.1
1978-79	5095.7	8533.8	1.7	461.2	565.0	1.2	3691.5	6274.1	1.7	877.9	1561.6	1.8	65.1	133.1	2.0
1979-80	5587.1	9580.3	1.7	487.3	662.4	1.4	4124.6	7141.7	1.7	902.1	1636.8	1.8	73.1	139.4	1.9
1980-81	5732.5	10307.8	1.8	529.2	745.9	1.4	4138.0	7510.5	1.8	988.4	1902.3	1.9	76.9	149.1.	1.9
1981-82	6171.2	10399.7	1.7	525.1	748.8	1.4	4527.0	7380.9	1.6	984.1	2017.5	2.1	135.0	252.5	1.9
1982-83	6367.2	11421.6	1.8	557.6	788.3	1.4	4713.5	8355.9	1.8	970.4	2027.2	2.1	125.7	250.2	2.0
1983-84	6498.0	10212.9	1.6	543.8	704.3	1.3	4820.0	7265.7	1.5	972.4	1911.5	2.0	161.8	331.4	2.0
1984-85	6546.8	11147.0	1.7	553.3	726.2	1.3	4820.1	8035.2	1.7	990.0	20367.8	2.1	183.4	347.8	1.9
1985-86	6722.1	13317.2	2.0	546.2	742.9	1.4	5007.9	10096.4	2.0	991.0	2130.4	2.1	177.0	347.5	2.0
1986-87	7055.3	11497.4	1.6	581.6	797.8	1.4	5275.4	8103.6	1.5	993.4	2166.1	2.2	204.9	429.9	2.1
1987-88	6876.8	12359.1	1.8	57 .2	770.4	1.3	5153.2	9084.6	1.8	991.4	2153.4	2.2	153.0	350.7	2.3
1988-89	5511.8	10714.6	1.9	584.5	825.1	1.4	5320.8	10280.8	1.9	989.1	2311.8	2.3	191.0	434.6	2.3
1989-90	*	*	*	*	*	*	5464.0	10328.9	1.9	*	*	*	197.10	447.4	2.3

* Indices sum to 100 for each period.

Source: Computed from MINFA series.

TABLE A-2.2

Area And Yield Effects for Selected Periods (Indices)*

NON-HYV PROD. WHEAT

Year	Pakistan area	Pakistan product	Pakistan yield	NWFP area	NWFP product	NWFP yield	Punjab area	Punjab product	Punjab yield	Sindh area	Sindh product	Sindh yield	Balochistan area	Balochistan product	Balochistan yield
1968-69	3792.2	2638.0	0.7	490.9	216.0	0.4	2630.8	1937.0	0.7	535.4	424.0	0.8	135.2	61.0	0.5
1969-70	3547.8	2501.0	0.7	488.9	233.0	0.5	2374.7	1732.0	0.7	509.9	426.0	0.8	174.4	110.0	0.6
1970-71	2848.9	1666.0	0.6	375.9	155.0	0.4	2046.1	1237.0	0.6	291.4	220.0	0.8	135.6	54.0	0.4
1971-72	2510.6	1602.0	0.6	313.0	125.0	0.4	1776.5	1238.0	0.7	252.5	195.0	0.8	168.3	44.0	0.3
1972-73	2594.8	1854.4	0.7	374.7	237.0	0.6	1841.3	1369.0	0.7	244.4	202.0	0.8	134.4	46.0	0.3
1973-74	2637.3	1870.0	0.7	386.5	230.0	0.6	1821.1	1311.0	0.7	278.0	242.0	0.9	151.8	87.0	0.5
1974-75	2089.4	1546.0	0.7	356.5	234.0	0.7	1470.6	1103.0	0.8	138.4	116.0	0.8	123.8	93.0	0.8
1975-76	2095.0	1655.5	0.8	272.9	186.1	0.7	1489.2	1171.6	0.8	228.8	217.7	1.0	104.1	80.1	0.8
1976-77	1790.8	1238.5	0.7	297.4	208.1	0.7	1163.5	775.8	0.7	208.9	169.8	0.8	121.0	84.8	0.7
1977-78	1675.5	1260.7	0.8	263.4	180.3	0.7	1150.9	879.9	0.8	132.5	99.5	0.8	128.7	101.0	0.8
1978-79	1591.4	1416.2	0.9	243.5	172.5	0.7	1114.5	1049.5	0.9	130.7	118.5	0.9	102.7	75.7	0.7
1979-80	1336.6	1276.2	1.0	270.2	200.1	0.7	827.0	771.8	0.9	124.4	212.6	1.7	115.0	91.7	0.8
1980-81	1251.2	1166.8	0.9	261.2	194.9	0.7	840.0	839.5	1.3	41.6	43.5	1.3	108.4	88.9	0.8
1981-82	1050.9	904.5	0.9	288.1	213.4	0.7	639.4	581.2	0.9	42.3	44.2	1.0	81.1	65.7	0.8
1982-83	1030.7	992.8	1.0	266.9	210.1	0.8	571.5	579.2	1.0	38.3	39.5	1.0	154.0	164.0	1.1
1983-84	845.2	669.0	0.6	249.8	155.5	0.6	428.2	357.1	0.8	38.3	34.3	0.9	128.9	122.1	0.9
1984-85	711.7	556.0	0.8	232.3	145.9	0.6	345.6	279.9	0.8	39.8	40.9	1.0	94.0	89.3	1.0
1985-86	681.2	605.8	0.9	235.7	163.6	0.7	335.1	335.2	1.0	39.8	41.8	1.1	70.6	65.2	0.9
1986-87	650.9	518.5	0.8	221.2	161.6	0.7	298.3	230.7	0.8	42.6	45.4	1.1	88.8	80.8	0.9
1987-88	431.6	316.0	0.7	177.3	128.8	0.7	190.6	119.2	0.6	33.4	27.0	0.8	30.3	41.0	1.4
1988-89	644.2	566.8	0.9	226.7	178.6	0.8	268.6	236.2	0.9	56.1	48.8	0.9	92.8	1036.3	1.1
1989-90	*	*	*	*	*	*	203.5	189.3	0.9	*	*	*	99.6	116.9	1.2

* Indices sum to 100 for each period.

Source: Computed from MINFA series.

TABLE A-2.3

Area And Yield Effects for Selected Periods (Indices)*

HYV Rice

Unit: Area ('000 acres) Production ('000 tons) Yield (tons/acre)

Year	Pakistan area	Pakistan product	Pakistan yield	NWFP area	NWFP product	NWFP yield	Punjab area	Punjab product	Punjab yield	Sindh area	Sindh product	Sindh yield	Balochistan area	Balochistan product	Balochistan yield
1967-68				No breakdown given											
1968-69	307.9	642.0	2.1	2.8	6.0	2.1	74.9	187.0	2.5	230.3	448.0	1.9	0.00	1.0	
1969-70	501.4	1009.0	2.0	2.4	6.0	2.5	96.7	260.0	2.7	401.0	742.0	1.9	1.21	1.0	0.8
1970-71	550.3	1042.0	1.9	2.8	6.0	2.1	99.1	269.0	2.7	423.7	746.0	1.8	24.69	21.0	0.9
1971.72	728.4	1386.0	1.9	4.0	6.0	1.5	194.2	396.0	2.0	508.7	956.0	1.9	21.45	28.0	1.3
1972-73	647.0	1235.0	1.9	3.2	7.0	2.2	126.3	251.0	2.0	494.5	944.0	1.9	23.07	33.0	1.4
1973-74	668.6	1279.0	1.9	14.6	19.0	1.3	127.1	265.0	2.1	505.4	970.0	1.9	21.45	25.0	1.2
1974-75	630.9	1089.0	1.7	13.4	18.0	1.3	110.9	212.0	1.9	475.1	826.0	1.7	31.56	33.0	1.0
1975-76	665.6	1290.1	1.9	12.3	18.5	1.5	116.1	221.3	1.9	522.1	1027.6	2.0	15.1	22.7	1.5
1976.77	677.5	1315.7	1.9	10.1	16.4	1.6	133.1	259.5	1.9	520.7	1015.8	2.0	13.6	24.0	1.8
1977-78	852.2	1671.2	2.0	10.2	16.2	1.6	292.6	579.2	2.0	541.2	1061.1	2.0	8.2	14.7	1.8
1978-79	1015.4	1948.8	1.9	10.8	17.4	1.6	381.6	710.8	1.9	598.8	1173.7	2.0	24.2	46.9	1.9
1979-80	964.1	1958.0	2.0	10.2	19.6	1.9	316.0	526.2	1.7	612.8	1333.3	2.2	25.1	78.9	3.1
1980-81	841.1	1795.7	2.1	11.9	23.9	2.0	198.7	332.0	1.7	599.9	1343.0	2.2	30.6	96.8	3.2
1981-82	872.2	2020.8	2.3	15.0	31.0	2.1	179.0	310.7	1.7	590.0	1398.5	2.4	88.2	280.6	3.2
1982-83	915.7	2123.6	2.3	15.3	31.6	2.1	202.4	357.1	1.8	585.4	1375.7	2.4	112.6	359.2	3.2
1983-84	941.3	2069.9	2.2	15.3	32.0	2.1	228.6	400.8	1.8	599.7	1322.6	2.2	97.7	314.5	3.2
1984-85	974.1	2038.7	2.1	15.3	30.8	2.0	308.8	568.3	1.8	576.4	1208.3	2.1	73.6	231.3	3.1
1985-86	902.3	1784.6	2.0	15.4	30.8	2.0	337.1	603.9	1.8	493.5	975.0	2.0	56.3	174.9	3.1
1986-87	1055.5	2130.3	2.3	17.5	35.5	2.0	383.2	690.8	1.8	598.3	1402.7	2.3	56.5	180.9	3.2
1987-88	952.6	1850.4	1.9	16.8	35.8	2.1	250.9	420.5	1.7	603.7	1393.1	2.3	81.2	220.4	2.7
1988-89	846.5	1611.5	1.9	17.4	38.7	2.2	195.9	302.9	1.5	572.3	1307.6	2.3	78.3	222.7	2.8
1989-90	842.7	1797.0	2.1	16.4	33.6	2.1	197.1	309.8	1.6	547.0	1220.6	2.2	82.2	232.8	2.8

* Indices sum to 100 for each period.

Source: Computed from MINFA series.

TABLE: A-2.4
Area and Yield Effects for Selected Periods (Indicies)*

Non HYV RICE

Pakistan			NWFP			Punjab			Sindh			Balochistan		
area	product	yield	area	product	yield	area	product	yield	area	product	yield	area	product	yield
1246.8	1367.0	1.1	44.9	39.00	0.9	753.5	900.0	1.2	404.7	391.0	1.0	43.7	37.0	0.8
1120.6	1354.0	1.2	50.2	43.00	0.9	722.8	915.0	1.3	302.3	355.0	1.2	45.3	41.0	0.9
953.0	1123.0	1.2	[illegible]	59.00	1.2	639.0	698.0	1.1	247.7	359.0	1.4	15.4	7.0	0.5
728.0	840.0	1.2	50.2	52.00	1.0	493.7	580.0	1.2	163.9	194.0	1.2	20.2	14.0	0.7
832.4	1058.0	1.3	49.0	58.00	1.2	560.5	734.0	1.3	207.6	259.0	1.2	15.4	7.0	0.5
843.3	1137.0	1.3	42.5	52.00	1.2	586.0	832.0	1.4	200.7	245.0	1.2	14.2	8.0	0.6
973.3	1188.0	1.2	47.8	58.00	1.2	710.2	922.0	1.3	212.1	206.0	1.0	3.2	2.0	0.6
1044.1	1293.3	1.2	50.7	32.0	0.6	761.2	985.90	1.3	209.0	258.5	1.2	23.2	16.9	0.7
1071.8	1421.7	1.3	53.0	69.0	1.3	786.7	1072.5	1.4	226.8	276.2	1.2	5.3	4.0	0.8
1046.9	1278.4	1.2	55.5	71.4	1.3	755.1	928.60	1.2	206.4	254.2	1.2	29.9	24.2	0.8
1010.2	1323.2	1.3	57.1	86.6	1.5	800.1	1055.10	1.3	135.9	167.2	1.2	17.1	14.3	0.8
1070.4	1257.8	1.2	57.0	85.1	1.5	863.6	992.2	1.1	132.8	165.8	1.2	17.0	14.7	0.9
1092.0	1326.6	1.2	54.3	81.2	1.5	863.2	1029.70	1.2	163.9	206.0	1.3	10.6	9.7	0.9
1103.2	1408.9	1.3	54.3	79.7	1.5	909.6	1140.2	1.3	137.0	185.7	1.4	2.3	3.3	1.4
1062.4	1321.1	1.2	55.2	81.1	1.5	870.5	1049.9	1.2	133.2	184.4	1.4	3.5	5.7	1.6
1057.2	1269.6	1.2	56.9	83.8	1.5	867.7	1008.60	1.2	122.3	156.2	1.3	10.3	21.0	2.0
1024.4	1276.5	1.2	57.1	84.7	1.5	811.8	966.60	1.2	113.3	136.7	1.2	42.2	88.5	2.1
960.9	1134.3	1.2	54.7	83.0	1.5	776.2	874.30	1.1	92.2	96.7	1.0	37.8	80.3	2.1
1010.1	1176.4	1.2	53.2	82.8	1.6	791.6	844.00	1.1	122.7	145.8	1.2	42.6	103.8	2.4
1010.4	1171.1	1.2	44.1	71.7	1.6	834.5	931.80	1.1	118.1	144.4	1.2	13.7	23.2	1.7
1132.5	1249.0	1.1	45.3	79.1	1.7	990.6	1064.40	1.1	113.5	128.1	1.1	28.4	56.5	2.0
1264.2	1423.1	1.1	45.4	80.8	1.8	1084.5	1172.40	1.1	108.3	119.4	1.1	26.0	50.5	1.9

TABLE A-3.1

Area And Yield Effects for Selected Periods

IRRIGATED WHEAT

Year	Pakistan area	Pakistan product	Pakistan yield	NWFP area	NWFP product	NWFP yield	Punjab area	Punjab product	Punjab yield	Sindh area	Sindh product	Sindh yield	Balochistan area	Balochistan product	Balochistan yield
1970-71	4392.1	5795.8	1.32	230.1	181.3	0.79	3366.3	4586.7	1.36	707.3	1027.8	1.45	88.4		
1971-72	4331.1	6240.6	1.44	264.7	301.9	1.14	3311.9	4890.3	1.48	660.7	990.5	1.50	93.8	57.9	0.62
1972-73	4444.4	6644.7	1.50	273.6	333.7	1.22	3438.1	5257.6	1.53	650.5	996.7	1.53	82.2	56.7	0.69
1973-74	4501.1	6759.6	1.50	293.9	379.9	1.29	3435.2	5197.0	1.51	685.2	1114.7	1.63	86.8	68.0	0.78
1974-75	4440.6	6891.8	1.55	276.5	362.7	1.31	3340.3	5297.0	1.59	733.0	1125.2	1.54	90.8	106.9	1.18
1975-76	4574.0	7648.1	1.67	284.5	398.4	1.40	3538.2	6000.8	1.70	676.6	1141.0	1.69	74.7	107.9	1.44
1976-77	4784.5	8133.6	1.70	284.1	408.6	1.44	3665.2	6276.9	1.71	782.0	1343.9	1.72	63.2	104.2	1.65
1977-78	4080.8	7369.2	1.51	278.2	381.9	1.37	3720.7	5543.6	1.49	809.3	1327.5	1.64	72.6	116.2	1.60
1978-79	5200.2	8724.7	1.68	286.3	408.1	1.43	3914.3	6570.7	1.68	905.9	1576.7	1.74	93.7	169.2	1.81
1979-80	5454.9	9567.6	1.75	298.8	479.8	1.61	4062.9	7092.0	1.75	982.4	1806.1	1.84	110.8	189.7	1.71
1980-81	5464.6	10095.5	1.85	303.1	524.6	1.73	4061.0	7470.7	1.84	988.1	1902.3	1.93	112.4	197.9	1.76
1981-82	5698.4	10049.8	1.76	305.2	5828.2	1.73	7425i.9	7219.1	1.70	983.7	2017.5	2.05	157.6	285.0	1.81
1982-83	5758.9	10867.7	1.89	306.7	542.6	1.77	4321.3	7992.1	1.85	970.1	2027.2	2.09	160.8	305.8	1.90
1983-84	5794.4	9674.5	1.67	292.6	497.2	1.70	4360.5	9622.0	1.59	972.1	1911.5	1.97	169.2	343.8	2.03
1984-85	5765.2	10537.5	1.83	304.2	524.8	1.73	4303.8	7636.3	1.77	989.7	2037.8	2.06	167.5	338.6	2.02
1985-86	5962.1	12506.7	2.10	305.1	536.1	1.76	4494.3	9486.2	2.1[illegible]	990.6	2130.5	2.15	172.1	353.9	2.06
1986-87	6207.2	10705.1	1.72	511.2	511.2	1.69	4714.1	7595.8	1.61	993.4	2166.1	2.18	197.4	432.0	2.19
1987-88	6137.9	11822.6	1.93	299.9	518.3	1.73	4669.2	8762.2	1.88	991.5	2153.4	2.17	177.3	388.7	2.19
1988-89	6317.1	13076.5	2.07	311.5	549.8	1.77	4804.8	9740.8	2.03	989.1	2311.8	2.34	211.7	474.1	2.24

* Indices sum to 100 for each period.

Source: Computed from MINFA series.

TABLE A-3.2

Area And Yield Efffects for Selected Periods (Indices)*

UNIRRIGATED WHEAT

Year	Pakistan area	Pakistan product	Pakistan yield	NWFP area	NWFP product	NWFP yield	Punjab area	Punjab product	Punjab yield	Sindh area	Sindh product	Sindh yield	Balochistan area	Balochistan product	Balochistan yield
1970-71	1570.5	603.5	0.38	359.8	149.3	0.41	109.3	361.7	0.36	129.7	92.5	0.71	71.7		
1971-72	1450.2	649.6	0.45	328.1	137.5	0.42	901.8	400.7	0.44	118.8	90.6	0.76	101.5	20.8	0.20
1972-73	1509.0	796.6	0.53	410.4	250.4	0.61	911.3	436.0	0.48	120.2	99.0	0.82	67.1	11.2	0.17
1973-74	1592.4	869.0	0.55	397.8	226.4	0.57	958.9	468.0	0.49	155.0	131.2	0.85	80.7	43.4	0.54
1974-75	1354.8	781.2	0.58	418.2	250.3	0.60	860.2	488.4	0.57	21.4	18.3	0.36	55.0	24.2	0.44
1975-76	1516.8	972.6	0.64	422.1	261.5	0.62	914.2	570.8	0.62	120.8	110.5	0.92	59.7	29.8	0.50
1976-77	1578.9	1009.4	0.64	432.6	302.6	0.70	916.0	531.1	0.58	145.4	134.7	0.93	84.9	42.0	0.49
1977-78	1478.4	997.8	0.67	417.0	306.4	0.73	880.4	546.6	0.62	96.7	99.6	1.03	84.3	45.2	0.54
1978-79	1487.0	1225.5	0.82	418.3	329.4	0.79	891.8	752.8	0.84	102.7	103.4	1.01	74.2	39.9	0.54
1979-80	1469.4	1289.4	0.88	458.8	382.8	0.83	889.1	821.6	0.92	43.8	43.3	0.99	77.7	41.7	0.54
1980-81	1517.1	1377.1	0.91	485.5	414.3	0.5	917.0	879.6	0.96	41.06	43.5	1.05	73.0	39.7	0.54
1981-82	1524.7	1254.5	0.82	508.0	433.9	0.85	915.7	743.0	0.81	42.3	44.2	1.04	58.7	33.4	0.57
1982-83	1638.1	1547.7	0.94	517.6	455.7	0.88	963.2	943.6	0.98	38.3	39.5	1.36	119.0	108.9	0.92
1983-84	1548.8	1207.6	0.78	500.7	362.7	0.72	838.0	700.7	0.79	38.3	34.3	0.90	121.8	109.9	0.90
1984-85	1494.0	1166.1	0.78	481.3	347.3	0.72	862.5	679.1	0.79	39.8	40.9	1.03	110.4	98.8	0.89
1985-86	1441.4	1417.3	0.98	476.9	370.3	0.78	848.9	946.3	1.11	39.9	41.7	1.05	75.7	59.0	0.78
1986-87	1499.2	1311.7	0.87	500.4	449.0	0.90	859.5	738.5	0.83	42.6	45.4	1.07	96.7	78.8	0.81
1987-88	1170.5	852.5	0.73	456.6	380.9	0.83	674.6	441.6	0.65	33.3	27.0	0.81	6.0	3.0	0.50
1988-89	1412.5	1342.7	0.95	499.7	453.9	0.91	784.6	776.2	0.99	56.1	48.8	0.87	72.1	63.8	0.88
1989-90	1386.5	1432.2	1.03	505.4	482.8	0.96	759.5	840.0	1.11	39.1	28.2	0.74	82.5	80.6	0.98

* Indices sum to 100 for each period.

Source: Computed from MINFA series.

TABLE A-4.1

Area And Yield Effects for Selected Periods (Indices)*

FAVOURABLE WHEAT

Year	Pakistan area	Pakistan product	Pakistan yield	NWFP area	NWFP product	NWFP yield	Punjab area	Punjab product	Punjab yield	Sindh area	Sindh product	Sindh yield	Balochistan area	Balochistan product	Balochistan yield
1971	4547.9	5618.9	1.24	261.0	158.8	0.61	3668.7	4627.6	1.26	591.7	832.5	1.41	26.5		
1972	4445.1	5989.9	1.35	282.3	248.7	0.88	3542.7	4928.7	1.39	556.7	799.2	1.44	63.4	13.3	0.21
1973	4547.1	6389.2	1.41	295.5	273.0	0.92	3635.6	5265.7	1.45	571.0	840.3	1.47	45.0	10.2	0.23
1974	4623.4	6482.8	1.40	291.2	279.9	0.96	3688.3	5239.0	1.42	615.1	949.4	1.54	28.8	14.5	0.50
1975	4362.2	6461.3	1.48	288.0	278.6	0.97	3504.6	5313.0	1.52	532.8	820.3	1.54	36.8	49.4	1.34
1976	4581.3	7227.0	1.58	276.0	279.7	1.01	3743.2	6032.8	1.61	536.1	867.4	1.62	26.0	47.1	1.81
1977	4828.2	7718.6	1.60	284.9	331.2	1.16	3879.9	6302.0	1.62	633.9	1030.1	1.63	29.5	55.3	1.87
1978	4784.9	6837.7	1.43	259.5	255.2	0.98	3879.6	5555.7	1.43	611.8	964.4	1.58	34.0	62.4	1.84
1979	5055.7	8161.3	1.61	260.3	282.0	1.08	4063.0	6619.5	1.63	678.1	1152.8	1.70	54.3	107.0	1.97
1989	5244.4	8930.3	1.70	298.3	363.9	1.22	4191.6	7122.3	1.70	690.1	1325.1	1.92	64.4	119.0	1.85
1981	5228.5	9408.6	1.80	286.8	395.1	1.38	4165.0	7464.0	1.79	709.6	1424.7	2.01	67.1	124.8	1.86
1982	5501.4	9849.9	1.79	290.8	388.5	1.34	4379.9	7742.3	1.77	717.4	1507.1	2.10	113.3	212.0	1.87
1983	5610.3	10154.5	1.81	315.2	413.6	1.31	4498.1	8035.3	1.79	701.6	1517.2	2.16	95.4	188.4	1.97
1984	5617.3	8926.9	1.57	299.9	367.9	1.23	4500.9	6886.9	1.53	703.6	1436.0	2.04	112.9	236.1	2.09
1985	5574.0	9792.8	1.76	292.4	365.8	1.25	4432.5	7606.3	1.72	745.7	1604.0	2.15	103.4	216.7	2.10
1986	5761.8	11806.6	2.05	318.1	412.8	1.30	4589.2	9485.4	2.07	746.4	1672.8	2.24	108.1	235.6	2.18
1987	5260.3	9058.8	1.72	335.2	451.0	1.35	4802.7	8309.7	1.73				122.4	298.1	2.44

* Indices sum to 100 for each period.

Source: Computed from MINFA series.

107

TABLE A-4.2

Area And Yield Effects for Selected Periods (Indices)*

MARGINAL WHEAT

Year	Pakistan area	Pakistan product	Pakistan yield	NWFP area	NWFP product	NWFP yield	Punjab area	Punjab product	Punjab yield	Sindh area	Sindh product	Sindh yield	Balochistan area	Balochistan product	Balochistan yield
1971	1417.7	780.4	0.55	328.9	171.8	0.52	706.9	320.8	0.45	245.3	287.8	1.17			
1972	1336.2	900.3	0.67	310.5	190.7	0.61	671.0	362.3	0.54	222.8	281.9	1.27	131.9	65.4	0.50
1973	1406.3	1052.1	0.75	388.5	311.1	0.80	713.8	427.9	0.60	199.7	255.4	1.28	104.3	57.7	0.55
1974	1470.1	1145.8	0.78	400.5	326.4	0.81	705.8	426.0	0.60	225.1	296.5	1.32	138.7	96.9	0.70
1975	1433.2	1211.7	0.85	406.7	334.4	0.82	695.9	472.4	0.68	221.6	323.2	1.46	109.0	81.7	0.75
1976	1509.5	1393.7	0.92	430.6	380.2	0.88	709.2	538.8	0.76	261.3	384.1	1.47	108.4	90.6	0.84
1977	1545.2	1424.4	0.92	431.8	380.0	0.88	701.3	505.0	0.72	293.5	448.5	1.53	118.6	90.9	0.77
1978	1574.3	1546.9	0.98	435.7	450.7	1.03	721.5	534.5	0.74	294.2	462.7	1.57	122.9	99.0	0.81
1979	1631.5	1788.9	1.10	444.3	455.5	1.03	743.1	704.0	0.95	330.5	527.3	1.60	113.6	102.1	0.90
1989	1679.9	1926.7	1.15	459.3	498.7	1.09	760.4	791.3	1.04	336.1	524.3	1.56	124.1	112.4	0.91
1981	1753.2	2064.0	1.18	501.8	543.8	1.08	813.0	886.3	1.09	320.1	521.1	1.63	118.3	112.8	0.95
1982	1721.7	2066.3	1.20	522.4	573.6	1.10	787.7	831.7	1.06	308.6	554.6	1.80	130.0	106.4	1.03
1983	1786.7	2260.9	1.27	509.1	584.7	1.15	786.4	900.4	1.14	306.8	549.5	1.79	184.4	226.3	1.23
1984	1725.9	1955.2	1.13	493.4	492.0	1.33	747.6	735.8	0.98	306.8	509.8	1.66	178.1	217.6	1.22
1985	1685.2	1910.8	1.13	493.1	506.3	1.03	733.8	709.1	0.97	283.8	474.7	1.67	174.5	220.7	1.26
1986	1641.7	2117.4	1.29	463.9	493.6	1.06	754.0	947.1	1.26	284.1	499.4	1.76	139.7	177.3	1.27
1987	1410.1	1611.9	1.14	467.5	509.2	1.09	770.9	890.0	1.15				171.7	212.7	1.24

* Indices sum to 100 for each period.

Source: Computed from MINFA series.

APPENDIX B

SUMMARY OF DATA AND LITERATURE ON DIFFERENCES IN INPUT ADOPTION AND OUTPUT INDICATORS BY FARM SIZE AND TENURE

INPUTS	SINDH		PUNJAB	
	(%)		(%)	
	1970	1980	1972	1980
FERTILIZER	60.0	73.0	55.0	76.0
Small	57.0	76.0	52.0	75.0
Medium	65.0	69.0	61.0	81.0
Large	67.0	59.0	58.0	74.0
Owner	55.0	68.0	52.0	72.0
O-C-T	59.0	73.0	54.0	80.0
Tenant	83.0	78.0	59.0	82.0
PLANT PROTECTION	2.0	3.0	2.0	2.0
Small	2.0	3.0	1.0	1.0
Medium	2.0	3.0	1.0	2.0
Large	2.0	5.0	3.0	4.0
TRACTOR USE	5.8	28.0	20.4	40.0
Small	4.2	25.0	12.7	39.0
Medium	6.7	30.0	19.5	38.0
Large	17.7	37.0	28.0	54.0
Owner	5.3	24.0	0.1	41.0
O-C-T	5.0	26.0	0.1	38.0
Tenant	6.1	33.0	0.4	35.0
TUBEWELL USE	2.8	6.0	39.0	49.0
Small	0.4	3.2	13.0	22.0
Medium	3.3	7.0	41.0	48.0
Large	8.7	7.1	44.0	50.0
Owner	2.6	NA	37.0	NA
O-C-T	4.7	NA	46.0	NA
Tenant	2.5	NA	47.0	NA

Source: Pakistan Agriculture Census (1972 & 1980)
NA = Not Available

OUTPUT

SOURCE	SAMPLE	REGION	CROPS	RESULTS
Ijaz Nabi 1986	Four Villages	Punjab	All	Farm size Small farmers have greater output in Rs/acre - soil depletion is lower - higher labor intensity - better management Tenancy Tenancy has no effect on productivity
Salam 1973	192 Farmers	Gujranwala Sahiwal	All	Farm size In small farms the high yield effect is disappearing. -green revolution.
Khan 1972-3	Nine Districts	Sind Punjab	All	Farm size Small farmers have lower output/acre -do not use new inputs
Aslam 1974-75	4 Villages 71 Farmers	Faisalabad	All	Farm size No difference in relative efficiency of small and large farmers
Mahmood Hasan Khan 1981	732 Farms	Punjab Sind	All	Farm size Negative relationship between farm size and crop output in Rs/acre. Cropping intensity is inversely proportional to farm size. Tenure Tenant farms show higher cropping intensity.
Derek Byerlee 1984		Punjab	Rice Wheat	Farm size Small farmers have lower yield/acre. Tenure Tenant farmers have lower yield/acre.
S. Sajidin Hussain 1984.		Mardan	All	Farm size Cropping intensity higher in small farms.
Mahmood Hasan Khan 1975	1000 Farmers	Punjab Sind	Rice Wheat	Farm size Yield/acre of large farms is higher than small farms -increased use of HYV seeds, chemical, fertilizers, pesticides, farm machinery and tubewell water.
PARC/CIMMYT STUDIES :				
Khaleel Tetlay 1990	71 Farmers (1986)	Multan District	Wheat Fodder	Farm size Cropping intensity is the same in all farm sizes. The proportion of area devoted to fodder decreases as farm size decreases.
Derek Byerlee 1986.	56 Farms ('84) 20 Farms ('85)	Swat	Maize	Farm size Farm size not significantly related to yields.
M. Ramzan Akhter 1986	150 Farms	Multan District	Wheat Cotton	Farm size Yield of small farmers and large farmers is the same. -bad weather in 1985. Tenure Yields of tenant fields and owner fields is the same -bad weather in 1985. Farm size Large farmers have more yield -use of fertilizers and insecticides.

OUTPUT

SOURCE	SAMPLE	REGION	CROPS	RESULTS
PARC/CIMMYT STUDIES:				
Derek Byerlee 1986		Pakistan	Wheat	Farm size Farm size is positively related to yields
Paul Heisey 1990	150 Fields (1987)	Swat Mts	Maize	Farm size In barani areas large farms have less cropping intensity as compared to irrigated areas. At lower elevations there was no difference between cropping intensities of small and large farms in irrigated areas.
Mohd. Shafiq 1989	301 Farmers (1988)	Pakistan	Cotton	Farm size Medium farms have higher yields than small and large farms. -use of high yield variety seeds.

INPUTS

SOURCE	SAMPLE	REGION	CROPS	RESULTS
Tariq Husain ('85-'86)	176 Farmers ('84-'85) 315 Farmers	Gilgit	Wheat	Farm size Inputs i.e. seed rate, nitrogen, phosphate, farm yard manure and irrigation intervals, show no significant difference between small and large farms. Large farms own more draft animals and show an increased use of threshers.
Derek Byerlee 1986	155 Villagers 150 Villagers	Punjab NWFP	Wheat	Farm size Small farm size shows greater percentage of tractor usage. Farm size has a positive influence on fertilizer use.
Mahmood Hasan Khan 1975	1000 Farmers	Punjab Sind	Rice Wheat	Farm size The proportion of area given to NHYV of wheat and rice does not change with a change in farm size. The employment of family labor decreases as farm size increases, regardless of the variety of wheat used. For rice (HYV) large farms use less labor -increased use of machinery.
Nadeem ul Haq & Mahmood 1981	Secondary Data	Pakistan	All	Farm size Medium sized farms have not utilized new technology.

112

APPENDIX C

DATA SOURCES

Two kinds of statistical data, macro and micro data, were used in this study. It was envisaged at the outset that the macro data would provide the general trend and direction of changes in crop productivity and the direction of agricultural input utilization in the country. The micro-level data which comprises of large and small survey data were expected to provide insight into farmers production conditions. In this way, it was hoped that a good grasp of both policy level issues and farmer related issues would be obtained.

In what transpired, however, restrictions imposed by data unavailability led to a shift in the emphasis of the data being used.

1. Macro Data

Macro data are defined as those data which cover the entire population of the agricultural sector. There are four major sources of macro data which allow a comparison over time.

- Agricultural Censuses, 1960, 1972, 1980.
- The Rural Credit Surveys, 1972 and 1985.
- Ministry of Food and Agriculture (MINFA), 1970-1988.
- The Pakistan Agriculture Data Set (Bob Evanson's Compilation).

These four data sets were available at district level, with the exception of the Rural Credit Surveys (RCS). The Agricultural Census do not provide estimates of crop production and yield at the farm level for the entire population. RCS contains some output data at district level but is not published and has a restrictive number of observations for some key variables. This limits the breadth of analysis of the study and implies a great deal of dependence on the micro level data to discover the potential sources of productivity.

This study relies heavily on data made available by the Ministry of Food and Agriculture. The data set provides the essential estimates for production and productivity at the district level since 1948/48 up to 1988/89 for the five major crops considered in this study. This unpublished data set desegregates wheat production into four levels; high yielding variety, traditional variety in irrigated and unirrigated cultivated areas. In addition to this data set, published data from MINFA was also utilized for area and production of crops dating back to the late 1940's. The data was analyzed using Lotus 123 worksheets.

The last source of macro level data was made available to EDC, courtesy of USAID/Pakistan. This was expected to be an ideal source of information for crop performance by districts dating back to the 1950s. The data set also included macro-level estimates of input

use on crops and resulting production estimates. The main purpose of the data set compiled by Bob Evanson was to conduct research into factors which directly effect wheat research in the country. In this data set, he has compiled a neat though incompatible data. However when examined against the MINFA data set, Bob Evanson's compilation is not consistent. As result the data set was not used in this study. The inconsistency of Bob Evanson's data set has been most unfortunate and denied our analysis of an important data set.

2. Micro Level Data

Micro level data are defined as farm-level samples from different regions at various points in time. Given the paucity of input level data at the macro-level, the study relies heavily on the micro surveys to provide levels of input use and the resulting changes in productivity.

a) WAPDA Expanded Agro-economic Survey, 1977

This survey, carried out in 1977, has 2002 respondents from regions in Punjab, Sind, and NWFP which fall under a watercourse command area. The results from the survey contributed towards the "Revised Action Plan for Irrigated Agriculture". No other policy document or analytical report has resulted from the survey finding. EDC has selected data from this large data set, in lotus format from the World bank. The data provide useful information on the cultural practices, input use and output for wheat, cotton and rice crops, and distinguishes between the variety (traditional or high yielding).

b) WAPDA Farm Survey, 1988

The Farm Survey, conducted in 1988, is very much on the same lined as the larger XAES data set conducted in 1977. The sample size, however is much smaller and is restricted to 504 respondents, very few of whom were interviewed in the first survey. This survey was also limited to areas along watercourses and only pertains to irrigated agriculture for all five crops under study. EDC has in its possession the complete data set and questionnaire.

The two data sets were available to EDC on soft copy and were analyzed using the statistical package SPSS 2.1 (PC version).