PD-ACC-359

AGENCY FOR
INTERNATIONAL
DEVELOPMENT

COUNTRY FIELD SUBMISSION
FY 1971

INDIA

ANNEX F

DEPARTMENT
OF
STATE

SEPTEMBER 1969

BEST AVAILABLE

August 1, 1969

ANNEX F

LONG RANGE AGRICULTURAL ADJUSTMENT ANALYSIS

Drafted by:

Ralph W. Cummings, Jr.

LONG RANGE AGRICULTURAL ADJUSTMENT ANALYSIS (LRAAA)

Introduction

Something fundamental and dynamic, with far-reaching consequences, has been introduced into the Indian agricultural scene since 1965. However, there were previous periods, such as the end of the First Five Year Plan, when optimism was similarly widespread.

With this history in mind, the objectives of this annex are twofold.

1. The first objective is to place the contribution of the new technology into perspective by describing its background and by making an explicit estimate of the impact of the high yielding varieties program to total foodgrain production during the past two (1967-68 and 1968-69) years. Our analysis suggests that the impact of the high yielding varieties program has been substantial, especially keeping in mind the newness of the program and the fundamental changes in attitude that are called for.

2. The second objective is to identify potential problem areas in the long-term growth of Indian agriculture in order that anticipation of and reaction to these expected problems (and positive forces) can accelerate the agricultural growth process and ease the attendant adjustment problems. This is the reason for the title of the annex "Long Range Agricultural Adjustment Analysis," or "LRAAA."

The exercise is organized in the Tinbergen/Theil policy analysis framework of targets and instruments - or in more lay terms - of goals and policies (Tinbergen, 1955; Theil, 1956; Fox, Sengupta, and Thorbecke, 1966)1/ We will use this framework to identify policy problems and to discuss analytical and empirical research, primarily carried out in India, which is relevant to the future.

1/ The studies are identified as in ( ) and an extensive but selected bibliography is attached at the end.

The exercise will be organized in four main sections.

..... The first section will describe the environment in which agriculture operates and, in general terms, the fundamental disequilibrating changes which the new technology has introduced.

..... The second section will discuss the primary objectives or targets of Indian agricultural development. These targets fall within the following four broad categories:

1. Increasing output of agricultural production

2. Inter-personal equity

3. Inter-regional equity

4. Resource mobilization, within the agricultural sector in the form of capital building in addition to a transfer of resources to aid non-agricultural growth

..... The third section will discuss the policies or instruments which can influence the achievement of the goals. These policies are discussed in terms of their functional areas but broadly they fall within the following four broad categories:

1. Enabling producers to reach the surface of the production function, i.e., to make more effective use of resources;

2. Enabling producers to move up the production function, i.e., to provide more production resources;

3. Enabling a shift upward in the production function, i.e., to increase the input/output quality of resources; and

4. Enabling those not fully participating in the economic matrix to enjoy some of the benefits of economic development.

..... The final section will be a summing up of the exercise and a series of questions regarding what more needs to be done.

It is hoped that the analysis can be a starting point and a focus to develop the policy information necessary to make maximum advantage of the growth potential now before India.

TABLE OF CONTENTS

Page No.

Introduction

Table of Contents

Tables

Figures

I. The New Strategy of Agricultural Development 1

A. The New Strategy of Agricultural Development 2

B. Progress Among Individual Crops 6

C. Relative Contribution of New Technology to 1967-68 and 1968-69 Output 8

1. Assumptions 8

a. Base Period 8

b. Foodgrain Area 9

c. Gross Irrigated Foodgrain Area 9

d. Per cent of Total Fertilizer Used on Foodgrains 9

e. Average Fertilizer Dosage - HYV 10

f. Fertilizer Response 12

g. Average Fertilizer Dosage - Local Varieties 15

h. Fertilizer Response - Local Varieties 16

2. Results 17

D. Relative Contribution of Rainfall 21

E. Conclusions 26

TARGETS 27

II. The Role of Agriculture in Indian Economic Development 28

A. Demand for Agricultural Products 29

1. Human Consumption 29

a. Base Period Consumption 30

b. Population 31

c. National Income 31

d. Income Elasticity of Demand 32

e. Results 32

2. Seed, Feed, and Waste 32

a. Seed 32

b. Animal Feed 32

c. Post-Harvest Losses 34

3. Total Domestic Foodgrain Requirements 35

4. Exports 35

5. Concluding Comments 35

B. Inter-personal and Inter-regional Distribution 37

1. Inter-personal Distribution 39

2. Regional Growth Rate 43

C. Resource Mobilization and Growth Generation 46

D. Summary 52

III. Projections of Long Range Agricultural Development 53
(The parameters of what can be expected if alternative assumptions regarding government support are carried out)

A. Aggregate Foodgrain Supply Projections 54

1. The Natural Resource Base for Crop Production 54

a. Water Supply 54

b. The Soil Resource 56

c. Technological Base 60

2. Factors Influencing the Translation of Potential into Future Performance 61

3. Projections 63

a. The "Five Per Cent" Annual Growth Rate of Foodgrain Production 63

1) Net Foodgrain Area Sown 63

2) Gross Irrigated Area Sown 64

a) Net Irrigated Area Sown 65

b) Multiple Cropping 65

3) Gross Areas Sown to HYV 65

4) Fertilizer Consumption 66

a) Past and Present Dosage Levels 66

b) Future 66

5) Increase in Technology 66

a) Base Level 66

b) Fertilizer Response 67

6) Results 69

b. Alternative "Low Metabolism" and "High Metabolism" Foodgrain Growth Paths 69

4. Concluding Comments 70

B. Cropping Pattern Changes 72

1. Foodgrain Price Projections 74

a. Statistical Relationships 74

b. Projections of Future Prices 77

1) Levels 77

2) Stability 80

3. Technology in Non-Cereals 81

4. Projections of Cropping Patterns and Non-Foodgrain Production 81

C. Inter-regional and Inter-personal Development Implications 85

1. Regional Growth Rates 85

2. Inter-Personal Income Distribution 89

D. Agricultural/Non-Agricultural Sectoral Relationships 94

IV. Targets (Summary) and Instruments (Introduction) - A Transition 96

A. Targets (Summary) 96

B. Instruments (Introduction) 98

INSTRUMENTS 101

V. Production Inputs Requirements 102

A. Fertilizer 103

1. Demand 103

2. Supply 108

B. Irrigation 110

1. Finishing Off Major Development 112

2. Public Tubewells 114

3. Private Tubewells Development 114

C. Plant Protection 116

D. Energy 117

E. Seeds 122

F. Concluding Comments 122

VI. Distribution of Inputs and Outputs 124

A. Distribution of Inputs 126

1. Fertilizer 126

2. Seeds 128

3. Pesticides 128

4. Farm Machinery 130

B. Output Marketing 131

C. Transportation and Storage 135

1. Transportation 135

2. Storage 138

D. Market Building and Rural Centering 143

VII. Economic Policy 146

A. Prices 146

1. Input vs. Output Prices 147

2. Output Prices 149

a. Price Level 149

b. Relative Prices 150

c. Price Stability 151

3. Buffer Stock 152

4. Support Prices 157

a. General 157

1) Risk 158

2) Input Response 160

b. Specific Levels 164

1) Terms of Trade 164

a) Commodity Terms of Trade 164

b) Corrections for Productivity Gains 167

c) New Technology 167

2) Costs of Production 167

a) Local Varieties 167

b) High Yielding Varieties 170

3) Synthetic Budgets 172

4) Modified Production Function Model 174

5) Concluding Comments 175

5. World Prices 176

6. Relative Rice/Wheat Prices 178

7. Concluding Comments 181

B. Taxation 184

C. Credit 187

D. Institutional Measures - Zones 191

E. Concluding Comments 194

VIII. Research and Technology (including education and extension) 195

A. Research 195

1. Background 195

2. Research Funding 197

a. Aggregate Investment 197

b. Allocation of Research Expenditures among Crops 200

c. Conclusions from Review of Past Research Funding 200

3. Implications for Future Research Investments 200

B. Agricultural Education 203

C. Extension 205

IX. Socially Oriented Programs 207

A. Dry Lands 207

B. Small Farmers 209

C. Tenants and Rentiers 210

D. Non-viable Small Farmers and Landless Laborers 213

E. Public Foodgrain Distribution 217

F. Concluding Comments 219

X. Long Range Agricultural Adjustment Analysis - Concluding Comments 220

Appendices 221

Bibliography 281

TABLES

1	HYV Program - Acreage Targets and Achievements	4
2	Estimates of Foodgrain Output Increase from 1959-60 to 1961-62 Average to 1967-68 with Following Input Increases	18
3	Projected Aggregate Human Consumption Demand for Selected Consumer Goods	33
4	Total Requirement of Foodgrains	36
5	Acreage and Production of A, B, and C Types of Areas	45
6	Foodgrain Production - Medium Projection	64
7	Foodgrain Production - Low and High Metabolism Projections	71
8	Price Projections	78
9	Projected Acreage Allocations - First Exercise	83
10	Supply and Demand Comparisons of "First Exercise" Cropping Pattern Projections	84
11	Comparison of Post-Independence and Projected Fourth Plan (Preliminary) Growth Rates by State	86
12	Fertilizer Requirements	106
13	Location of Public Storage	141
14	Inter-relationship of Instruments in Buffer-Stock	153
15	Parity Prices of Rice and Wheat	166
16	Cost of Production of Local and High Yielding Varieties	171
17	Data Taken from GOI Report on High Yielding Varieties Program, Kharif 1966-67	173

18	Comparison of Indian Prices for Wheat, Maize, and Rice with Prices in Other Countries	177
19	Incidence of Direct Taxes on Indian Agriculture	183
20	Open and Concealed Taxes on and Subsidies Given to Indian Agriculture	185
21	Government Agricultural Research Budgets and Agricultural Research Workers	199
22	Selected Research Expenditures Compared to Various Criteria	201

FIGURES

1	Relationship Between Cereal Yields and Rainfall Index (All-India: 1951-52 to 1966-67)	22
2	The Ratio of Rainfall to Potential Evapotranspiration	55
3	The Ratio of Rainfall to Potential Evapotranspiration for the 8 Month Period 1 July to 31 March	57
4	Generalized Soil Map of India	58
5	Average Response of Cereals to Fertilizer	68
6	The Marketing System - Flow Diagram	134A

I. THE NEW STRATEGY OF AGRICULTURAL DEVELOPMENT

Food self-sufficiency has been an important goal of post-Independence India. During the First Five Year Plan, the approach was to achieve production increases by emphasizing institution building (e.g., Community Development) and extensive agricultural practices (e.g., more acres tilled, more area under canal command). 1/ Favorable rains resulted in increased production which gave planners the hope that the right approach had been followed. The Second Five Year Plan directed more attention to the industrial sector while continuing to emphasize extensive practices in agriculture. This policy continued into the Third Five Year Plan period. Finally, the drought of 1965-66 preceded by four years (1960-61 through 1963-64) of relatively stable foodgrain production dramatically focused attention on the low level of success of this approach. 2/

1/ Another way of describing these policies is that the emphasis in the First Five Year Plan was on closing what was presumed to be a large technological gap between technologies then commonly in use in India and those available both by transfer from economically advanced countries and from India's own best farms. This was presumed to be mainly an educational and motivational problem amenable to particular kinds of institutional approaches, namely extension, community development, and land reform. The problem, in other words, should not be thought of in terms of institutional versus non-institutional approaches but in terms of the kinds of institutions which were presumed to be needed in order to increase production in light of what was considered to be the best available diagnosis (note from W.E. Hendrix).

2/ Blyn (1968) estimated a growth of crop output between 1891-1947 of 0.37 per cent per year. The increase in foodgrains output was much slower than that of non-foodgrains. His data show a decline in the rate of growth in crop output during the latter half of the period as compared to the first half.

The all-India annual compound rates of growth between 1952-53 and 1964-65 were 2.50 per cent for foodgrains, 3.99 per cent for non-foodgrains, and 3.01 per cent for all-crops. The all-crops growth rates of individual states ranged from a low of 1.17 per cent for Assam to a high of 4.56 per cent for Punjab (India, 1966a).

Hopper (unpublished) calculated the following growth rates in per cent (compound) per annum of production, area, and productivity of Indian agriculture during the periods of the Five Year Plans, 1951-52 to 1964-65:

continued

A. The New Strategy of Agricultural Development

The "New Agricultural Strategy" as enunciated in the Fourth Five Year Plan Draft (original) (India, 1965c) in 1965, marked a significant departure from these previous agricultural development efforts. Some productive parts from past programs were being recognized. The New Strategy attempted to redirect the successful previous activity areas into an integrated, comprehensive program with the objective of attaining foodgrain self-sufficiency by 1970-71.

The New Strategy focused on combining high yielding varieties of seeds with a "package" of complementary inputs concentrating on selected water-assured acreages.

(Contd.)

Plan Period	Crop	Production	Area	Productivity
First Plan (1951-52 to 1955-56)	Foodgrains	6.18	3.28	2.79
	Non-foodgrains	3.21	2.44	0.74
	All crops	5.11	3.15	1.90
Second Plan (1956-57 to 1960-61)	Foodgrains	4.20	1.34	2.81
	Non-foodgrains	3.45	1.27	2.16
	All crops	3.93	1.33	2.57
Third Plan (1961-62 to 1964-65)	Foodgrains	2.26	0.03	2.23
	Non-foodgrains	4.21	0.52	3.66
	All crops	2.95	0.13	2.81

Note: These rates have been determinedbby a least squares fit of $I_t = ab^t$ to the years involved. The calculated rates have been carried to two decimal places, but, at best, these two decimal places are indicative only. Because of the short periods embraced by each rate calculation, each must be regarded as "suggestive," and no claim is made that the evidence is "conclusive."

Foodgrain production fell to 72 million tons in 1965-66, an almost 20 per cent decline from the 89 million ton record in 1964-65, and rose only to 75 million tons in 1966-67.

The availability of high yielding varieties of seeds was the critical new element. Short-strawed wheat varieties were obtained from the Rockefeller Foundation in Mexico and dwarf rice varieties were obtained from Taiwan and the International Rice Research Institute in the Philippines. Indian research programs generated new hybrids of jowar, bajra, and maize and the ADT-27 rice variety (See Section on Research and Technology).

The fundamental policy change was to concentrate production inputs on highest productivity areas. 3/

In addition, there were commitments to:

..... make available required inputs, particularly chemical fertilizers, assigning priority to scarce foreign exchange when necessary;

..... actively encourage domestic and foreign investment in fertilizer and other agricultural inputs;

..... implement a "producer-oriented" incentive price policy;

..... reorganize agricultural research into a coordinated program of all-India schemes;

..... refocus extension activities;

..... support a system of state agricultural universities which would make scientific activity directed toward practical application a permanent part of the Indian scene; and

..... extend the quantity and distribution of rural credit.

The pattern of planning is flexible allowing changes to be made from season to season as experience provides additional guidelines with regard to the responsiveness of local cultivators and the adaptability of varieties to regional conditions. By 1973-74 it is proposed to have 60 million acres under high yielding varieties.

The results of some of these policy directives were:

..... acreage under HYV reached 21 million acres by 1968-69 (Table 1)

3/ Too much can be made regarding the degree to which these inputs are actually concentrated now. Basically, they are made available to those who can pay. When input supplies are made more generally available, as has been the case recently, the rationing device is more economic than administrative.

F-4

Table - 1

HYV Program - Acreage Targets and Achievements

'000 acres

Crop	1964-65 Acreage		1966-67		1967-68		Targets	
	Total	Irrigated	Target	Coverage	Target	Coverage	1968-69*	1973-74
Rice	89,819	33,172	3,254	2,142	6,158	4,409	9,120	25,000
Jowar	44,297	1,666	927	243	2,560	1,408	3,155	8,000
Bajra	28,963	NA	375	145	1,151	1,037	2,778	7,000
Maize	11,406	NA	910	513	1,616	703	1,683	5,000
Wheat	33,246	11,964	1,593	1,278	4,562	7,269	10,909	15,000
Total			7,080	4,321	16,233	14,826	27,540	60,000

Notes: *The 1968-69 target was originally 21 million acres (rice--8.5; jowar--2.5; bajra--2.5; maize--2.5; wheat--5.0). In early fall of 1968 Central teams visited different states to finalize agricultural development programs for 1968-69. They reviewed the target earlier proposed for 1968 on the basis of actual acreage during kharif 1967, performance during 1967-68 and the likely shortfall in coverage during the current kharif season on account of drought and floods. They then indicated targets for summer/rabi 1968-69 on the basis of availability of agricultural inputs.

..... production inputs were expanded rapidly, for example fertilizer availability increased from 671,000 tons in 1964-65 to 2,063,000 tons in 1967-68;

..... indigenous fertilizer production capacity increased from 701,000 tons in 1964-65 to 1,466,000 tons in 1968-69; 4/

..... support prices were raised to incentive levels, procurement was carried out at prices higher than the support levels by a government corporation (Food Corporation of India) formed especially for this purpose, and a buffer stock was begun;

..... agricultural research was focused into all-India coordinated research schemes under the overall direction of a reorganized Indian Council of Agricultural Research;

..... extension was refocused from a generalized community development objective to more production-oriented Intensive Agricultural District Programs (IADP) and Intensive Agricultural Area Programs (IAAP);

..... nine state agricultural universities modeled after the U.S. land grant college system combining teaching, research, and extension have been established; and

..... the cooperatives are becoming more viable credit sources while the commercial banks are beginning to actively enter the field of rural lending.

The results of the first two years were masked by unprecedented, consecutive droughts. However, in 1967-68, Indian foodgrain production rose well above the previous best record output to an unofficially estimated level of 97-98 million tons, over 10 per cent above the previous record output (1964-65) and 30 per cent above the previous years drought-reduced level. Even though 1968-69 rainfall was well below normal, 1968-69 foodgrain production is only marginally below the previous year's level.

4/ These figures refer to installed capacity at the end of the fiscal year. 1964-65 capacity is composed of 441,000 tons N and 260,000 tons P_2O_5; 1968-69 capacity is composed of 1,031,000 tons N and 435,000 tons P_2O_5.

B. Progress Among Individual Crops

Wheat provides the clearest example of success among the individual crops.5/ Mexican varieties produce double the yields of local varieties.6/ They respond to management techniques similar to those practised on local wheats by Indian farmers. Due to their photo-insensitivity and short field duration they are easily fitted into multiple cropping patterns. As a result they are opening new production possibilities in the north and spreading to new areas in the south and east. Indigenous research has already provided new varieties with higher yields and more acceptable grain qualities of color and taste than the original varieties.7/

Some potential threat to these wheat varieties may lie in the homogeniety of germplasm base and the potential vulnerability of the crop to attack by new races of rust. However, by and large experience from the early warning surveillence carried out during 1967-68 and 1968-69 suggests that the Mexican varieties have higher resistance to the rusts presently active in India than the local varieties. Research is underway to broaden the plant base of these high yielding varieties.

Less spectacular, yet encouraging, progress has been made with rice (Hopper and Freeman, 1969). The new varieties such as IR-8 and Taichung (Native)-1 require more complex management than local varieties, particularly with regard to water. Furthermore, in large part due to the lush growth and thick stands, both IR-8 and Taichung (Native)-1 were more susceptible to some pests, particularly gall midge, planthopper,

---

5/ The experience with Mexican wheats reflects the remarkable speed with which the New Strategy was implemented. The first small trials were carried out in 1963-64. By 1968-69, almost all of the irrigated wheat area in India was sown with dwarf wheats (IARI, 1968).

6/ IADP records for Ludhiana district (which is a successful IADP district) give the following results (Ford, 1967):

Mexican 1966-67 (mostly Lerma Rojo)	4235 lbs/acre
Indian 1966-67	2108 lbs/acre

The PEO all-India survey of the 1967-68 crop on farms where both local and HYV (mostly Lerma Rojo) of wheats were grown together gave the following comparative yields (India, 1967e):

HYV	2471 lbs/acre
Local	1395 lbs/acre

7/ For example, in the PEO surveys conducted in 1967-68, actual cultivator yields for the newer varieties averaged (India, 1967e):

PV-18	(red colored)	3615 lbs/acre
S-227	(amber colored)	3157 lbs/acre

and cutworm, and Taichung (Native)-1 was found to be more susceptible to bacterial leaf blight than the local varieties.8/

Strengths and weaknesses appeared under field conditions. ADT-27, a lower yielding but short-duration dwarf variety developed in India is more easily managed than most new rice varieties and has had wide acceptability in Tamil Nadu state. It has enabled a large portion of rice acreage, particularly in Tanjore district, to be double cropped. On the other hand, Taichung (Native)-1 a dry season crop in most of southeast Asia, was given initially to farmers during the wet (kharif) season in which it was vulnerable to attack by bacterial leaf blight. As a result, Taichung (Native)-1 is no longer recommended for the kharif season and is being rapidly replaced by IR-8.9/

In sum, agronomic practices have lagged behind the plant breeding work with rice. Even acknowledging this, average yields of the high yielding varieties are much higher than for local varieties and the problems are correctable with continued research and experience. Such research is well along. Promising crosses of dwarf materials with disease resistance, better grain qualities, and higher yield potential are already being made available for release.10/

Generally, success also has followed the introduction of high yielding varieties of the other important cereal crops - millet (bajra), sorghum (jowar) and corn (maize). Hybrid millet and sorghum, which are normally grown on poorer land with variable rainfall, have sufficient

---

8/ The incidence of blight, hitherto not a serious problem in India, is likely overdrawn because of incorrect identification.

9/ The PEO all-India survey from the 1967 kharif harvest (500 crop cuts) gave the following average varietal paddy yields (India, 1967d):

IR-8	3588 lbs/acre
ADT-27	2083 lbs/acre
Tainan-3	1998 lbs/acre
TN-1	1709 lbs/acre

10/ As a result of the research work carried out within the country, especially during the last two years, two new varieties have been developed and have now been approved by the Central Variety Release Committee. They are: Jaya and Padma. Jaya is 10 days earlier than IR-8 and about 10 per cent higher yielding. It is expected that Jaya will replace IR-8 in all the areas for which the latter has so far been recommended. Padma has a medium slender type of grain and is suitable for cultivation as a summer crop in Bihar, boro crop in West Bengal and early kharif crop in Orissa. It is about 7-10 days earlier in maturity than Taichung Native-1, with which it has to be compared as a variety suitable for rabi cropping. Padma is about 8 per cent lower yielding than Taichung Native-1, but its superior grain quality and earliness, even as compared to Taichung Native-1, should be a great advantage.

yield differentials to be attractive. The major advantage of these two crops is that their superior yields show up even under poor management conditions. Problems still exist. Sorghum is susceptible to shootfly. The yields of hybrid corn are only about 30 to 40 per cent above the best local varieties. Furthermore, corn is a relatively long-duration crop grown during the kharif (southwest monsoon) period in the north and is sensitive to excess water.11/ However, steady progress is being made in increasing corn acreage in the north. It is a newer crop in the hilly areas of south and is rapidly becoming popular because it requires less water than rice and has much higher yields than millets and sorghum.

C. The Relative Contribution of New Technology to 1967-68 and 1968-69 Output

In order to estimate the relative contribution of new technology to the record 1967-68 and 1968-69 outputs, we have adapted a model developed by Hendrix, Naive, and Adams (1968). The basic methodology is to estimate additive production contributions of changes in area sown, irrigation, fertilizer, and seeds to a normal base period output.

The procedure hinges on two groups of assumptions: In the first group are those which determine the area fertilized and irrigated for foodgrain production. The second group consists of the rates of fertilization and the corresponding response coefficients to estimate production increments from the areas under high yielding varieties and irrigated and unirrigated local varieties. First, a review of these assumptions is made here based on the information available on fertilizer trial experiments and practices followed by the farmers. Secondly, the relative contribution of the new technology will be calculated.

1. Assumptions

a. Base Period

The average of 1959-60 to 1961-62 was chosen as a representative base period because: (1) fluctuations in production caused by weather were relatively moderate, (2) fertilizer consumption was relatively low, (3) the use of improved crop varieties was also low, and (4) given the three previous important considerations, the base is relatively recent (Hendrix, Naive, and Adams, 1968, p. 11).

11/ In north India the relatively long duration of hybrid maize presents acceptance problems because the kharif crop must be harvested in time to plant wheat, the major rabi crop.

b. Foodgrain Area

Foodgrain area for 1967-68 was reported as 300 million acres (India, 1968k). Informed opinion indicates that about 10 million of these acres are of the "swing" variety - lower quality lands which are brought into cultivation when rainfall is favorable. Since this increment is composed of low production-potential land, inclusion biases our production estimates upward.

c. Gross Irrigated Foodgrain Area

In 1965-66, the last year for which crop-wise data are available, the gross irrigated acreage was 76.4 million acres of which 77.8 per cent was under foodgrains[12/] (India, 1968k).

Foodgrain acreage for 1967-68 increased substantially over 1965-66 which was the first drought year. A substantial amount of this increase was at the expense of sugarcane, a crop which has a high proportion of irrigated acreage, but whose price relative to foodgrains was depressed in 1966-67. The high yielding varieties have very profitable response to irrigation.

For these reasons, we have assumed that 80 per cent of the estimated 86.5 million acres of gross irrigated sown acreage in 1967-68 was sown to foodgrains.

d. Per cent of Total Fertilizer Used on Foodgrains

A series of studies conducted during the Second Five Year Plan period reported that approximately 75 per cent of the total consumption of nitrogenous and phosphatic fertilizers was applied to foodgrains (India, 1964b, p. 213).

In 1965, the Report of the Committee on Fertilizers headed by Mr. B. Sivaraman had estimated that foodgrains would require 70 per cent of the total quantity of nutrients by 1970-71 based on cropped area and recommended doses (India, 1965a, p. 8). This estimate was made before the introduction of high yielding varieties and new strategy of intensive cultivation. On the basis of more recent experience, the Fourth Plan

---

12/ The data on irrigated acreage are apparently in process of being revised. The gross acreage figure for 1967-68 has been adjusted downward significantly - apparently due to a higher depreciation rate - for the Fourth Plan estimates. Data previously available for 1964-65 gave 77 million gross irrigated acres of which 74.3 per cent were under foodgrains.

Working Group (revised) estimated that foodgrains would require 80 per cent of the total nutrients by 1973-74 (India, 1968d).

We are assuming the allocation of 75 per cent of total fertilizer to foodgrains for 1967-68.13/

e. Average Fertilizer Dosage - HYV

Analysis of the all-India coordinated agronomic trials for high yielding varieties gives the following optimal nitrogen dosages:

	Year	Source	(lbs/acre) Approximate optimal N dosage 14/	(lbs/acre) Approximate recommendations $N/P_2O_5/K_2O$
Rice				
Dwarf	1966-67	AICRIP, 1967	114	80/60/40
Local indica	1966-67	- do -	79	(100/60/40)15/
Wheat				
Sonora-64	1966-67	Cummings, Herdt & Ray, 1968	131	80/60/40
Lerma Rojo	1966-67	- do -	109	(100/60/40)
C-306	1966-67	- do -	96	
Local irrigated	1964-65	Minhas & Srinivasan, 1966	88	
Local Unirrigated	1964-65	- do -	61	
Sorghum	1965	Murty, 1967	118	60/40/30
Corn	1961,1962, 1963	V.H.Shah, 1967	131-175	80/60/40 (100/60/40)
Millets	1965	Murty, 1967	138	60/40/30

13/ An additional check was made by aggregating (by crops) Donahue's estimated 1970-71 fertilizer requirements. His data gave 75.12 per cent of total nutrients to foodgrains (Donahue, 1966).

14/ Economic Optimal dosages are based on roughly a 3.5 to 1 fertilizer to foodgrain price ratio. Data from all-India coordinated agronomic trials were fitted to quadratic response functions and then solved for optimum levels.

15/ Higher recommendations for the Punjab are given in parentheses.

Based on the following surveys, average actual use appears to be well below optimal:

(1) Ludhiana district fertilizer use on high yielding varieties of wheat during 1966-67 was as follows (Ford, 1967):

Nutrient	Average Rate	X	%Application	=	Weighted Rate
N	86 lbs/acre		100		86 lbs/acre
P_2O_5	30 lbs/acre		71		21 lbs/acre
K_2O	57 lbs/acre		35		20 lbs/acre
					127 lbs/acre

The range of use was from 24 to 261 lbs/acre.

(2) The Program Evaluation Organization survey of 1967 kharif (India, 1967d) found:

a. Nitrogen applied to about 2/5th of HYV paddy at about 1/2 recommended rate.

b. Phosphates applied to about 1/3 of HYV paddy at 1/2 to 2/3 recommended rate.

c. Potash to about 1/10 of plots but average dose near to recommended range.

For hybrid varieties, the proportion of plots covered by nitrogenous fertilizers was the highest for irrigated corn followed by sorghum and irrigated millets. The largest proportion of plots covered with more or less the recommended dose was observed in the case of hybrid corn. For sorghum and millets the rate of application was much below the recommended level. Similar practices were reported in case of phosphatic and potashic fertilizers.

Admittedly, fertilizer was not fully available for 1967-68 kharif. Adequate supply was available for rabi 1967-68 which is concentrated in the northern wheat areas and accounted for about 3/5 of eventual 1967-68 high yielding varieties acreage.

(3) The PEO survey of the 1967-68 rabi season (India, 1967e) found the following average dosages to be used on wheats:

	Cultivators	Dosage lbs/acre
N Basal dosage	73.5%	33.5
P_2O_5	53.0%	42.0
K_2O	small	

(4) In summary, we have assumed that all cultivators sowing HYV used fertilizer and used an average of 60 lbs/acre total nutrients in 1967-68 and 70 lbs/acre in 1968-69.

This is admittedly a speculative guess although we would argue that:

a. While the evidence on actual use suggests a smaller percentage of users, average dosages are higher than we assumed;

b. A large proportion of cultivators who adopt the HYV, adopt all or nearly the entire package; and

c. The dosages we assume are still well below economic optimum even assuming large risk factors, etc.

f. Fertilizer Response - HYV

Analysis of the all-India coordinated trials for the high yielding varieties (two local varieties are included for comparison) gives the following approximate average nitrogen response for the present technology at the relevant ranges of dosage:

		Source	lbs/acre 40	50	60	80	100
Rice							
Dwarf	(1966-67)	AICRIP, 1967	26.84	25.78	24.72	22.60	20.48
Local indica	(1966-67)	-do-	18.16	17.16	16.16	14.16	12.16
Wheat							
Sonora-64	(1966-67)	Cummings, Herdt & Ray, 1968	29.74	28.73	27.72	25.70	23.68
Lerma Rojo	(1966-67)	-do-	26.03	24.98	23.93	21.83	19.73
C-306	(1966-67)	-do-	19.62	18.70	17.78	15.94	14.10
Sorghum	(1965)	Murty, 1967			18.30		
Corn	(1961-1963)	V.H. Shah, 1967			19.80		
Millets	(1965)	Murty, 1967			20.40		

At the 60 lbs/acre level which we suggest was the average dosage during 1967-68, a combined average (weighted by 1967-68 HYV acreage) nitrogen response from the above summary data would give:

Crop	1967-68 HYV acreage %	Average response at 60 lbs/acre N	
Rice	29.7	24.72	734.18
Wheat (LR)	49.0	23.93	1172.57
Sorghum	9.5	18.30	173.85
Corn	4.7	19.80	93.06
Millets	7.0	20.40	142.80
			2316.46

or a 23 to 1 ratio.

We have not included separate response data for phosphorous (P_2O_5) and potash (K_2O). The responses to these elements are generally lower than to nitrogen (N). Including these nutrients in an additive function would lower the average response ratio of nitrogen alone.16/

Furthermore, given the newness of the high yielding varieties, management practices must still be developed. Water control is a key variable in maximum yield response. For these reasons, we assume that at this early stage of introduction, actual experience will be somewhat below experiment station results.17/

16/ Generally, the contribution of P_2O_5 and K_2O have been found to be additive to N, especially at the lower dosages (Panse, Abraham, and Leelavathi, 1964). However, Hopper (1967) analyzing a carefully controlled experiment with local varieties and Kahlon and Kaul (1968) analyzing fertilizer response on high yielding varieties have reported significant interaction between N and P_2O_5. The Kahlon and Kaul data for K-227 wheat, a very high yielder, is as follows:

$$Y = 2251.16 + 22.416N + 33.667P - .115N^2 - .329P^2 + .188NP$$

Average response at different N and P_2O_5 levels (in kgs/hec):

	N				
P_2O_5	60	80	100	120	140
20	19.4	16.4	13.4	10.4	-
40	20.6	18.5	16.2	13.6	-
60	19.1	18.1	16.6	14.7	-
80	16.3	16.2	15.4	14.2	12.7

17/ Hopper (1968) argues that many cultivators do better than the experimental results. For example, the farmers yields on national demonstration trials have averaged significantly higher than experiment station yields. "In explaining this phenomenon, senior research scientists contend that it is easier to take a large farm field and manage it for a high yield than it is to manage a small plot within the constraints of experimental design."

Furthermore, IADP analysis of Ludhiana district fertilizer use and yield data indicates that progressive cultivators approximate experimental results. In 1966-67, cultivators in Ludhiana district had average yields of 4310 lbs/acre from Mexican varieties with average use of 86 lbs/acre of N (in addition to 21 lbs/acre of P_2O_5 and 20 lbs/acre of K_2O). Inserting 86 lbs/acre of N into the 1966-67 equation for Lerma Rojo derived from experimental data gives an output of 3524 lbs/acre of foodgrains which is below Ludhiana performance (Ford, 1967; Cummings, Herdt and Ray, 1968).

For these reasons, we have decided to settle on a 13.5 to 1 average response ratio at the expected total nutrient dosage. We have checked this ratio for internal consistency with 1964-65 (when no HYV were utilized), 1967-68, and 1968-69 data. It is a key variable in this analysis and should be subjected to further analysis as new data are available.

g. Average Fertilizer Dosage - Local Varieties

Studies carried out by the Government of India during the late 1950's give the following summary picture of fertilizer use on local varieties.

	Percentage of irrigated area benefitted by fertilizers	Percentage of total area benefitted by fertilizers	Percentage of the recommended dose applied	
			Nitrogenous Fertilizer	Phosphatic Fertilizer
Paddy	64	48	58	58
Wheat	77	30	24	64
Millets	-	4	19	12
Maize	19	16	13	-
Jowar	15	-	-	-
Bajra	1	7	63	-

Source (India, 1964b)

Comparison of data collected in the early 1960's with data from the late 1950's indicated that there had been a substantial increase in the percentage of area fertilized but no increase in dosage. In summary, what information we do have on local varieties indicates that:

a. irrigation is an important determinant of the dosage,[18/]

b. little fertilizer is used on unirrigated crops unless rain is assured.

18/ Consumption of total plant food ($N+P_2O_5+K_2O$) per acre under cultivation in each of India's then (1963-64) major 15 states correlated with proportion of irrigated foodgrains acreage to total acres in foodgrains gives as r of 0.823 (significant at 1% level) (Hopper, 1965b).

h. Fertilizer Response - Local Varieties

We assume fertilizer is applied only to land which is irrigated or has assured rainfall.

The limitations of using aggregate response ratios to estimate production increments needs to be re-emphasized. Responses to fertilizers have shown wide variation by crop and by region to the application of different plant nutrients.

The Institute of Agricultural Research Statistics has conducted over 10,000 experiments on fertilizer response based on cultivator's field trials over India (Panse, Abraham, and Leelavathi, 1964). These "yardsticks" are based on local varieties and do not include the interaction terms between various agronomic practices such as fertilizers, crop varieties, pest control, improved cultivation practices, etc.

The results of tests running from the beginning of the First Five Year Plan up to 1963 of response curves fitted by quadratic functions and standardized to 20 and 40 lbs. per acre are summarized below:

Crop	Nutrient	20 lbs/acre average	40 lbs/acre average
Rice	N	10.8	8.2
	P_2O_5	7.1	5.5
Irrigated wheat	N	14.1	11.5
	P_2O_5	8.7	7.5
Unirrigated wheat	N	7.6	
	P_2O_5	4.1	
Maize	N	12.0	9.6
	P_2O_5	6.8	5.8

Source (Panse, Abraham and Leelavathi, 1964)

A 9 to 1 ratio appears to be a conservative average for total nutrients at 20 lbs. per acre.19/ 20/

2. Results

The results of fitting these assumptions into our model for 1967-68 are shown in Table 2. Assuming "normal weather," the 1967-68 production is estimated at 95.3 million tons of foodgrains.21/

19/ The GOI assumes 10 to 1 response ratio for N and 6 to 1 for P_2O_5. W.D. Hopper came to the conclusion that 10 to 1 for N was about right but 6 to 1 for P_2O_5 was conservative (Hopper, 1965b).

If we accept the 10 to 1 and 6 to 1 ratios, a weighted average (by N and P_2O_5 availability in 1967-68) would give a 9 to 1 ratio.

20/ There are two additional internal checks on the assumed fertilizer allocation rules:

a. The marginal responses of HYV and local varieties of wheat and rice at the assumed dosage levels (60 lbs NPK/acre for HYV and 20-30 lbs/acre for irrigated and rain-assured (locals) are closely equal (Cummings, Herdt and Ray, 1968; Minhas and Srinivasan, 1966).

b. The implicit yields are also roughly consistent with survey results (Ford, 1967; India, 1967d; India, 1967e). Assuming a 750 lbs/acre base yield difference for irrigated over unirrigated varieties (Hopper, 1965b) and further assuming that the base yields of HYV and local varieties are roughly equal on irrigated lands (AICRIP, 1967; Cummings, Herdt and Ray, 1968; Minhas and Srinivasan, 1966; Murty, 1967; and V.H. Shah, 1967), our implicit cereal yields are approximately:

HYV (irrigated or rain + NPK)	2050 lbs/acre
Local (irrigated or rain + NPK)	1450 lbs/acre
Local	475 lbs/acre

21/ It is mere coincidence that our estimate gives approximately the same answer as the GOI "final estimate" of foodgrain production. Two clarifications might be made: (1) the 10 million incremental acres of "swing" land presumably has much lower yield potential than the average - the way it figures in our calculations may lead to an overstatement of production by as much as two million tons; (2) the GOI "final estimate" is a conservative figure - there is some opinion that actual 1967-68 production of approximately two to three million tons higher might be the eventual revised figure.

Table - 2

1967-68 Production Estimate

F-18

Estimates of foodgrain output increase from 1959-60 to 1961-62 average to 1967-68 with following input increases 1/

Input & Outputs	('000)	1959-60 to 1961-62 Ave.	Area	H.Y.V.	Local	Total change	Estimate for 1967-68
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Grain area	acres	287,044	13,021	-	-	13,021	300,065 2/
Gross irrigated grain area	acres	55,125	2,503	11,000	572	14,075	69,200 3/
Fertilizer for grain	tons	131	6	404	641	1,051	1,182 4/
H.Y.V.	acres	-	-	14,826	-	14,826	14,826 5/
Production	tons	80,465	3,653	5,454	5,769	14,876	95,341

1/ Increases in grain output estimated as follows:
Col. 4 - Yield held constant; irrigated area, fertilizer use, and production increase at rate of area increase (4.54per cent)
Col. 5 - High Yielding Varieties - fertilizer use at 60 lbs/acre; 13.5 to 1 production/fertilizer response ratio.
Col. 6 - Local varieties - residual amount of fertilizer used on irrigated and rain assured area at response ratio of 9 to 1.

2/ India, 1968k.

3/ Estimate of 86.5 gross irrigated acres sown in 1967-68 of which 80 per cent to foodgrains.

4/ Total consumption estimated at 1.576 million nutrient tons (1.071 million tons N; 0.335 million tons P_2O_5; 0.170 million tons of K_2O) of which 75 per cent used on foodgrains.

5/ GOI estimate.

On the basis of the above assumptions, we calculate that the contribution of the new technology embodied in the high yielding varieties in 1967-68 under "normal weather" conditions compared to what might have been forthcoming if that acreage were sown with local varieties to be approximately:

		(000 tons)
a) HYV	14,826 acres	
	60 lbs NPK/acre 13.5 to 1 response rate	5,454
b) Local	14,826 acres	
	30 lbs NPK/acre 9 to 1 response rate	1,820
Difference in 1967-68 output attributable to new technology		3,634

The significant changes in input uses from 1967-68 to 1968-69 are as follows:

..... Gross area sown to foodgrains declined to approximately 290 million acres, a decline of 10 million acres 22/

..... Fertilizer consumption (distribution) increased to 1.980 million nutrient tonnes, an increase of approximately 400,000 tonnes 23/

..... Gross irrigated acreage increased to 89.0 million acres, an increase of approximately 2.5 million acres 24/

22/ This is an unofficial estimate based on first GOI estimates of area for all crops except barley and rabi pulses (excluding gram). We have assumed acreage of the latter two crops to remain the same as in 1967-68 and have adjusted the first estimates with inflators based on previous experience.

23/ This is composed of 1.4 million tons of N, 0.4 million tons of P_2O_5, and 0.18 million tons of K_2O (India, 1969c). We suspect that this figure may be high. It is assumed that NPK was used at 70 lbs/acre on HYV during 1968-69 (a 10 lb/acre increase over 1967-68).

24/ This is approximately the amount estimated in the Fourth Plan (draft) 1969 (India, 1969d) and for the most part represents the tubewell boom in northern India and the expansion of minor irrigation in the south. Major and minor irrigation expansion was slowed substantially during 1966-69, a casualty of the financial restraint in reaction to to the inflation generated by the two droughts and the industrial recession.

..... High yielding variety acreage increased to approximately 21 million acres sown, an increase of over six million acres (India, 1969c)

The contribution of the new technology embodied in the HYV in 1968-69 under "normal weather" conditions compared to what might have been forthcoming if the acreage were sown with local varieties was approximately:

		(000 tonnes)
a) HYV	21 million acres with NPK at 60 lbs/acre and production at 13.5 to 1 response	9,018
b) Local	21 million acres with NPK at 30 lbs/acre and production at 9 to 1 response	2,577
	Difference in 1968-69 output attributable to new technology	6,441

We immediately must qualify these figures by explaining that this "normal weather" estimate is more accurately a "normal yield" estimate based on inputs actually used. The levels of input use (as well as input productivity) are influenced by weather. For example, the decline in total foodgrain acreage in 1968-69 is directly a result of the low rainfall giving insufficient moisture to sow a crop on marginal rain-fed lands. Better rains would also have undoubtedly led to greater increases in acreage under high yielding varieties and fertilizer consumption.

The area irrigated during the last two-three years has increased rapidly. This was partly attributable to the high prices and the recognized vulnerability of production to the monsoon - but also partly attributable to the increased profitability resulted from the higher yields of the high yielding varieties. Furthermore, the potential of the New Strategy has prompted a series of policy changes placing more emphasis on input availability, introducing a more producer-oriented price policy (which was particularly valuable during the 1967-68 wheat harvest), etc. which has provided incentives even to local technology.

In other words, there is no simple answer to the relative contribution of the new technology to 1967-68 output or to output in succeeding years. We would consider our crude estimates both for "normal weather" output as well as for difference in 1967-68 and 1968-69 outputs directly attributable to the new technology to be conservative.

D. Relative Contribution of Rainfall

The fortune of Indian agricultural production has traditionally risen or fallen relative to the strength of the monsoons. Therefore a rainfall index was calculated to measure the strength of the monsoon during 1967-68 and 1968-69. The details are given in Annex A. In summary:

1. 1967-68 rainfall was above normal but less favorable than 1964-65 levels. The generally excellent 1967-68 winter rainfall in the north almost made up for the less than average southwest and post-monsoon rains in the non-wheat growing areas.

2. 1968-69 rainfall clearly was below average over most of India with conditions most unfavorable over the central plateau and over some paddy growing areas of the south and over the entire north, particularly during the rabi period.

In order to analyze the influence of this rainfall on foodgrain production, several relationships were examined. A basic assumption underlying this analysis was that technology was relatively constant during the 1951-52 through 1966-67 period before the high yielding varieties were introduced to any significant acreage. Therefore, yield was hypothesized to be a function of rainfall (measured by the index) and time (which serves as a proxy for inputs).

First a linear regression was fitted to the 1951-52 through 1966-67 data with the following results.25/

$$y_t = 286.43 + \underset{(0.67)}{2.48}\, x_t + \underset{(1.61)}{10.74}\, t$$

$r^2 = 0.79$

y = cereal yields in lbs/acre

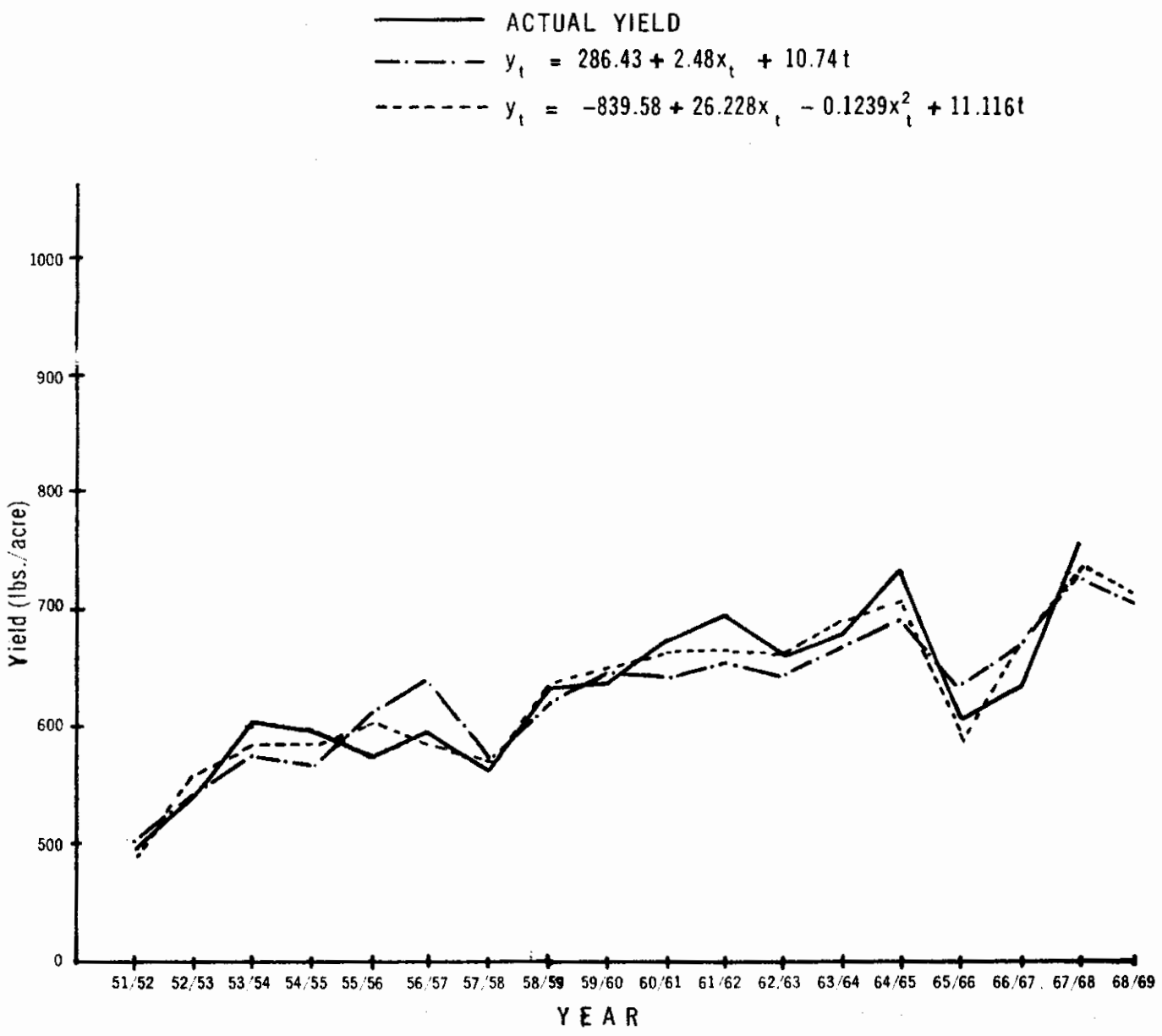
x = rainfall index

t = time, t = 1.....16

25/ Results are compared with observations in Figure 1.

Figure 1

RELATIONSHIP BETWEEN CEREALS YIELD AND RAINFALL INDEX
(All India : 1951-52 to 1966-67)



From these results, if we hold time constant, a one unit change in rainfall index can be expected to increase cereals yield by almost 2.5 lbs/acre or when multiplied by the approximately 237 million acres sown to cereals, to increase total cereals production by about 269,000 tonnes.

Examination of the linear fit reveals that actual yields during the high and low rainfall years, particularly during 1956-57, deviate most from estimated values. This performance would be consistent with the explanation that both too much rainfall, i.e., floods or water-logging, as well as too little rainfall, i.e., drought, should have detrimental influence on yield. In order to test a curvilinear relationship between rainfall and yield, a quadratic function was fitted with the following results:

$$y_t = -839.58 + \underset{(6.1647)}{26.228}\, x_t - \underset{(0.0321)}{0.12397}\, x_t^2 + \underset{(1.1242)}{11.116}\, t$$

$$r^2 = 0.90658$$

where y = cereals yields in lbs/acre

x = rainfall index

t = time, 1951-52 = 1.....1966-67 = 16

In this relationship the contribution of rainfall to yield changes from one rainfall amount to the next with the "optimal" production rainfall contribution appearing at an index reading of 105.8.

This analysis of the relationship of rainfall and production under "normal technology" in combination with the analysis of the incremental contribution of the new technology carried out in the previous section now gives us another method to estimate production on the basis of an objective assessment - given level of inputs, weather, and new technology.

Inserting the 1967-68 all-India rainfall index of 103.0 into the curvilinear equation gives a "normal technology" yield of 736 lbs/acre for 1967-68. If we add to this figure, the increment to 1967-68 cereal output which is estimated to be attributable to new technology of 33 lbs/acre, we arrive at a 1967-68 "weather corrected" yield of 769 lbs/acre. The "weather corrected" yield estimate multiplied by estimated 1967-68 cereal acreage of approximately 244 million acres would give total cereal production estimate of 85.3 million tonnes. If we add an estimated 12.2 million tonnes of pulses to the cereal production

estimate, we arrive at 97.5 million tonnes of total foodgrains as our objective production estimate based on 1967-68 inputs, technology, and weather. This is quite close to the unofficially estimated 1967-68 output level.26/

Using the 1968-69 all-India rainfall index value of 89.14, we calculate a "normal technology" yield of 713 lbs/acre which, when added to the contribution of new technology of 60 lbs/acre, gives a "weather corrected" yield of 773 lbs/acre or 83.3 million tons of cereal production. An additional 10.0 million tons of pulses gives a 93.3 million ton "weather corrected" estimate of 1968-69 output.27/

In summary,

1. In 1967-68 new technology contributed 33 lbs/acre to yield totalling three and one half million tons extra production. Favorable weather gave an additional boost.

2. In 1968-69, the poor rainfall caused a shortfall of 24 lbs/acre in yield which was more than offset by the yield contribution of new technology of 60 lbs/acre.28/ Or another way of looking

---

26/ It is our opinion that the official GOI 1967-68 foodgrain production figure of 95.6 million tons is conservative.

27/ First estimates place 1968-69 gram acreage as 7 per cent below 1967-68. Acreage of other pulses would be down even more. Only about 10% of pulse area is irrigated (India, 1968b). Therefore, yields would also be depressed.

Actual acreage sown during 1968-69 was depressed due to poor rains. A more realistic "normal weather" estimate for 1968-69 might therefore be 98 million tons - with poor rainfall accounting for a shortfall of approximately six million tonnes output.

28/ Two equations were fitted to test the responsiveness of acreage sown to rainfall availability during 1951-52 to 1966-67:

$$A_t = \underset{}{167.06} + \underset{(0.084)}{0.355}\, x_t + \underset{(0.200)}{2.237}\, t \quad (R^2 = 0.91)$$

$$A_t = \underset{}{75.202} + \underset{(0.787)}{2.306}\, x_t - \underset{(0.004)}{0.011}\, x^2_t + \underset{(0.703)}{4.004}\, t - \underset{(0.042)}{0.105}\, t^2 \quad (R^2 = 0.96)$$

where:

A_t = acreage under cereals in million acres
x_t = rainfall index for cereals (Appendix A)
t = trend in new lands brought under cultivation and multiple cropping

(All coefficients are significant at the 5% level)

continued

at this is that without the new technology, 1968-69 foodgrain output would have been nearly six and a half million tons less than that what will actually be harvested.29/

The interpretation of the first equation is that a change of one index number in the rainfall index would result in a change of 355,000 acres in cereal acreage sown, if the time trend is held constant. Assuming no effect on yields (which is not an accurate assumption), this acreage change would by itself affect cereal production by approximately 100,000 tons per index number on the rainfall index or in terms of the 1968-69 reading, provide a net subtraction of about a million additional tons of cereals output.

29/ We cannot end this section without re-emphasizing our acknowledgement that this weather/production research is preliminary and we hope that much more research can be carried out. Perhaps the most serious problem in this aggregate approach is that distribution of rainfall by amounts and by timing is grossed over. Obviously, it makes a difference whether rainfall is spread evenly over a period, or more specifically, falls at crucial plant growth periods (i.e., the crown root and the milk stages in wheat) as compared to occurring in one deluge, i.e., a flood. Such analysis would require disaggregation by time periods as well as by states in order to pick up the individual characteristics of crops specific to certain areas. Furthermore, the relationships for individual states would be heavily influenced by the cropping patterns which could be expected to change over time. In other words, such analysis would have to be continuously updated.

A second line of research would involve investigation about the effects of the agricultural development policies regarding the future sensitivity of production to rainfall. The most obvious influence is the spread of irrigation, particularly tubewells which are relatively insensitive to a single year's rainfall for water supply. A more subtle relationship is the relative sensitivity of the new varieties to water. Millets and sorghum areas indicated that these HYV held up very well, even better than local varieties, under moisture stress. The HYV of wheat provide a different example: the timing of water application is very important for maximum tillering. However, increasingly in the future, crop production periods will overlap. Therefore, it will be more difficult to generalize rainfall requirements on basis of individual field observations. Statistical relationship can provide quantitative measurements with known error.

For more careful analysis of weather/production relationships than we have been able to carry out, we recommend papers by Mann (1955), Oury (1965, 1967, 1968, 1969), Krishna and Rao (1967), and Bean (1969).

F. Conclusions

In summary, the impact of the high yielding varieties has been significant during 1967-68 and 1968-69. This impact becomes more clear for 1968-69 when the relative contribution of rainfall is evaluated in the analysis of factors explaining output. The technological credentials are impressive and cultivator acceptance, as shown by the spread of acreage is demonstrated.

The problems are identifiable and correctable. If research is funded at necessary levels, if production inputs are made available in the quantities and at the times and places required, and if the government continues to provide stable, incentive prices, then expansion of coverage up to the limits of irrigated and rain-assured acreages at a fairly rapid rate appears to be promising. If these steps occur, then Indian foodgrain production can double its present approximate two and one-half per cent rate of annual increase.

It is the purpose of the remaining sections of this annex to explore these ifs, to pose the questions of what it will take in order to achieve and sustain a higher trend of production; to turn potential into actual performance. In order to do this we will next discuss:

1. The general order of targets which can be idealistically desired if agriculture is to play a key role in Indian economic development;

2. The limits of agricultural output targets which can be realistically expected; and

3. The parameters of policies which must be considered in order to achieve these targets.

TARGETS

II The Role of Agriculture in Indian Economic Development

The agricultural sector accounts for approximately three quarters of employment, one-half of national income, forty per cent of the capital formation, and three quarters of exports (if we include manufactured agricultural products) in the Indian economy. These statistics speak both for the importance of agriculture in the Indian economy as well as for the fact that the agricultural sector in India has not been a dynamic force in the economic growth process in the past. 1/

The central problem of economic development is the mobilization and allocation of resources for growth in all areas of the economy. All scarce resources such as administrative skills and capital must be allocated in such a way that resources are fully employed, output is maximized (over some period chosen by the planners) and additional productive resources are created. Agricultural development cannot be planned or executed apart from the total economy. Seen in terms of the structural transformation of the overall Indian economy, the agricultural development problem is to mobilize and allocate resources in such a manner that the absolute production by the agricultural sector is increased while its relative contribution to national income and to employment is decreased.

In other words, agricultural development is not an end in itself but must fit within the total economic development strategy. The overall objective is to increase the standard of living of the entire country. In general terms, then, the target of agricultural development can be stated as "increasing agricultural production combined with equity consistent with overall economic development." In recognition of the interdependence of the agricultural sector with total economic development, we might therefore list the specific objectives of agricultural development in the following four categories which can be operationally defined and measured: 2/

1/ Theoretical discussions of the role of the agricultural sector in overall economic growth can be found in Kuznets, 1956; Jorgenson, 1961; Fei and Ranis, 1961; Johnston and Mellor, 1960; Johnston and Mellor, 1961; Mellor, 1967b; and Schultz, 1967; Hendrix and Sen, 1969

2/ The objectives in the agricultural section of the revised Fourth Five Year Plan (India, 1969d, p.112) are explicitly stated as follows: "The first objective is to provide the conditions necessary to sustain increase of about 5 per cent per annum over the next decade. The second objective is to enable as large a section of the rural population as possible, including the small cultivator and the farmer in dry areas, to participate in development and share its benefits." Furthermore there is explicit recognition that "The pace of development in the agricultural sector sets a limit to the growth of industry, of exports, and of the economy as a whole and constitutes a major condition for achieving economic and social stability and improving the levels of living for the mass of the people." The Plan goal is for net domestic product to increase at an annual rate of 5.5%, exports to increase at 7%, and investment to increase at an annual growth rate of 11.3%.

1. Increased level of agricultural production, including appropriate cropping pattern shifts to satisfy specific categories of demands.

2. Inter-regional equity.

3. Inter-personal equity.

4. Generation of new resources to promote continued growth in both agricultural and non-agricultural sectors (i.e. resource mobilization)

The purpose of this section is to discuss the order of requirements of the agricultural sector from the demand side. Section III will follow by discussing the parameters of supply possibilities in order to determine the general feasibility of the targets.

A. Demand for Agricultural Products 3/

Output demand (or requirements) can be separated into three primary categories:

..... human consumption
..... seed, feed, and waste
..... exports

1. Human Consumption

In principle, calculation of future human consumption demand is a relatively straight-forward procedure. If prices are constant, future demand would be a function of changes in population (maintaining same consumption per capita) and income (increasing consumption per capita), or expressed as a simple formula:

$$D = p + nq$$

Where:

D = percentage change in demand
p = percentage growth in population
n = income elasticity of demand (percentage change in consumption divided by percentage change in income)
q = percentage change in per capita income

In order to translate these changes into figures on quantities demanded, the percentage changes compounded over the target period of time are added to a base consumption figure which supposedly represents an equilibrium position relative to population, income, and prices.

3/ This section builds largely on work of S.K. Ray, 1968.

While recognizing the conceptual simplicity of this approach, for the approximate purposes of this exercise, the more difficult task is to determine "reasonable" or "best guess" values for the parameters.

We have reviewed the data and studies relative to the relevant variables in a separate paper (Ray, 1968) and have made preliminary projections for (1) rice, (2) wheat, (3) other cereals, (4) total cereals, (5) pulses, (6) foodgrains, (7) starchy roots, (8) fruits and vegetables, (9) edible oils, (10) sugar and gur, (11) milk, (12) meat, fish and eggs, and (13) cotton clothing (inclusion of cotton in the demand estimates is made due to the reason that any significant increase in demand for cotton might lead to shift in acreage from foodgrains) based on the following assumptions:

a. Base Period Consumption

For any particular year, the per capita availability might be determined at the national level by dividing the aggregate supply by the estimated population. The aggregate supply is obtained from the production estimates, opening and closing stocks with the Government, imports and exports, and non-food utilization statistics comprising seed, feed, waste, and manufacturing uses for non-food purposes. Production data are generally obtained from crop-cutting surveys of yields and patwari records of acreage and suffer from the basic limitations of non-comparability over time mainly due to extension of coverage and varying techniques of estimation. Government stock and import and export data are fairly reliable. No data are available on private stocks. Holdover private stocks apparently serve as the first line of buffer, supplementing consumption during poorer production years and being rebuilt during surplus production years. This factor alone could lead to a difference of 10-20 per cent between availability derived from aggregate supply and actual consumption in a given year. The conventional method attributes 12.5 per cent of the gross foodgrains production for non-food utilization. This estimate, in use for many years now, has the advantage of historical continuity but is not based on any scientific study. The reliability of production estimates for foods other than foodgrains is still low. The presence of all of these unknown factors introduces serious questions in relying on aggregate supply data to estimate actual consumption.

Panse (1961) compared per capita consumption estimates for different food items in India for 1956-59 with survey data and found significant differences. Sukhatme (1962) revised Panse's estimates in 1962 and the results were closer to the derived availability data for this period of relatively stable production. We have used the Sukhatme consumption estimates for food items and NCAER (1962) estimates for cotton clothing.

The 1956-59 period therefore has the following advantages:

1. It is a period of relatively stable production and prices.

2. We can evaluate the reliability of our estimates from at least two sources, and 4/

3. Most of the income elasticity data are fitted from data during the late 1950's.

however:

4. The base period is over ten years old and, if we are to use it, we must assume that there have not been significant changes in income distribution, relative prices, or socio-economic forces influencing taste since that time.

b. Population

The Expert Committees "High Projection" (India, 1964c) adapted to the New-Plan periods of 2.7, 2.6, and 2.2 per cent annual growth for the Fourth, Fifth and Sixth Plans, respectively, was accepted for population projections5/. Rural-urban migration is assumed to grow at the rate of 4, 5 and 6 per cent per annum during the Fourth, Fifth and Sixth Plan periods respectively.

c. National Income

National income is assumed to grow at the rate of 5 per cent per annum during the Fourth and Fifth Plans and will rise to 6 per cent per annum during the Sixth Plan period. Increase in per capita income is estimated from national income and not from total disposable income. 6/

4/ The Panse data for this period are the only survey data on food consumption which we have come across which are consistent with food availability figures calculated from aggregate production data. Without exception, the survey data aggregate to higher availability figures.

5/ Even though the Fourth Five Year Plan (revised) assumes at 2.5 per cent population growth rate, we feel that the "High Projections" may be conservative. To reduce the population growth rate by 0.5 per cent in face of still decreasing death rates assumes a significant and sustained family planning program - an assumption which is still a bit risky to make at this early date.

6/ In effect we are assuming a reasonably optimistic, although attainable, growth rate in national income and also assuming that savings grow proportionately to income - which is a weak assumption at that growth rate.

d. Income Elasticity of Demand

The income elasticity values are probably the most sensitive of all the parameters in the projections. S.K. Ray (1968) has reviewed the elasticity coefficients and standard errors obtained from consumption surveys of the NSS and NCAER. There is a wide range in results. For this reason we have decided to use three sets of elasticity coefficients - high, medium, and low - for each item (Appendix B).

It should be noted that the income elasticity coefficients selected for foodgrains range between 0.29 and 0.45 as compared to the present GOI assumption of 0.50. Even though our figures appear conservative, we are still somewhat uneasy. The implicit assumptions regarding relative prices, income distribution, and tastes must be noted and subject to adjustment when new information are available.

In effect, our assumption is that the income elasticity for total agricultural products probably lies within the range of 0.5-0.8. This figure also is below present official estimates and should be subjected to serious further investigation.

e. Results

The results of the projected aggregate demands of various agricultural commodities for human consumption alone are listed in Table 3.

2. Seed, feed, and waste

A significant amount of foodgrains produced in India is used for other than human consumption. We have independently estimated requirements for the following categories:

a. Seed - multiplying recommended seed rates (India, 1968b) times estimated acreage under respective crops. 7/

b. Animal feed would be used for bullock power and for meat, eggs, poultry, and dairy products. The demand for bullock feed should not increase much if at all but there should be a healthy demand for feed to produce the latter four foods. We have therefore assumed the demand for foodgrains for animal feed to increase at the same proportion as the demand for milk, beginning with 5.0 per cent of total grain production in 1956-59 and increasing to 6.5, 8.0, and 7.1 per cent of foodgrain production at the end of the respective Plan Periods. 8/

7/ The acreage assumptions are calculated in section III.

8/ These projections do cause us some concern as being optimistic although they are not as optimistic as the Mellor and de Pontes (1964) estimates which are for total concentrates. For one thing, we are not sure how the base feed consumption in 1956-59 is divided among bullocks (which we do not project to increase very much) and food-producing animals.

(footnote to continue on next page)

Table - 3

Projected Aggregate Human Consumption Demand for Selected Consumer Goods
(High, Medium, Low)

Item	Unit	1968-69			1973-74			1978-79			1983-84		
		High	Medium	Low	High	Medium	Low	High	Medium	Low	High	Medium	Low
1. Rice	mil. tons	36.19	36.07	35.97	42.91	42.42	41.92	50.53	49.52	48.49	59.70	57.75	55.79
2. Wheat	"	11.65	11.57	11.48	14.76	14.38	13.99	18.62	17.82	17.00	24.32	22.32	21.02
3. Other Cereals	"	25.36	25.35	25.33	29.72	29.64	29.56	34.58	34.40	34.23	40.04	39.72	39.40
4. Total Cereals	"	73.20	72.99	72.78	87.39	86.44	85.47	103.73	101.74	99.72	124.06	120.14	116.21
5. Pulses	"	12.79	12.75	12.72	15.51	15.39	15.30	18.55	18.33	18.29	23.17	22.63	22.14
6. Foodgrains	"	85.99	85.74	85.50	102.90	101.83	100.77	122.28	120.07	118.01	147.23	142.77	138.35
7. Starchy Roots	"	5.82	5.81	5.80	6.81	6.79	6.77	8.00	7.94	7.91	9.45	9.36	9.26
8. Fruits & Vegetables	"	16.02	15.94	15.88	20.57	20.24	19.94	26.34	25.66	25.34	35.42	34.04	32.77
9. Edible Oil	"	2.21	2.19	2.18	2.79	2.71	2.65	3.52	3.37	3.24	4.66	4.36	4.03
a. 5 Major Oilseeds*/	"	6.72	6.66	6.63	8.50	8.25	8.07	10.72	10.27	9.87	14.21	13.30	12.29
10. Sugar & Gur	"	9.12	9.09	9.07	11.85	11.75	11.65	15.42	15.22	15.02	21.35	20.94	20.61
11. Milk	"	28.90	28.81	28.71	39.07	38.65	38.19	52.66	51.72	50.74	75.92	73.92	71.80
12. Meat, Fish & Egg	"	2.40	2.40	2.38	3.08	3.05	3.00	3.95	3.87	3.78	5.29	5.14	4.95
13. Cotton Cloth	bil. meters	7.95	7.84	7.78	10.62	10.29	9.82	14.05	13.21	12.36	19.59	17.92	16.20
a. Raw Cotton	mil. tons	6.12	6.03	5.98	8.17	7.92	7.55	10.81	10.16	9.56	15.07	13.78	12.46

*/ The five major oilseeds - groundnut, rapeseed & mustard, sesamum, safflower, and niger - which have from 28 to 40 per cent oil extraction, account for 95% of total vegetable oils.

c. Post harvest losses - estimated at 9.3, 8.0, and 7.1 per cents 9/ respectively of gross production of foodgrains at end of each Plan Periods. The gross production figures are taken from the medium projections in section III.

(footnote 8/ continued from previous page)

8/ Oilseed cake from groundnuts or soybeans could become a more economic feed substitute than foodgrains. Finally the distribution system associated with animal products must undergo significant modernization if milk production is actually to increase at the above rates. (Nightingale, 1969).

9/ Estimates of post-harvest losses range from a low of 3-5% up to as much as 15-20% of production. The available studies are reviewed in Majumdar and Parpia, (1966) and in the Report of the National Rodent Control Committee, GOI, (1966).

Perhaps the latest and most authoritative study has been carried out by the Committee on Losses of Foodgrains during Post-harvest Handling and Storage appointed by the GOI and chaired by V.G. Panse. The summary of the findings (all that has been reported to date) is as follows (India, 1967b):

" i) Loss needs a realistic definition. It is defined by the Committee as reduction in food supply brought out by either reduction in weight or deterioration between two handlings and on the whole between production and consumption.

ii) Population of domestic rodents that causes loss to stored grain is considered on par with human population. Maximum loss on account of domestic rodents is estimated at 1.9 million tonnes of grain or 2.5% of total production.

iii) Qualitative damage caused by insects is quantamised on the basis that each affected kernel has on an average lost half its value in terms of food value.

iv) Present estimates of possible losses on an average basis are given for the threshing yard, transit, processing, rodents, insects and moisture. Total figure amounts to about 9.33%. Major portion of this loss is avoidable."

3. Total Domestic Foodgrain Requirements

The total foodgrain requirements for human consumption, seed, animal feed, and waste are shown in Table 4.

If we accept these requirement figures literally, they suggest a domestic supply/demand gap of approximately 7 to 8 million tons of foodgrains in 1968-69 or 2 to 3 million tons more than is closed by foodgrain imports. (Table 10 based on normal weather production estimates). This may mean that there is still some excess food demand in the economy which is being held down - in order to check inflationary pressures - by public distribution, zones, and rationing. However, another interpretation might be that our parameters need rechecking, especially that:

1) The income elasticity figures are too high,

2) The base consumption estimate was too high, or

3) Our seed, feed, and loss deduction (which amounts to 18.7 per cent of the 1968-69 low projection as compared to the standard GOI deduction of 12.5 per cent) is too high.

4. Exports

We have not included export requirements in this review primarily because we have not had time for a satisfactory study. While tea and coffee are grown in specialized areas, cotton (textiles) sugar, oilseeds (oilcake) and jute - the large present foreign exchange earners - do compete directly for productive resources, most particularly land, with other crops. At first glance, we do not expect India to become a direct foodgrain exporter in the near future although it is possible that seeds and animal products could lead to indirect exports of foodgrains.

Therefore, we must add some unknown figure to our requirement estimates for domestic uses to derive total minimal requirements.

5. Concluding Comments

These estimates of demand requirements should be interpreted - in the sense of target setting - as minimum targets to maintain table prices. If the rate of agricultural production, and most particularly, foodgrain production, is lower than these targets, then inflationary forces would be generated.

If one has to settle on a "point estimate" then we would suggest, especially to be consistent with the medium foodgrain production growth rate, that the medium demand projection should be given closest attention.

Table - 4

Total Requirement of Foodgrains
(in million tons)

	1968-69	1973-74	1978-79	1983-84
1. High Projection				
a) Human consumption	86.0	102.9	122.3	147.2
b) Seed	5.9	6.0	6.0	6.0
c) Feed	4.9	8.4	12.3	18.0
d) Losses	9.1	12.0	13.1	14.3
e) Total	105.9	129.3	153.7	185.5
2. Medium Projection				
a) Human consumption	85.7	101.8	120.1	142.8
b) Seed	5.9	6.0	6.0	6.0
c) Feed	4.9	8.4	12.3	18.0
d) Losses	9.1	12.0	13.1	14.3
e) Total	105.6	128.2	151.5	181.1
3. Low Projection				
a) Human consumption	85.5	100.8	118.0	138.4
b) Seed	5.9	6.0	6.0	6.0
c) Feed	4.9	8.4	12.3	18.0
d) Losses	9.1	12.0	13.1	14.3
e) Total	105.4	127.2	149.4	176.7

However, we would also point out that:

a. We have made reasonably optimistic assumptions about growth in national income. The growth rates postulated do require a continuing aggressive agricultural sector and a responsive non-agricultural growth. To this extent, these estimates are somewhat self-justifying.

b. The wide range of income elasticities of demand given would depend very importantly on the rate of growth as well as the distribution of income. For example the income elasticity of foodgrain demand for human consumption would fall off more rapidly with faster income growth rates - which would be offset partially by higher elasticities for dairy and poultry products. Similarly, one would expect the demand for foodgrains to decline more rapidly if gains are focused among higher-income land-owners as opposed to landless laborers.

c. Price changes have not been taken into account. In effect, we have been assuming a stable price situation. There is little empirical information on the possible price elasticities of demand for foodgrains. We would guess that foodgrain demand is relatively price inelastic, probably in the range of 0.3 to 0.5.

In conclusion, these demand estimates are tentative but are presented as a "best guess", given the time and information available.

B. Interpersonal and Interregional Distribution

Perhaps the most vocal political issue associated with the New Strategy is who gains the advantages of the new technology.

Over time and particularly through the first half of this century when technological change was slow, Indian agriculture has slowly evolved in to an equilibrium which - while being characterized by wide disparities with regard to inter-regional and inter-personal incomes - has been relatively static and accepted. 10/

The new technology has upset this equilibrium. It is almost inevitable that certain groups of people gain more than others even though most groups may benefit somewhat, either directly (through higher incomes) or indirectly (through lower food prices). In a country which is dedicated to developing a Socialistic Pattern of Society and in which the "demonstration effect" is clearly active, the implications of inter-personal and inter-regional distribution cannot be ignored.

M.N. Srinivas (1968) has very vividly stated the potential problem as follows:

10/ The basic analytical framework for this discussion is developed in more detail by Rosen (1967)

The general optimism which Indian agriculture has roused among the cognescenti, highlights, paradoxically, the country's political instability. But many may be led to think that the country has turned the political corner and that gheraos, bundhs, strikes, violence and arson are a thing of the past. Such men are probably optimistic by temperament, their optimism bearing little relation to facts. Or they might share the widespread belief that good harvests ensure political stability. But while it is true that famine conditions favour disorder, a good harvest going with a bad distribution system might also be productive of unrest. Besides, even a succession of good harvests will not transform our underdeveloped economy into an affluent one. For several years to come, millions will still be under-nourished, poorly clothed, badly housed, and will not be having access to education and adequate medical help. In other words, many sections of our society will continue to have adequate economic reasons for resorting to political agitation. Here it may be pointed out that agitations are more likely to become widespread when the economy has started moving and the expectations of people have risen than in a stagnant economy. For good or ill, the apathy which Indians were accused of even as recently as 1930s is no longer there. Ever increasing numbers of the people are being rapidly mobilized, socially and politically, and this means that the people's expectations have been raised and the government is clearly incapable of satisfying them. The politics of scarcity stares India in the face.

In other words, independence and adult franchise have brought enormous power to the dominant peasant castes, and if a long-run view is taken of political affairs in India, it may be all to the good that this very powerful, widespread but unorganized category of people have acquired a stake in democracy. But it is also necessary to recognize that there are forces abroad which may liquidate democracy. These are really the deep-rooted forces of casteism, communalism, regionalism and linguism. These have been with us for several decades but what is new is that the leaders of the dominant castes have a deep and vested interest in casteism, regionalism, and linguism, and are not unsympathetic to communalism. Besides, the overall context of the operation of these forces, has changed radically. To repeat, large numbers of our population have been politicized and this has made them keenly aware of their rights and produced acute dissatisfaction with their condition. They are combustible tinder for any ambitious and unscrupulous demogogue. In this connection it is essential to point out that the techniques of protest popularised by Gandhi have been put to effective use by individuals, groups and political parties. Fasts, strikes and civil disobedience have been undertaken to promote regional, linguistic, communal and a variety of other demands. The use of techniques popularised by Gandhi without the underlying Gandhian spirit has regulated in the widespread holocaust of the last few years. A militant advocacy of group interest ignoring the wider context, a climate of violence in all areas of public life, characterize the Indian polity today.

The question can be looked at from two levels:

1. an absolute measure of how much living standards of the lower income rural population are changed, or

2. a relative measure of changing income distribution among the various economic groups in the rural sector.

In terms of development targets, the general order of choice is easy to state; at least on first consideration:

1. The minimum target would be that all economic groups, most particularly the low income groups, improve their standard of living by some degree.

2. The more desirable target is that relative income differences among different regions and people be narrowed.

We will discuss the feasibility of each of these targets as well as attempt to assign specific quantitative measurements in section III. Here we attempt to identify the dimensions of the problem.

1. Inter-personal Distribution

Basically, for policy purposes, the economic groups can be divided into the following categories:

.... larger and medium land owners,
.... small holders,
.... tenants and rentiers, and
.... laborers.

If, for the sake of beginning, we arbitrarily set the dividing line between large and small holders at 5.0 acres (and we'll qualify this division later) we see that:

a. The rural population is divided (by households) between the first two and the fourth categories as follows (Appendix C)

landless laborers	23.09 per cent
.... small holders	51.64 per cent
.... medium and large holders	25.27 per cent

The small holders also provide labor to larger holders and industry in order to earn cash income above the subsistence production on their holdings. This arrangement has been the traditional method of enlarging small holdings to economically viable size.

b. The owned land area is allocated as follows:

.... small holdings	16.32 per cent
.... large holdings	83.68 "

About 25 per cent of the land is still held under various systems of tenure in which the returns from land are divided. Renting and tenancy is a traditional means of bringing small holdings upto viable size. 11/ Only about half of the tenant land is held under systems which restrict the progress of technological change and do not provide incentives. (Mellor, 1968c. citing evidence provided by Khusro).

In other words, India is a land of small farmers but not necessarily of small farms. This land-holding situation, of course, varies from one part of the country to another. (Appendix D). For example one acre holdings account for almost half the total number in Kerala but less than five per cent in Rajasthan, Punjab, Mysore, Gujarat, Madhya Pradesh, and Maharashtra.

11/ Sundaram (1968) analyzing data of the eigth (1953-54) and sixteenth (1959-60) rounds of the National Sample Survey shows that:

(1) The percentage of "leased-in" area has declined from 20.34 to 12.53 of total land cultivated.

(2) Small farmers appear to "lease-in" proportionately more land than larger farmers. In the 16th Round, small size-holders (0-5 acres) leased in from 16.5 to 25 per cent of cultivated area as opposed to less than 10 per cent leased in by holders of above 50 acres of cultivation.

The relationship between size holding and productivity has been the source of as many research efforts and papers as almost any topic in India. 12/ With the exception of the article by Kahlon and Kapur (1968), all of these studies discuss the pre-HYV technology.

The studies of farm management (India, 1954; India, 1966) indicated that size holding and yield were inversely coorelated. Eventually, the statistical basis of this generalization has been challenged and the conclusion appears to be accepted that it is difficult to generalize from aggregate data that has not been subjected to careful scrutiny. However, it does appear that if acreage is corrected for fertility, and proper yield and income variables are chosen, then there is a strong general tendency towards constant returns to scale in Indian agriculture. (Khusro, 1964). Subsequent investigations have been made to determine the role of the valuation of the family labor and bullock labor (particularly with regard to excess capacity) in these calculations.

One of the primary arguments in favor of maintaining a skewed income distribution is that those with higher incomes have more money to save (W.A. Lewis, 1955). No conclusive studies come in mind immediately relating size-holding to capital investment or to income transferred to financial institutions, although Mukhoti, (1966 and 1968) gives evidence to support this view, particularly with regard to the role of large holders as moneylenders, Sundaram, (1968) shows data that tractors are concentrated on larger holdings, and the UPAU (1969) study should also produce interesting data on this subject. To my knowledge, there is little data to suggest that revenues from taxation of agricultural incomes (including indirect taxes such as excises) are progressive.

12/ See for example: India, 1954; R. Krishna, 1959; D. Narain, 1961; R. Krishna, 1962b; C.H.H. Rao, 1962; A.K. Sen, 1962; Majumdar, 1963; C.H.H. Rao, 1963; A.K. Sen, 1964; Agarwala, 1964; A.K. Sen, 1964a; Khusro, 1964; Bardhon, 1964; Agarwala, 1964a; Majumdar, 1965; Paglin, 1965; India, 1966; C.H.H. Rao, 1966; A.P. Rao; Kahlon and Kapur, 1968; Rudra, 1968a; Rudra, 1968b; and Saini, 1969.

We will discuss the trends in wages in section III. For now, it should be noted that while some gains in incomes of laborers can be generated by forces, within agriculture, i.e., creation of employment, the real solution to this problem must be the result of growth in the non-agricultural sector, i.e., from non-agricultural growth "pulling" workers to industry in addition to technological change "pushing" labor out of agriculture.

One final argument for increasing the standard of living of the lower income groups as much as or more than that of the upper income groups is that this group accounts for a disproportionate share of the population whose level of nutrition is at the very lowest level. The income elasticities of demand for many of the more basic foodgrains and fibers (i.e. cotton textiles) are undoubtedly higher for the lower income groups. The distribution of income has a definite effect on the pattern of demand which in turn will influence the direction of agricultural adjustment.

This argument has a second aspect however. Income changes apparently will motivate the Indian consumer to demand a more varied and presumably a more balanced and nutritious diet than the heavily cereal based diet which he presently consumes. In increasing order of annual compound percent increases of total demand (the medium demand projections), the individual food components line up as follows:

1.	Other cereals	3.0 per cent
2.	Rice	3.2 "
3.	Starchy roots	3.2 "
4.	Pulses	3.9 "
5.	Wheat	4.6 "
6.	Edible oils	4.7 "
7.	Fruits and vegetables	5.2 "
8.	Meat, fish, and eggs	5.2 "
9.	Sugar and gur	5.7 "
10.	Milk	6.5 "

With regard to nutrition planning, it should be noted that diet change induced by economic forces, while inevitable, may also be slow particularly as experienced by low income groups. The prices of edible oils, fruits and vegetables, meat, eggs, fish, sugar, and milk (plus pulses) are higher than is easily within reach of the low income groups. The lower income groups can participate via higher incomes or lower prices for these particular products. The level of income change required to significantly upgrade diets of these low income groups does not appear feasible unless a massive effort is launched. If such demand were generated, unless productivity in these non-foodgrain commodities were increased through technical change generated by agricultural research, price increases would result - thereby nullifying the apparent income distribution advantages.

Even with the highest order of targets which we are considering in this exercise, it will take several years before Indian nutrition reaches minimal levels (Patwardhan, 1960; Sukhatme, 1961; Panse, 1961; Sukhatme, 1962; Panse, Amble, and Abraham, 1964; and PSAC, 1967).

In summary, the alternative targets of raising absolute incomes and narrowing relative income distribution would have strong political and humanitarian appeal. A failure to achieve either or both of these targets could result in political instability. The economic justification for the narrowing of income distribution requires more study.

2. Regional Growth Rate

During 1952-53 to 1964-65, the all-India annual compound rate of growth in crop output was 3.01 per cent (Appendix E). Within this aggregate, individual state growth rates ranged from a high of 4.56 per cent for the Punjab to 1.17 per cent for Assam. Within both the high (e.g. Punjab and Madras) and low (e.g. U.P. and Orissa) growth states, there is wide diversity of growth performance among districts. Agricultural growth in selected Indian states and districts has compared favorably with that in several of the more dynamic agricultural countries of the world; in other districts there has been even negative growth.

Analysis of factors explaining post-Independence Indian production performance indicates that while additions of new acreage were an important contributor to growth in many states, especially during the early Plan periods, irrigation development is perhaps the most important variable explaining changes in productivity (Appendix E). There is a high degree of complementarity between irrigation, fertilizer consumption, and improved seeds. 13/ Under these criteria, the dry, unirrigated lands offer the poorest growth prospects.

Identification of areas which qualify as dry lands is an elusive task. Approximately 20 per cent of net acreage in India is irrigated but less than half of this irrigated area can be classified as having assured-water (Appendix F); major irrigation and surface storage are dependent on rainfall and the public water distribution is seldom effectively managed down to the farm level. Even holdings which are served by tubewells, the most assured source, can have the command

---

13/ Consumption of total plant food ($N + P_2O_5 + K_2O$) per acre under cultivation in each of India's then (1963-64) major 15 states correlated with proportion of irrigated foodgrains acreage to total acres in foodgrains gives an r of 0.823 (significant at 1% level) (Hopper, 1965b).

irrigation area almost halved during the very important "heading" period for wheat when temperatures are high, winds are brisk, and water demand great.

The unirrigated land is divided almost equally among areas with less than 30 inches, 30-46 inches, and greater than 46 inches of rainfall annually (Appendix G). However, in most of these areas (Coastal Andhra, Tamil Nadu, and south interior Mysore being the primary exceptions), over two-thirds of this rainfall is concentrated during the June-September southwest monsoon period (Appendix H). Furthermore, the probability of drought (-20 per cent normal rainfall) is as high as one in three years in Rajasthan, western U.P., Gujarat, much of Andhra, and Tamil Nadu. Only Assam can expect to escape drought in less than one in five years.

S.R. Sen (1967) has attempted an operational classification to divide areas into the following categories for purposes of agricultural policy:

(A) Areas where there is an assured water supply both in volume and in spread either from assured rainfall or from sources of irrigation (e.g., tubewells, deep bore wells, canals from snow-fed rivers or storage dams) which are not unduly dependent on the vagaries of the monsoon;

(B) Areas where supply of water either from rainfall or sources of irrigation largely dependent on the monsoon (e.g., tanks, ordinary wells, run of the river canals depending entirely on the monsoon) is subject to large fluctuations in terms of volume or spread. These areas may again be divided into two broad sub-groups:

(B_1) those where droughts are relatively less frequent; and

(B_2) those where droughts are relatively more frequent.

(C) Areas where there is no dependable irrigation and where rainfall is scanty and precarious.

The results are shown in Table 5. His data indicate that over 40 per cent of the area and 35 per cent of the people are included in categories B_2 and C, the highest risk areas. Presumably these areas include anything from western Rajasthan and some areas in Punjab up to higher rainfall areas with very poor distribution. What is actually "dry land" can differ from area to area and from year to year. However, what is also clear is that this area includes a large part of the people and area of India.

Table-5

Acreage and Production of A, B and C Types of Areas

Category (1)	No. of Districts (2)	Ave. area under food-grains 1961-64 (mil.Acres) (3)	Percent-age to all India (4)	Ave. Prod-uction of foodgrains 1961-64 (million tonnes) (5)	Percent-age to all India (6)	Ave. Yield per acre (lbs.) (7)
A	101	91.4	31	30.0	37	720
B	89	78.8	27	22.4	28	622
B_2	41	43.2	15	11.1	14	560
B (B_1+B_2)	130	122.0	42	33.5	42	605
C	99	77.1	27	17.0	21	485
All-India	330	290.5	100	80.5	100	609

Source: S.R. Sen, 1967.

Politically, the problem of regional income distribution has both easier as well as more difficult aspects than the problem of inter-personal equity.

1. The new technology can be applied even to the dry areas in some, although not necessarily to an impressive degree, therefore the prospects for absolute increases in almost all areas are promising.

2. Furthermore, there is no clear large regional or economic block which is entirely left out.

3. However, unless new technologies are developed, the prospects for narrowing regional growth differences do not appear to be promising; the high yielding varieties thrive on water-assured acreages and those areas which are richly water-endowed will benefit much more than those which are not.

Therefore, the objective of attaining some minimum growth rate in all areas appears to be most promising. Ultimately the alternative target of narrowing regional agricultural growth must be weighed by comparing the political advantages of support from slower-growth states against the prospects of foregone aggregate growth from the diversion of resources from high to lower productivity investments. 14/

C. Resource mobilization and Growth Generation

The agricultural sector is such a dominating portion of the Indian economy because of the low level of overall economic development. As such it is the obvious primary source for resource mobilization if the overall economic growth process is to accelerate.

However, experience in the developed countries has shown that economic forces have, in the past, led to a reduction in relative importance of the agricultural sector to employment and national income even though activity in the agricultural sector has been encouraged and absolute agricultural production has increased rapidly.

Kuznets has explained this dilemma as follows: "one of the crucial problems of modern economic growth is how to extract from the product of agriculture a surplus for the financing of capital formation necessary for economic growth without at the same time blighting the growth of agriculture, under conditions where no easy quid pro quo for such surplus is available." (Owen, 1966, p.58)

14/ A key assumption to this conclusion is that of a fixed financial resource base - which, of course, might be relaxed, i.e., become a policy variable, if the objectives of growth plus equity are sufficiently motivated.

The Schumpeterian theory of economic development perhaps provides the most relevant guide to clarifying this situation in the Indian context.

Prior to the New Strategy, Indian agriculture had settled down into an equilibrium of slow growth just about adequate to sustain the growing population at marginal level (Hopper, 1965c). Purchased inputs represented less than five per cent of output costs and most capital was of the classical on-farm generated kind such as bullocks, wooden implements, organic manure, dug wells, etc. Furthermore, only a quarter to a third of agricultural production was actually sold on organized markets. The factors of production were allocated relatively efficiently but returns to new investments were low, hence reinvestment of profits was low (Hopper, 1965a; Schultz, 1964). There was not sufficient technological change to lead to decreasing output prices; taxation would have led to decreased profits, and, probably, decreased production; and there was limited interchange between the agricultural and non-agricultural sectors.

Introduction of the new technology upsetsthis equilibrium; a disequilibrium growth potential is now created. The productivity of input factors is now greatly increased. The mobilization and allocation problem becomes a new ballgame.

In this situation there are several ways that the agricultural investment to bolster the future growth potential of agriculture and the transfer of resources from agriculture to other sectors can be brought about.

1. The most obvious means is that the cultivators will consume part of their production but sell a larger part for cash profits; the increased cash profits provide an expanding market for non-agricultural output which in turn, creates non-agricultural profits for investment.

2. Secondly, the cultivators may reinvest their earnings in agricultural capital improvements which increase the future productive capacity of agriculture as well as provide a market for non-agricultural output.

3. Thirdly, the cultivators may put their earnings in savings, which, if directed into the financial channels, can be utilized for capital investments by other cultivators or by the non-agricultural sector.

4. If the growth in agricultural supply exceeds the growth in demand, output prices will fall which:

   a. if applied to food prices, will take pressures off demands for industrial wage increases;

b. if applied to raw material prices, will lower industrial input costs. Both of these actions would contribute to greater business profits which, in turn could lead to reinvestment;

c. if there were a continual stream of new cost-reducing agricultural technology available, it would lead to continued high agricultural investments in order to keep costs below the falling prices;

d. if the capital build-up in agriculture, resulting in need for fewer laborers, is accompanied by an aggressive non-agricultural employment market, then a transfer of labor from agricultural to non-agricultural employment will result. 15/

e. an alternative use of this "surplus labor" is for construction of such labor-intensive rural works as farm to market roads, irrigation and drainage projects, etc.

15/ This has been the pattern of structural transformation, with minor variations, in the western developed countries. Economic forces have acted to "push" workers out of agriculture and "pull" workers into other sectors. Technological change in agriculture has increased the real productivity per agricultural worker; the increased output has been produced with the same number or fewer workers.

The expenditure elasticity of demand for foods is less than unity; as incomes increase, consumers have spent an increasing proportion of their additional incomes on non-agricultural commodities. In developed countries, the supply generated by the more productive agricultural sector has increased faster than the demand for agricultural commodities, prices have been forced down, and the income per agricultural worker has declined relative to other employments. These conditions have encouraged agriculturists to look for higher earnings in other occupations. The industrial sector, faced with a higher expenditure elasticity of demand for its output, and the service sector, with lower rates of productivity increase, have absorbed some of the surplus (to agriculture) manpower. In this growth process, the relative contributions of industry and services to employment and to national income have increased. Agricultural expansion has been part of an expansion of the total economy and has been dependent upon (as well as has contributed to) this overall expansion.

5. The "surplus" or new difference between costs and incomes can be taxed either by financial taxes on inputs or incomes or by compulsory procurement at below market prices. The taxed "surplus" is then reinvested by the government. (Mellor, 1967a; Schultz, 1967). This has not been the strategy followed in the past by India nor, short of drastic political change, does it appear to be the strategy to be adopted in the future. 16/

The route of price adjustments is an economically efficient growth strategy in theory. In essence, continued agricultural growth depends on (1) continued growth in demand for agricultural products and (2) a fairly flexible adjustment mechanism. Neither resource adjustments through prices nor taxation will lead to aggressive growth without continued technological change. However, the public sector entering more directly through taxation may lead to better distributional results. (Owen, 1966).

What this discussion comes down to is that the post-Independence agricultural growth rate of 2½ to 3 per cent punctuated by frequent shortfalls has been a drag on past economic growth in India. A five per cent agricultural growth rate would enable a more impressive overall performance and might even lead to some decline in the agricultural price index 17/ thereby resulting in a transfer of resources via the price system especially if continued technological change is forthcoming. A 7½ per cent agricultural growth rate would generate even more resource transfer.

However, there are economic costs to accelerating the agricultural growth rate. In a relatively fixed resource situation - i.e., where it is not probable that domestic demand for agricultural output will expand rapidly, that financial resources will be reinvested in agriculture or transferred to other sectors, that labor will be released to non-agricultural sectors (or would be released without any other better employment opportunity), or that agricultural exports would increase - the trade-off with short-run non-agricultural growth (and therefore in long-run agricultural growth) from putting too many resources in the agricultural sector may be considerable (Mellor, 1967a). To find out what extent these constraints operate in India, if at all, is a researchable problem.

16/ The use of PL-480 foodgrains has been another means of public transfer of resources from one sector to another.

17/ Assuming that the total demand for agricultural products increases at an average rate of 4½ to 5 per cent.

There is some optimal relationship between non-agricultural and agricultural growth rates for the resource situation which India has now and will face in the future. To determine what this relationship is in India's future growth context - both in aggregate and qualitative terms - is a very important research priority.

The solution to this would be to develop a disaggregated growth model which would be built around a production function of the agricultural economy emphasizing both the relationships among factors of production within agriculture as well as the intersectoral relationships between agricultural and non-agricultural sectors and which would specify the agricultural input requirements, investment needs, output generation, and intersectoral resource transfers necessary to support alternative growth rates.

One problem in such an ambitious task is that presently productive inputs account for a very small percentage of output. As a result, the available input/output studies reflect very limited inter-dependence between the agricultural and non-agricultural sectors.

Simple models have been developed by Sastri (1964), Rudra (1964), Ramsunder (1965) and Mehta (1969) to test out inter-sectoral balances in the Indian economy. 18/ Unfortunately, the value of these models is a function of the assumptions on which they are constructed. The Rudra, Ramsunder, and Mehta exercises minimize the inter-sectoral interaction by defining the agricultural sector to include agricultural-related

---

18/ B. Sen made an evaluation of these models. Essentially, these models are of the following type:

$$X_1 = X_{11} + X_{12} + F_1 \quad \ldots (1)$$

$$X_2 = X_{21} + X_{22} + F_2 \quad \ldots (2)$$

where X_1 and X_2 are gross values of output of agricultural and non-agricultural sectors respectively, and F_1 and F_2 are the final demands for the output of two sectors. The final demands are estimated values of household consumption, plus government consumption, plus exports, minus imports, plus stocks, plus capital formation or investment. The technical coefficients (a_{ij}s) are taken from the 1960-61 input/output table.

industries. 19/ Also investment is largely confined to the non-agricultural sector. These assumptions were for a particular purpose - not the one we have suggested. The results suggest that the balanced rate of growth in the non-agricultural sector corresponding to a five per cent per annum rate of growth of agriculture, is 10.2 per cent (Rudra), 10.8 per cent (Ramsunder) and 8.8 per cent (Mehta). However, the way the sectors have been grouped means that a high rate of growth in agriculture (and 5 per cent per annum is historically high for agriculture) does not lead to a correspondingly high intake of agricultural products in the non-agricultural sector as inputs. The rates of growth in non-agricultural sector generated by the model are not a function of growth in agriculture, but of investment, net exports and consumption demand coming from households and government, and of non-agriculture's dependence on its own inputs. It should be noted again that all investments in these models occur only in the non-agricultural sector.

We cite these studies as a constructive beginning to the type of research which must be carried out to get a better grasp of the resource mobilization target. The overall growth rate of the economy is determined in the Harrod-Domar sense as the product of the output/capital ratio and the marginal propensity to consume. Technological change in agriculture could reduce the overall output/capital ratio for the economy. The marginal propensity to save could be increased by reinvested capital expenditures in agriculture and through resource transfers from agriculture to non-agriculture via agricultural price decreases and by taxation of agricultural incomes. We do not at the present time have much more than an approximate notion of what the magnitude of these flows should be. 20/

19/ All three authors use essentially the same sector-grouping scheme, according to which the agricultural sector is composed of crop production, animal husbandry, plantations, forestry plus all industries which are directly dependent on agriculture for their inputs - food processing, textiles, leather and leather products, rubber products etc.; the non-agricultural sector is defined to include all industries not dependent on agriculture for their input requirement, such as all mining and mineral based industries, construction, chemicals, etc.; the rest of the industries - transport, railway, coal and fuel - are included in a 'universal intermediary' or a 'residual' sector. Judging by the technical coefficients used, some minor adjustments have been made by all three authors in the aggregation of sub-sectors; the technical coefficients are not identical.

20/ Schultz (1953), Nichols (46), and Tang (47) were among the early economists to explore the inter-sectoral relation growth relationships in the U.S. and Kuznets (1956) and Owen (1966) have carried out analysis on a more general basis. With regard to India, Hendrix (1969) has developed both the theoretical and quantitative dimensions of past agricultural-non-agricultural relationships.

D. Summary

It appears that a minimum of a five per cent agricultural growth rate is necessary in order to:

1. fulfill demands for food and fiber generated by a five per cent overall growth rate;

2. generate enough "trickle down" so that some minimum gains are passed on to the lower income groups and low growth regions, and

3. make some beginnings at a transfer of resources to the industrial sector to accelerate the structural transformation that must occur.

We will attempt to be more specific about each of these targets in the next section.

III. PROJECTIONS OF LONG RANGE AGRICULTURAL DEVELOPMENT (THE PARAMETERS OF WHAT CAN BE EXPECTED IF ALTERNATIVE ASSUMPTIONS REGARDING GOVERNMENT SUPPORT ARE CARRIED OUT)

Our next task is to identify whether the target "requirements" for an accelerated agricultural and overall economic growth rate suggested in the previous section are feasible targets; i.e., whether they are consistent with the range of expected input availabilities and, given alternative supply and demand paths, what inter-personal, inter-regional, and inter-sectoral relationships, appear likely.

In order to explore a range of alternatives, we will describe three scenarios of foodgrain production over the next fifteen year period:

... a medium or "most likely" rate which averages a 5% compound growth rate;

... a "slow metabolism" performance somewhat above the post-Independence growth rate, averaging a 3½% compound growth rate in yields; and

... a "high metabolism" performance which gives a 6% compound growth rate in foodgrain yields with a slightly lower growth rate in total foodgrain produce due to cropping pattern adjustments.

With the aim of making the primary input assumptions of the projections as clear as possible, we will employ a relatively simple methodology, developed in earlier papers by Holst (1967) and Hendrix, Naive, and Adams (1968), of using a synthetic production function assuming additive input responses of the type:

production = f (land, water, seeds, fertilizer)

Given the basis underlying natural factors such as soil type, intensity of sunlight, temperature, and rainfall, man can influence production by (a) improving management, (b) increasing the quantity of inputs, and (c) changing technology (increasing the quality of inputs). These actions are translated into (a) enabling the cultivator to move toward the limits of the given production function, (b) moving further up along the given production function, and (c) shifting upward to a new production function. This is the setting for the input/output relationships which will be discussed in sections V through XI.

From these projections we will then describe the order of changes in prices, cropping patterns, regional and personal income distribution, and agricultural/non-agricultural sectoral relationships which might be anticipated as feasible parameters for the future.

A. Aggregate Foodgrain Supply Projections

1. The Natural Resource Base for Crop Production

(Consideration of the technical potential for agricultural production must include examination of the influence of certain physical environmental factors such as soil, rainfall and temperature. The following brief discussion of each generally borrowed directly from the report by Russell and Brinegar (1969) is in the nature of background rather than of "supply" in the economic sense.)

The soils and climate of India constitute a resource base, which if properly developed and wisely managed, is capable of supporting levels of production that will meet the nation's food needs for the predictable future. For most of the country, temperature and day length place little or no constraint on plant growth during any season. On the other hand, rainfall is highly seasonal and varies widely in quantity in different parts of India.

The soil serves as a "staging area" for the water and nutrients required by living plants. Soils differ widely in their inherent capacity to perform these functions and it is often necessary to introduce management practices to correct sub-optimum levels of nutrients, improper drainage or physical conditions that impede root development or to supplement the natural soil moisture supply with irrigation.

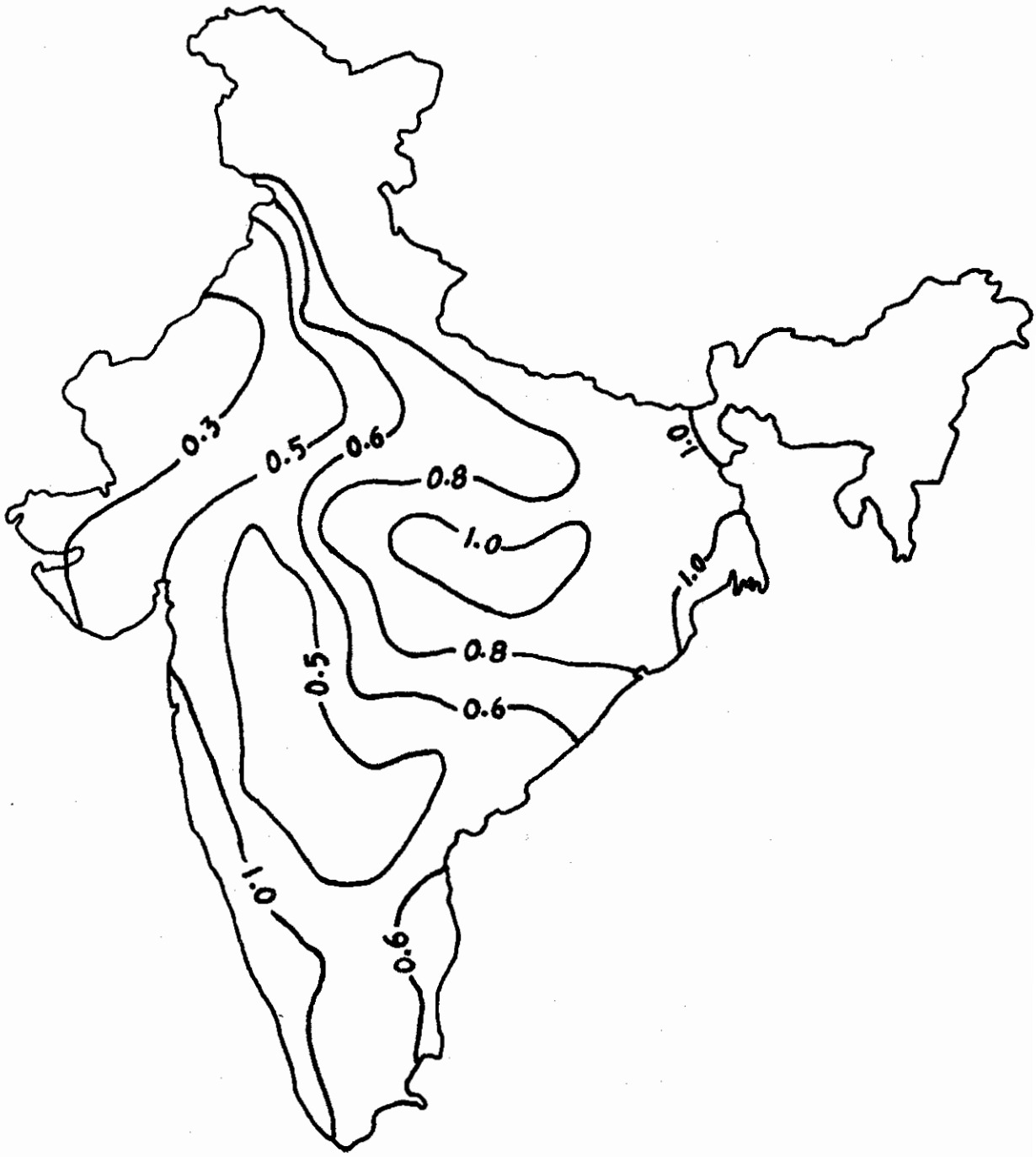
a. The Water Supply

The geographic distribution of annual rainfall and annual potential evapotranspiration[1/] were compared and the ratio between them is shown in Figure 2. From this figure it is clear that except for areas in Assam, Bihar, West Bengal, Madhya Pradesh, the Malabar coast and in the mountains the average annual potential evapotranspiration exceeds the average annual rainfall. This indicates that for most of India it is not possible to meet fully the 12-month evaporative demand of cultivated areas even if it were technically possible to retain on each acre of such areas all of the rain that falls on it. To meet the crop needs beyond those supplied by indigenous rainfall, it is necessary to supplement the latter with run-off water from other non-agricultural areas.

1/ Evapotranspiration is a measure of the demand for water based on selected factors including temperature, humidity, and plant cover and includes water used by plants in transpiration for growth in addition to evaporation from adjacent soil and from surface of open leaves.

Figure – 2

THE RATIO OF RAINFALL TO POTENTIAL EVAPOTRANSPIRATION



The Outline map for this figure was taken from Indian Agricultural Atlas, Directorate of Economics & Statistics, Ministry of Food & Agriculture, Government of India, 1958.

The comparative seasonal distribution of water supply and demand is the primary determinant of the ways in which regions can be utilized. An analysis of the seasonal distribution of the ratio of actual evapotranspiration (AE) to potential evapotranspiration (PE) shows that current rainfall and profile stored water are usually sufficient to meet crop needs for a kharif crop, may be adequate also to meet the requirements for a rabi crop, but only in limited areas are they also sufficient for the high water demands of crops produced in the hot, dry zaid season.

If the PE and P for the zaid season (April, May and June) are subtracted from the annual PE and P values, one obtains the potential water demand (PE*) for the nine months production season consisting of kharif and rabi crops. Figure 3 shows how the $\frac{P^*}{PE^*}$ varies in India. This indicates that the indigenous water supply is sufficient to meet the potential demands for a double cropping system for a significantly large part of India. The double-crop water demands for an even larger area can be met if foreign water from those parts of catchment areas not suitable for intensive crop production can be supplied to supplement the indigenous supply of the double-cropped area.

b. The Soil Resource

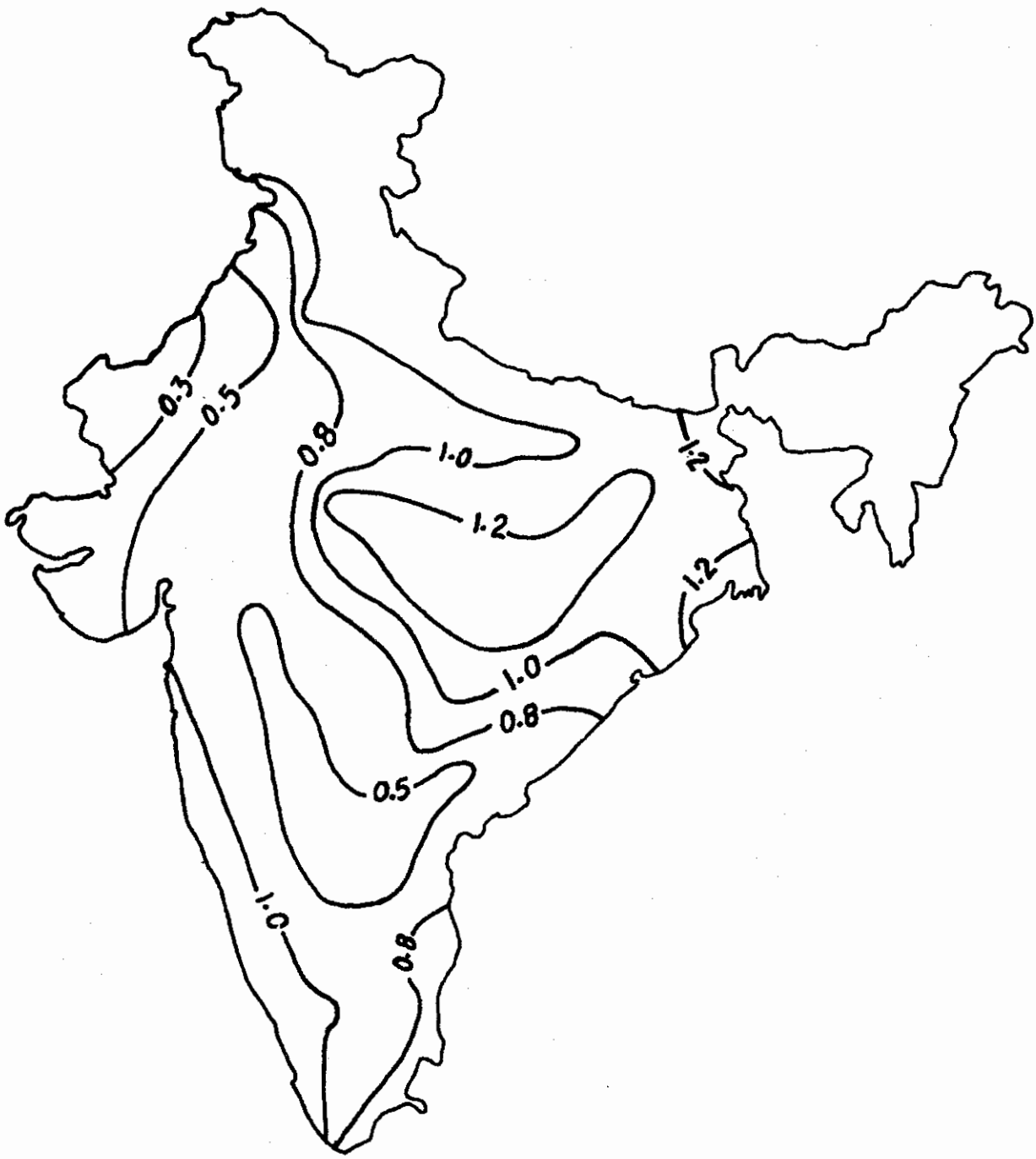
The basic potential of the soils of the major regions shown in Figure 4 is considered here to be largely determined by the physical capability of the soil and the underlying parent material to provide sufficient storage of water to bring the seasonal supply and demand functions into balance. In most instances the full expression of the physical potential will require the correction through fertilization of the basic inadequacy of nutrients that exist in most of the soils of India.

(1) Alluvial soils represent nearly 25 percent of the total land area of India and perhaps 40 percent of the nation's currently cultivated acreage.

Characteristically sufficient water is available to permit crop production on a year-round basis on the alluvial soils. Although indigenous rainfall is insufficient to meet the annual evapotranspiration demand in much of the alluvial soil area and surface storage is not feasible because of the nearly level topography, the underground storage capacity, recharge, and withdrawal characteristics are favorable to pump irrigation. Water management in the alluvial soil areas should treat indigenous rainfall perennial stream flow and underground recharge, storage and withdrawal as a total dynamic hydrologic unit. When considered in this light there seems little reason to doubt the assertion that the water

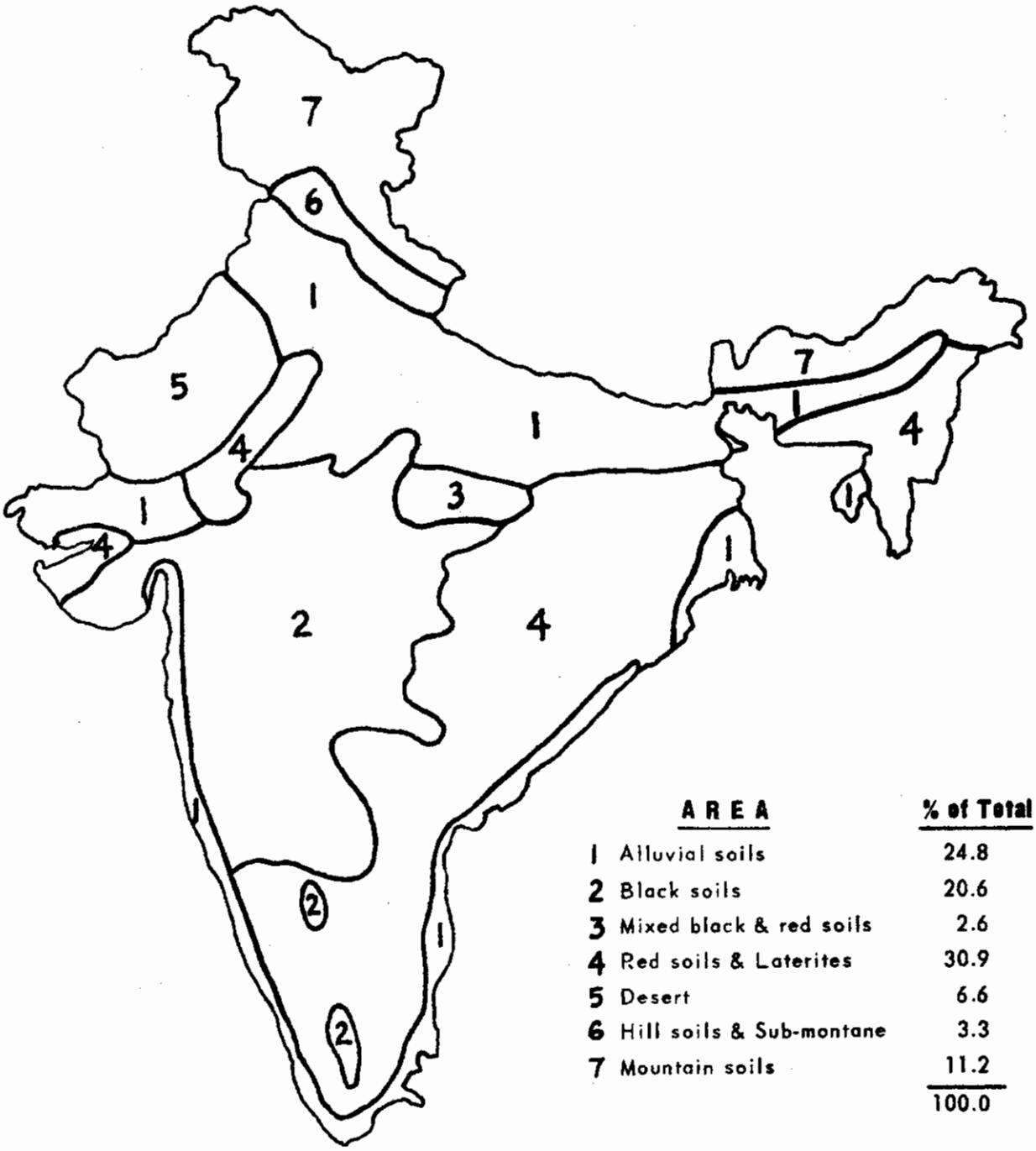
Figure -3

THE RATIO OF RANFALL TO POTENTIAL EVAPOTRANSPIRATION FOR THE 8 MONTH PERIOD 1 JULY TO 31 MARCH



The outline map for this figure was taken from Indian Agricultural Atlas, Directorate of Economics & Statistics, Ministry of Food & Agriculture, Government of India, 1958.

GENERALIZED SOIL MAP OF INDIA



AREA		% of Total
1	Alluvial soils	24.8
2	Black soils	20.6
3	Mixed black & red soils	2.6
4	Red soils & Laterites	30.9
5	Desert	6.6
6	Hill soils & Sub-montane	3.3
7	Mountain soils	11.2
		100.0

The outline map for this figure was taken from Indian Agricultural Atlas, Directorate of Economics & Statistics, Ministry of Food & Agriculture, Government of India, 1958.

resources are sufficient to permit year around cropping in most, if not all, of India's alluvial soils.

In Assam and much of West Bengal and Bihar, the major water management problem is drainage and flood control during the monsoon. In the lower rainfall areas of central and eastern Uttar Pradesh and the coastal delta areas, drainage problem, while not so severe, are also present. In the other river and delta areas drainage is more a localized problem. In northwestern India, supplementary water during the rabi period is the greatest requirement.

In summary it can be stated that if indigenous rainfall, exogenous stream and canal flow and the inherent storage capacity of underground aquifers are properly managed, the extensive alluvial soils of the Indo-Gangetic plain, the coastal deltas and the riverine flood plains of the major rivers of peninsular India are capable of producing crops on a 12-month basis. Given existing knowledge, proven production technology and current prices, it is estimated that the total annual agricultural production of the alluvial soils of India potentially can be increased by a factor of ten times the current level. 2/

(2) Red soils, as a class, are the most extensive in India. However, they do not have as great a potential for meeting India's food needs as do the alluvial soils discussed above. This arises because of their lower capacity for moisture storage in the root zone, lower inherent nutrient status and less favorable topography. The potential of the red soils for multiple cropping is lower than that of the alluvial soils because of the general lack of adequate aquifers for storage of exploitable groundwater and because extensive irrigation with foreign water is less feasible because of topographic limitations. The red soils, however, are responsive to improved management and as discussed above are in many areas suited for much more intensive use. It is estimated that double cropping could be practiced on 50 percent of the red soils now under cultivation and that 12-month cropping is technically feasible on perhaps 10 percent of the cultivated red soils. Based on this evaluation, it is estimated that with present knowledge, existing technology and current prices, the food production on the red soils could be increased to five times its present level.

(3) Black soils occupy most of the drier western part of the central Deccan plateau. They present difficult soil management problems especially under irrigation.

2/ There are a series of assumptions regarding best technology, management, and investment hidden in this statement. It and the corresponding ones following, should be considered as evaluations of potential if many things (discussed in the latter sections on instruments) are done.

Because of their inherent moisture holding characteristics and relatively high base status, the black soils have considerable potential for double-cropping. Expansion of kharif crop production in the more humid parts of the black soil region is critically dependent upon the development of suitable high yielding short-season crop varieties and improved technology for seedbed preparation and weed control. Improved methods of harvesting of surplus monsoon rainfall for profile or groundwater storage for rabi crop use, would also increase the food production of the black soils. It is estimated that with present knowledge, existing technology and current prices, the food production of the black soils could be increased to three times its present level. If suitable techniques for tillage and timely seedbed preparation could be developed for the black soils, the productivity of this important area could be increased to five times its current level.

(4) Other soils. The remaining 20 percent consists of the desert soils of Rajasthan and the soils of hills and mountainous regions, principally in the northern regions. It is estimated that the cultivated area in these two groups of soil represent not more than 2 percent of India's total.

Food crop production on the desert soils is almost wholly dependent on the development of irrigation. Indigenous water resources are so limited that such development depends on the importation of water into the area from the Indus catchment basin. The desert soils are inherently rich in bases and many have profile characteristics that make them well suited for intensive cultivation if supplied with adequate water of suitable quality. Both the quantity and quality of the water used to irrigate desert soils be sufficient to maintain a net downward flex of water through the soil profile. Although very large capital investments are required to develop them, the desert soils if properly managed can make a significant contribution to meeting India's food needs.

The soils of the hills and mountains represent a very heterogenous group. Many are uniquely suited for such crops as tea, coffee and tree fruits. The temperature and moisture conditions are often suited for vegetables or off-season speciality production. Improvements in productivity of these soils will be associated with the development of varieties and cultural practices to meet special needs and will often be dependent on improved off-farm storage, processing and marketing facilities and transportation.

c. Technological Base

India now has advantage of a quantum jump in technology over previous local varieties (Section I). For the five major

cereals, present yields of 50 to 100 percent higher than desi varieties are possible on irrigated lands (Hopper, 1968). Possibilities for multiple cropping are greatly increased. Furthermore, these breakthroughs, some of which were originated abroad but all of which have been adapted and further developed by Indian research institutions, should be the first of a series of technological changes. The past pattern of research developments in western countries has been that the pace accelerates over time, i.e., that knowledge is cumulative. 3/ What has happened in the five major foodgrains can be extended eventually to the pulses and non-foodgrains also. (Appendix I)

2. Factors Influencing the Translation of Present Potential into Actual Performance

Whether India will translate this physical potential into actual production over the longer-run depends on many "ifs".

Perhaps the most important long-term if is the very key variable, irrigation development. The uncertainty of the monsoon has posed constraints on Indian agricultural production programs from time immemorial. Once water is available, high yielding varieties can be adopted, fertilizer dosages can be increased, and land can be multiple-cropped. 4/

With the high yielding varieties the quality of irrigation becomes increasingly important . For example, the dwarf wheats have identifiable periods, i.e., at the crown root stage, at which time the difference of one irrigation can add as much as 900 lbs per acre to yield (Hopper, 1968). The photo-insensitivity of new rice varieties can lead to staggered sowing and harvesting dates in adjoining fields which means that the previous schedules of canal release may not provide irrigation to all plots as needed. One of the primary reasons for the successes of the dwarf wheats has been the water management available from private tubewells. 5/

3/ We are not prognosticating additional jumps in cereal yields of 50 to 100 percent, but a sustained level of continuous improvements in quantity and quality of production which is much higher than past years.

4/ Appendices G and H give basic data regarding quantity and distribution of rains by major reporting areas as well as the distribution of acreage sown of irrigation by rainfall area within states. Louis Bean (1969) has carried out some work in efforts to identify regularity in rainfall patterns for predictive purposes. Cummings and Ray, 1969a and 1969b attempted to quantitatively relate rainfall to foodgrain production.

5/ Appendix F lists irrigated areas by types of irrigation in each State.

The 1973-74 target of 60 million acres can be reached if coverage increases at an annual rate of about 7½ million acres. However, this coverage will soon be a function of the quality of irrigated land available; one current estimate puts this figure at about 12 million acres for wheat, 35-49 million acres to the three hybrids, bajra, jowar, and maize, and 20-30 million acres to rice to which might be added any double-cropping on the same acreage (Hopper, 1968). Since HYV wheat has almost completely covered irrigated acreage by 1968-69, this will require that HYV rice and eventually hybrid maize, jowar and bajra begin to be adopted aggressively in order to maintain the recent foodgrain growth rate. A comprehensive program of irrigation distribution, land preparation, and drainage must receive priority attention.

A second variable which can pose a constraint at different points in the future but also most importantly in the medium to longer-run is technology. Even with only slight improvement of present technology, there is substantial growth potential to be exploited for the next ten years. The short-run modifications must be carried out primarily with rice. The All-India Coordinated Rice Improvement Program is already releasing varieties with superior yield and grain qualities to the original germplasm[6/] (Hopper and Freeman, 1968).

In the future new varieties improvements are anticipated increasing the yields, decreasing the field duration, increasing grain quality, and increasing disease and pest resistance. Furthermore, eventually, some success is hoped for increasing the yield potential on non-irrigated low rainfall lands. At present, however, the best bet appears to be in changing dry lands to irrigation (Cummings and Ray 1969b). The solution to the technology problems appear to be relatively assured - if sufficient research support is given.

In the short-term, increasing fertilizer consumption can have a great effect. The HYV utilize higher dosages and utilize NPK more efficiently than local varieties, but all varieties, even local varieties on non-irrigated lands are fertilized at well below economically optimum dosages. Other inputs such as plant protection, seed multiplication, and increasingly, mechanization, will also play key roles from the present onward.

Finally, we must mention a series of variables, which while falling outside the production function, very importantly determine the rate of progress. These include price incentives which would be provided through aggressive overall economic growth

---

6/ Annex J gives an indication of the potential by states for future development.

reinforced by government policy, modernized input and output distribution systems including transport, roads, and storage, and extended rural credit. These variables will be discussed in more detail in later sections.

In other words, there is range of possible growth paths which might result in the future - and also a parallel range of adjustment problems which must be anticipated.

3. Projections

The following reference years are used:

1964-65: the last pre-drought year; also the last year for which we have irrigation data.

1967-68: the last year for which we have confirmed input and production data.

1969-69: latest year.

Since we have some input and production data for all of these years, we have used these periods to make calculations to check out the internal consistency of our assumptions.

Projections are made at intervals as follows:

1973-74 end of Fourth Plan

1978-79 end of Fifth Plan

1983-84 end of Sixth Plan

a. The "Five Per Cent" Annual Growth Rate of Foodgrain Production

The following combination of inputs - one among many possible, but one which is probably if the government provides adequate support - can provide a five per cent average annual growth rate in foodgrain production over the next fifteen years.

The land use assumptions for this projection are given in Appendix K. The fertilizer dosage and response assumptions and the foodgrain production results are shown in Table 6.

The important assumptions are:

1) Net foodgrain area sown will increase only slightly.

2) Gross irrigated area sown will increase rapidly, continuing and even accelerating the rate of growth attained during the recent three year period. This will reflect the interaction of two forces:

Table 6

Foodgrain Production
Medium Projections

	Units	1964/65	1967/68	1968/69	1973/74	1978/79	1983/84
1. Gross sown area	mil. acres	390.7	392.5	394.2	414.6	429.4	445.3
2. Allocated to: cereals	"	231.5	244.1	240.0	245.0	245.0	250.0
3. pulses	"	58.8	56.0	55.0	60.0	60.0	60.0
4. non-foodgrains	"	100.4	92.4	99.2	109.6	124.4	135.3
High Yielding Varieties - Irrigated cereals							
5. Gross area	mil. acres	-	15.0	21.0	50.0	90.0	110.0
6. Average NPK dosage	lbs/acre	-	60	70	85	100	120
7. Package response ratio	-	-	13.5	13.5	13.5	13.5	13.5
8. Package increase	lbs/acre	-	810	945	1148	1350	1620
9. Basic cereal yield	"	-	1300	1300	1300	1300	1300
10. Package cereal yield	"	-	2110	2245	2448	2650	2920
11. HYV cereal production	mil. tons	-	14.4	21.4	55.6	108.4	146.0
Local varieties - irrigated cereals							
12. Gross area	mil. acres	53.2	40.0	35.8	21.5	-	-
13. Average NPK dosage	lbs/acre	30	40	40	50	-	-
14. % of area receiving NPK	-	40	70	70	90	-	-
15. Average NPK dosage - All area	lbs/acre	12	28	28	45	-	-
16. Fertilizer response ratio	-	9	9	9	9	-	-
17. Increase due to fertilizer	lbs/acre	108	252	252	405	-	-
18. Basic cereal yield	"	1350	1300	1300	1300	-	-
19. Total yield	"	1458	1552	1552	1705	-	-
20. Cereal production local	mil. tons	35.3	28.2	25.3	16.7	-	-

Table 6 (continued)

Foodgrain Production
Medium Projections

	Units	1964/65	1967/68	1968/69	1973/74	1978/79	1983/84
Unirrigated cereal varieties							
21. Gross area	mil. acres	178.3	189.1	183.2	173.5	155.0	140.0
22. Average NPK	lbs/acre	10	15	20	30	35	35
23. % of area receiving NPK	-	20	20	22	30	30	40
24. Average NPK dosage - All area	lbs/acre	2.0	3.1	4.4	9.0	10.5	14.0
25. Fertilizer response ratio	-	9	9	9	9	9	9
26. Increase due to fertilizer	lbs/acre	18	28	40	81	95	126
27. Basic cereal yield	"	450	450	450	475	500	525
28. Total yield	"	468	478	490	556	595	651
29. Cereal production	mil. tonnes	37.9	41.1	40.8	43.8	41.9	41.4
30. Total cereal production (normal weather)	"	73.2	83.7	86.5	116.1	150.3	187.4
31. Average cereal yield	lbs/acre	696	754	793	1042	1350	1649
Compound growth yield	per cent	-	-	-	5.6	6.2	4.1
Pulses							
32. Total production (normal weather)	mil. tonnes	12.0	11.5	11.3	13.0	13.6	14.3
33. Yield	lbs/acre	450	450	450	475	500	525
Foodgrains							
34. Total production (normal weather)	mil. tonnes	85.2	95.2	97.8	129.1	163.9	201.7
35. Compound growth	per cent	-	-	-	5.8	4.9	4.2
36. Average yield (normal weather)	lbs/acre	646	698	737	931	1182	1431
37. Compound growth	per cent	-	-	-	4.8	4.9	3.9
38. Weather index [Appendix A]	index	104.8	103.0	89.1	-	-	-
39. Reported Production	mil. tonnes	89.0	98.0	94-96	-	-	-

a) Net irrigated area sown will increase, particularly in the north through use of privately financed, minor irrigation such as tubewells. The huge, unutilized groundwater potential (Appendix T), the experience of the two drought years, the success of the dwarf wheats which have demonstrated the profitability of adequate water management, incentive prices, and the extension of rural electricity all are positive factors. 7/

b) Multiple Cropping is also assumed to accelerate, particularly on areas of improved water control - which includes drainage, irrigation, and/or land shaping - if sufficient energy is made available to increase the speed of land preparation and harvesting and if incentive prices continue to prevail.

In this regard, the energy situation is worth re-emphasizing. The black cotton soils of West Central India are one clear illustration of an area whose cropping potential is inhibited by water management and availability of on-farm power. Land lies idle until the monsoon rains; after the rains the land becomes very difficult to work. Furthermore, more timely operations in the interval between wheat and kharif crops in the north could permit triple and quadruple cropping with addition of such crops as mung, beans and potatoes taking advantage of the shorter field duration and later planting requirements of the dwarf wheats.

3) Gross areas sown to HYV will increase to the target projected in the Fourth Plan but only 50 million acres of this will be on irrigated acres, the remainder on

---

7/ Not all the new minor irrigation directly goes to increase net area cultivated however (Annex L). Part of the increase will provide supplemental benefits to existing irrigated area thereby increasing quality of previous coverage. Another large increment is necessary merely to offset depreciation. During 1969-74, the GOI estimates that 14 million gross acres of new irrigation is necessary to increase coverage by 10 million acres at the end of the period.

Net irrigated area averaged an increase of approximately 1.0 million acres annually between 1952-53 and 1964-65. Between 1964-65 and 1967-68, the annual increase jumped to 3.1 million acres, in part due to emergency reaction to the droughts. We assume that future expansion will be well above the historical rate but below the accelerated response to the emergency period.

Previous Page Blank

rain-assured areas.[8] Further development of rice and the hybrids should begin to payoff toward the end of the Fourth Plan with rapid expansion in rice acreage particularly. Expansion will continue to be strong into Fifth and Sixth Plans and will extend to rain-assured areas.

4) Fertilizer Consumption

a) Past and present dosage levels are estimated from survey data referenced in section I. The allocation among HYV and irrigated and non-irrigated local varieties was checked for consistency against total fertilizer consumption and aggregate foodgrain production.

b) It is assumed that future fertilizer consumption will increase steadily but at a rate below the Fourth Plan targets. The output response for the HYV is so much higher than that of desi varieties that faster growth of fertilizer consumption would lead to rapidly falling foodgrain prices which would in turn lead to a "backing off" by cultivators. One of the primary differences in assumptions of these projections as compared to the Fourth Plan Draft is that at 13.5 to 1 NPK response ratio (rather than 9 to 1) is assumed. The implication of the HYV is that less NPK is needed to produce a given amount of foodgrains than is needed with local varieties. Even with the assumptions of NPK increase which we have assumed, average dosage, will still be well below optimum even by 1983-84.

5) Increase in technology in future:

a) The base yield for irrigated and non-irrigated local varieties were adopted from a study by Hopper (1965b).

Nitrogen response trials, carried out on irrigated land, generally indicated higher base yields (with no nitrogen) for high-yielding varieties as compared to local, irrigated varieties (Hopper, 1968; AICRIP, 1967; Cummings, Herdt, and Ray, 1968; Murty, 1967; V.H. Shah; 1967)

8/ The sowing of HYV on rain-assured acreage is accounted for by an accelerated increase in average NPK dosage on non-irrigated foodgrain area.

Since many of the experimental plots retain residual fertility from previous trials and are treated with a basal dosage of P_2O_5 for the nitrogen trials, it is difficult to prove genetic superiority although there is some evidence of this especially with bajra and jowar.

We are assuming, for the time being, no difference in base yield between HYV and local, irrigated, Furthermore, the base is not assumed to change over time.

b) Fertilizer Response

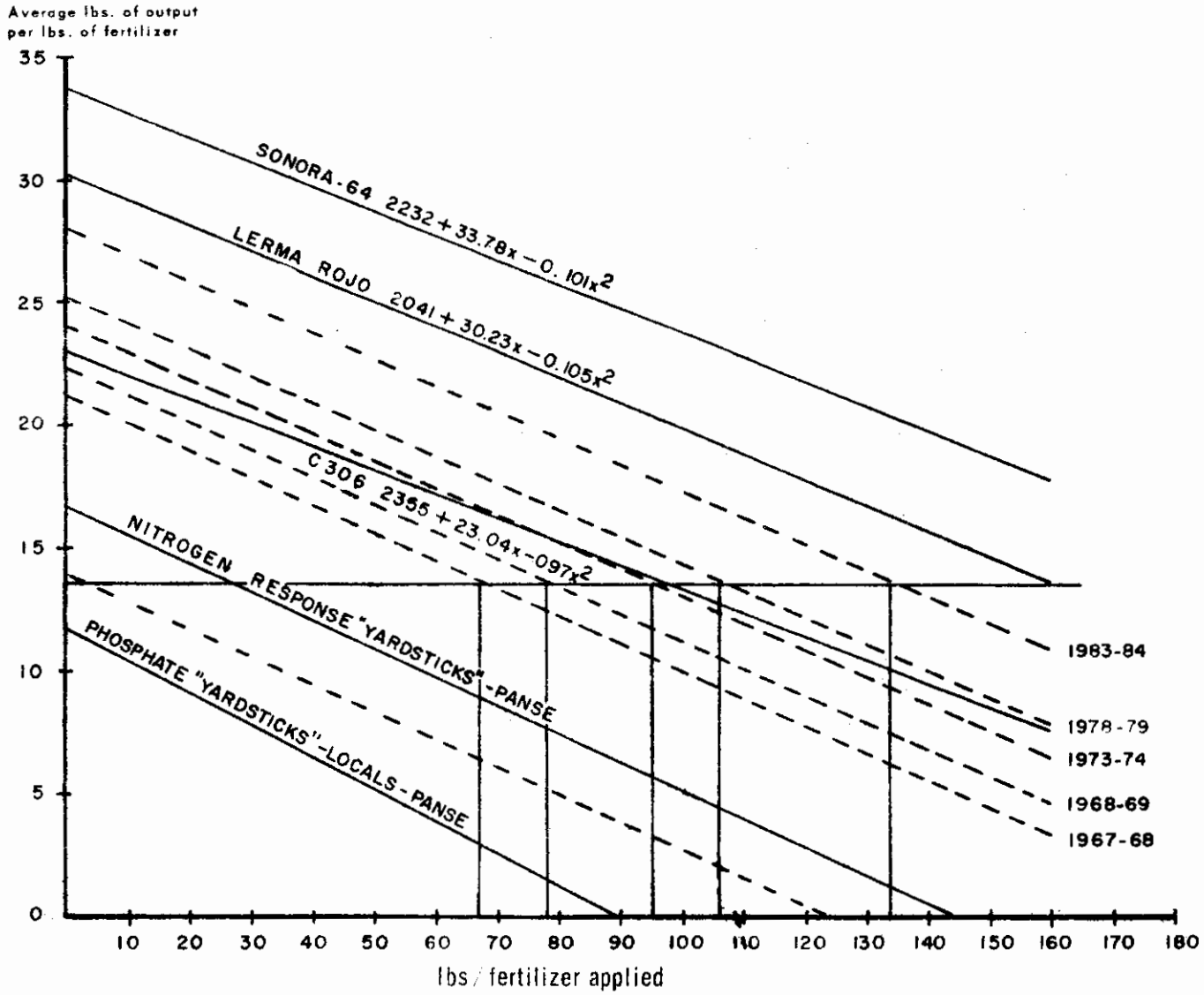
Fertilizer response studies for local and high yielding varieties under the present technology were summarized in Section I.

In the future, the technology is assumed to change gradually, i.e., the average NPK/ output response ratios are assumed to shift upward.

The assumption is illustrated by Figure 5. With no technological change, the average response ratio would decline as dosages are increased (i.e., the average nitrogen/output response for C-306 is 18.7 to 1 at 50 lbs N/acre but falls to 14.1 to 1 at 100 lbs N/acre.). However, technological change (i.e., moving from C-306 to to Lerma Rojo to Sonara-64) means that at a constant 50 lbs N/acre, the response ratio increases from 18.7 to 28.7 or the average response of C-306 (i.e., assumed to be an earlier technology) at 40 lbs N/acre is the same as that of Lerma Rojo (assumed to be a more advanced technology) at 100 lbs N/acre. The dashed lines illustrate the level of our assumption of technological change and are consistent with range of response variation in present varieties (solid lines) as well as with experience of field results over time (i.e., Ford, 1967), and a comparison of Herdt and Mellor 1964 results with those of AICRIP, 1967).

Figure 5

AVERAGE RESPONSE OF CEREALS TO FERTILIZER



6) Results

Our "most probable" foodgrain production scenario gives a 15-year projection which averages for the entire period (compounded annual) annual growth of 5.3 percent in cereal production, 5.0 percent in cereal yields, and 5.0 percent in total foodgrain production. The Sixth Plan five-year rate, however, is significantly lower than the Fourth Plan rate of growth.

b. Alternative "Low Metabolism" and "High Metabolism" Foodgrain Growth Paths

The quantum change in cereal technology has been added to a foodgrain production which was already growing at a rate of 2½ percent annually since Independence. Therefore, it is difficult to imagine a growth rate of foodgrain production over the next decade of less than 3½ per cent annual trend.

This lower limit to growth, which might be called a "low metabolism" performance as compared to our "most probable" projection, could be brought about for any of several reasons separately or in combination such as failure of new technology to develop as expected (particularly in rice), bottlenecks in input supplies especially fertilizer in the early stages and irrigation, mechanization, and pesticides in later stages, or failure to continue to implement an incentive price policy to encourage production which might also include adequate market development.

On the other hand, while a five per cent annual foodgrain growth rate has been postulated as our "most probable" guess (and in many quarters, this rate would be regarded as optimistic), it is possible to visualize a faster pace. Causes which might lead to such an accelerated foodgrain production, for example, might include a rapidly changing technology including further yield advances in wheat, rapid development of new varieties and corresponding management practices in rice, technical advances in agronomy for barani areas including progress with pulses, and accelerated irrigation, mechanization, fertilizer, and pesticide use.

Actually what would happen in our "high metabolism" projection would be a very rapid increase in cereal yields balanced off by downward adjustments in cereal acreage. Barring the development of export markets, the growth of effective demand operating through the price mechanism poses constraints on the absolute increase in total foodgrain production.

The output projections for the "slow metabolism" and "fast metabolism" growth paths, arranged in the same format as for the "most probable case", are shown in Table 7. As we move progressively up from the slow, through the medium, to the fast growth paths, we are making more optimistic assumptions, respectively, for each of the following categories: NPK dosage on each area, percentage of non-HYV area receiving NPK, irrigated cereal acreage, HYV acreage, and technology.

4. Concluding Comments

The synthetic production function we have used allows subjective choice regarding rates of change of individual inputs - these same growth rates might be projected with a different combination of assumptions. As an example, the Fourth Plan draft projects an output growth rate which is quite similar to our medium rate but with much higher fertilizer inputs, slightly lower irrigation growth, slightly higher assumption about the coverage of HYV, and apparently, much more pessimistic assumption about future technology. The fertilizer and technology assumption appear (these are related) to be the essential difference with our projection.

This technique has an apparent simplicity which is deceptive. It appears that there is perfect substitution among inputs and that there are constant returns to inputs such as fertilizer, irrigation, or new land, i.e., at a given time the ten millionth new acre of HYV varieties is assumed to have the same base yield as the first new acre. For example, taken literally, this scheme might be interpreted as inferring that a million ton increment to cereal output could be just as easily attained by increasing any of the following single factors by the stated amount (without changing other factors correspondingly) during the Fourth Plan period:

- Area under (base yield):

  HYV or local, irrigated - 1.69 million acres
  non-irrigated cereals - 4.63 million acres

- NPK dosage on (fertilizer response):

  HYV - 74,000 nutrient tonnes
  Local cereals - 111,000 nutrient tonnes

- Percentage of unirrigated area receiving NPK - 5 percent.

Table 7

Foodgrain Production
Low and High Metabolism Projections

	Units	1968/69	Low Metabolism 1973/74	Low Metabolism 1978/79	Low Metabolism 1983/84	High Metabolism 1973/74	High Metabolism 1978/79	High Metabolism 1983/84
1. Gross sown area	mil. acres	394.2	414.6	429.4	445.3	414.6	429.4	445.3
2. Allocated to: cereals	"	240.0	250.0	250.0	250.0	240.0	220.0	210.0
3. pulses	"	55.0	56.0	60.0	60.0	56.0	60.0	60.0
4. non-foodgrains	"	99.2	108.6	119.4	135.3	118.6	149.4	175.3
High Yielding Varieties - Irrigated cereals								
5. Gross area	"	21.0	40.0	70.0	90.0	60.0	95.0	110.0
6. Average NPK dosage	lbs/acre	70.0	77.0	90.0	110.0	100.0	125.0	150.0
7. Package response ratio	-	13.5	13.5	13.5	13.5	13.5	13.5	13.5
8. Package increase	lbs/acre	945	1040	1215	1485	1350	1688	2020
9. Basic yield	"	1300	1300	1300	1300	1300	1300	1300
10. HYV yield	"	2245	2340	2515	2785	2650	2988	3320
11. HYV production	mil. tons	21.4	42.6	80.0	113.9	72.3	129.0	166.0
Local varieties - irrigated								
12. Gross area	mil. acres	35.8	26.6	7.8	-	17.0	-	-
13. Average NPK dosage	lbs/acre	40.0	45.0	45.0	-	50.0	-	-
14. % area receiving NPK	-	70	85	85	-	90	-	-
15. Average NPK dosage - All area	lbs/acre	28.0	38.0	38.0	-	45.0	-	-
16. NPK response ratio	-	9	9	9	-	9	-	-
17. Increase due to fertilizer	lbs/acre	252	342	342	-	405	-	-
18. Basic cereal yield	"	1300	1300	1300	-	1300	-	-
19. Yield	"	1552	1642	1642	-	1705	-	-
20. Production	mil. tons	25.3	18.6	5.5	-	13.2	-	-

Table 7 (continued)

	Units	1968/69	Low Metabolism 1973/74	1978/79	1983/84	High Metabolism 1973/74	1978/79	1983/84
Unirrigated cereals								
21. Gross area	mil. acres	183.2	183.4	172.2	160.0	163.0	125.0	100.0
22. Average NPK	lbs/acre	20.0	25.0	30.0	35.0	25.0	30.0	35.0
23. % of area receiving NPK	-	22	30	30	30	30	30	30
24. Average NPK dosage - All area	lbs/acre	4.4	7.5	9.0	10.5	7.5	9.0	10.5
25. NPK response ratio	-	9	9	9	9	9	9	9
26. Increase due to NPK	lbs/acre	40	68	81	95	68	81	95
27. Basic cereal yield	"	450	475	500	525	475	500	525
28. Yield	"	490	543	581	620	543	581	620
29. Production	mil. tonnes	40.8	45.3	45.5	45.1	40.2	33.0	28.2
30. Total cereal production	"	86.5	106.5	131.0	159.0	125.7	162.0	194.2
31. Average cereal yield	lbs/acre	793	937	1153	1399	1153	1620	2034
Compound growth			3.4	4.2	3.9	7.8	7.0	4.7
Pulses								
32. Total production	mil. tonnes	11.3	12.1	13.6	14.3	12.7	14.3	15.0
33. Average yield	lbs/acre	450	475	500	525	500	525	550
Foodgrains								
34. Total production	mil. tonnes	97.8	118.6	144.6	173.3	138.5	176.3	209.2
35. Compound growth	%		3.9	4.0	3.7	7.2	4.9	3.5
36. Average yield	lbs/acre	737	852	1026	1230	1029	1385	1705
37. Compound growth	per cent	-	2.9	3.8	3.7	6.9	6.1	4.2

Previous Page Blank

In actual fact, there are probably diminishing returns to each factor considered separately which would be offset only by changes in technology (the average response curve is downward sloping), or increases in complementary factors. The optimal combinations of inputs would presumably be derived through economic decision making.

With knowledge of the possible demand projections in the preceding section, we feel that the "five per cent" rate is most probable, that the input assumptions are economically feasible and within supply possibilities, and that the input/output assumptions appear reasonable. Our further analysis will be based on this five percent aggregate foodgrain growth rate as a focus.

B. Cropping Pattern Changes[9/]

During the first half of this century, when technological change in agriculture was gradual if at all, Indian cropping patterns have adjusted to a long-term equilibrium so that only moderate improvements in income could be expected from changing the crop acreages within this traditional environment. Basically, this equilibrium was attained by cultivators who adjusted their relative acreage in response to relative price signals reflecting changing supply and demand. It is now generally accepted that Indian cultivators make these adjustments as rapidly as farmers in western countries. 10/

9/ Studies carried out in the Punjab by K.S. Mann (1967/1968) are one example of how this exercise might be undertaken with greater precision.

10/ In India, no less than many western countries, empirical evidence is accumulating in impressive amounts to indicate the operational economic function of prices. To cite some of the studies which are still relevant: Hopper (1965a) has demonstrated for one U.P. village that cultivators allocate resources rationally (in the economic sense) within the traditional context they know; R. Krishna (1963a) has calculated this for Punjab State; Randhawa (1963) has shown in an all-India linear programming analysis that only moderate improvements could be expected from changing crop acreages under the traditional agriculture; R. Krishna (1963b) has demonstrated that cultivators do adjust relative acreages to relative prices by documenting the rapid acceptance of new and better varieties of cotton in West Punjab; Falcon (1962, 1964), Stern (1962), Narain (1965), Venkataramanan (1958); Gupta and Maud (1962) and J. Krishna and Rao (196) have studied similar relative price/acreage response behavior in Punjab, U.P., West Bengal, and other Indian states; R. Krishna (1962a) has calculated the price responsiveness of producers in marketing their output; NCAER (1964)

The new technology has upset the previous equilibrium.

1. On the supply side, future yield increases of five to seven per cent annually in cereals - are likely while short-term prospects for technology in non-foodgrains promises little change from historical rates.

2. On the demand side, the income elasticities of demand for foodgrains are generally considerably lower than those for non-foodgrains.

In this sub-section we shall make use of the supply and demand foodgrain projections (including assumptions regarding technological change in foodgrains), review projections of foodgrain prices, briefly discuss possible changes in technology in non-foodgrains in order to determine the parameters of possible cropping pattern changes.

It should be noted that these calculations are all very rough - and should be considered as suggestive of more careful work which must be carried out.

(footnote 10/continued from the previous page)

and Krishnan (1965) have demonstrated that Indian consumers are price conscious in their purchasing decisions; and Cummings (1968a), Lele (1967, 1968b) and Kulkarni (1965) have shown for wheat, jowar, paddy, and groundnuts that the private market is an effective transmitter of signals during "normal" periods with regard to the correspondence of spatial and seasonal prices with transportation and storage costs. Furthermore, the "high" foodgrain prices generated by the two drought years, 1965-66 and 1966-67, had an undeniable influence on inducing cultivators to increase input use and adopt HYV especially wheat during the recent surge of new technology.

To quote Raj Krishna (1967a):

"It cannot be asserted that all farmers everywhere respond strongly to economic incentives. However, a growing volume of evidence shows that with a minimum degree of monetization and the development of transport a fairly large proportion of farmers do respond to them in some aspects of their behavior. It follows that while all necessary techno-organizational measures should be taken to increase the physical outputs obtainable from given inputs, these measures should be combined with economic policies designed to take advantage of the price responsiveness of supply and factor demand wherever it is positive. In many situations the rate of absorption of new knowledge and inputs may depend critically on the price and risk milieu."

1. Foodgrain Price Projections

a. Statistical relationships

The mechanism by which foodgrain prices either adjust to general supply and demand changes in India is not fully understood. Logic would lead one to believe that current prices are based primarily on current availability and that expected prices are based primarily on expected availability.

The problem with this seemingly logical conclusion is that the limited statistical evidence is inconclusive. Mellor and Dar (1967) have fitted price data to three variables; current year's supply-demand gap, previous year's supply-demand gap, and money supply. 11/ Their results suggest that the weight of the previous year's supply-demand gap is about four times heavier than this year's gap in influencing this year's prices. The economic implication of this result is that cultivators stocks serve as private buffers; that these stocks are adjusted to compensate for shortfalls or abundance in the current year but are brought back into some normal relationship during the second year. The statistical implication is that the reported data on "foodgrain availability" are not inclusive. Private stocks probably tide over production deficits and then are rebuilt from surpluses. There are no official data on private stocks by which to correct the production data in order to obtain a more accurate "availability" figure.

11/ $P_t = 41.48 + 0.56\ (D-S)_{t-1} + 2.25\ (D-S)_{t-2} + 2.06\ M_t$

$R^2 = 0.83$ where

P_t = price of foodgrains in first week of April of year (t).

D = estimated aggregate real demand for foodgrains for the year commencing July 1 (estimated from 1949-50 base plus population and income effects).

S = estimated aggregate supply of foodgrains for the year commencing July 1.

t-1 = the year commencing July 1 preceding April 1 of the year (t).

t-2 = the year commencing July 1 of the year preceding t-1.

M_t = total money supply in the first week of April of year (t).

On the other hand, there are at least three studies which suggest that the relationship between current prices and availability is more direct. Ray (1968) has fitted an equation to 1951-52 through 1967-68 data to current and lagged per capita availability. 12/ Joshi obtained a high correlation between current prices and the ratio of current per capita availability to money supply. 13/ An equation by Divatia and Pani (1968) also apparently weighs current production heavily as an explainer of current year prices. 14/

12/ $P_t = 87.63 - \underset{(27.43)}{242.86}\ A_t - \underset{(28.53)}{145.48}\ A_{t-1} + \underset{(0.41)}{5.69}\ I_t \qquad r^2 = 0.93$

where P = index of wholesale prices of foodgrains (calendar year),
A = per capita availability of foodgrains in quintals per year, and
I = index of per capita income at 1948-49 constant prices (fiscal year ending in t th calendar year).

13/ For foodgrains $Y = 18.3131 + \underset{(0.0798)}{0.5578}\ X$

$R^2 = 0.8029$

Where Y = Average Wholesale Price Index for the crop year July-June.
X = Ratio of money supply, as of 31 March, to availability during the succeeding year July-June (per cent).

For rice $Y = 20.8955 + \underset{(0.0312)}{0.5601}\ X$

$R^2 = 0.9671$

Where Y = Average Wholesale Price Index for the year November-October.
X = Ratio of money supply on 31 August to availability of rice during the succeeding year November-October (per cent).

14/ Divatia and Pani (1968) have fitted a number of combinations of independent variables to explain variations in cereal prices from 1951-52 to 1966-67. On the basis of expected sign and relatively low standard errors of the coefficients, they have chosen the following equation as having the best fit:

$$\log P_t = 0.64 - \underset{(0.44)}{0.35} \log S_t - \underset{(0.40)}{1.05} \log S_{t-1} + \underset{(1.60)}{1.41} \log (INA)_t + \underset{(0.74)}{0.16} \log (LNA)_t + \underset{(0.21)}{0.51} \log P_{t-1} \quad (r^2 = 0.950)$$

where P_t = Index Number of Wholesale Prices of Cereals, 1952-53 = 100

S_t = Index Numbers of Gross Availability of Cereals, 1950-51 = 100

(footnote to continue on next page....)

Similar problems also arise in the analysis of seasonal prices. For example, studies indicate that private traders do not appear to be more than moderately successful in anticipating the seasonal movements (Lele 1967; Cummings 1968a).

In summary, while the evidence is mixed, the foodgrain prices and availabilities do appear to be related in some manner; the problems most probably are found less with the concepts than with the date. 15/

(footnote 14/ continue from previous page)

$(INA)_t$ = Index Numbers of Incomes in Non-Agricultural Sector (at constant prices), 1950-51 = 100.

$(LNA)_t$ = Index Numbers of Total Monetary Resources (Total currency with Public + Net demand deposits + net time deposits excluding PL-480 funds), 1950-51 = 100.

They state:

"It would appear from the equations that current year's production (supply) does not affect current level of price as much as the production (supply) in the previous year. However, though the supply variable (S_{t-1}) relates to production in the agricultural year (July to June), the impact of marketing of rabi crop (in the period April to June) on the dependent price variable is reflected in the equations as the latter is an average of the monthly price indices of the fiscal year. The lower figure for the coefficient of current year's production can therefore be partly explained as only a part of the total production (kharif output) has an impact on the average price level the way it is calculated."

15/ Two areas of data do require particular attention: (1) improved information on inter-state movements and on private stocks and (2) development of price indices designed specifically for this particular analytical problem.

The functional form of the price/quantity relationship also requires further study. The variability in price is much greater than the variability in foodgrain production (and presumably also in availability). This suggests that a more complex exponential function rather than a simple linear form should be tested.

b. Projections of Future Prices

1) Levels

If there were minimum friction in the economy, the future level of foodgrain prices should be calculated by the following equation.

$$p = \frac{s - d}{E}$$

p = price level
s = percentage change in supply
d = percentage change in demand
E = price elasticity of demand

Assuming the Medium demand projection, where the percentage change in foodgrain demand is 3.5 per cent annually, and a price elasticity of demand for foodgrains of 0.5, 16/ then the "low metabolism", medium, and "high metabolism" foodgrain supply growth rates would give a range of price decreases from zero to three per cent annually. The "low metabolism" prices would be relatively steady over the whole 15 year period while the "high metabolism" path would suggest a fairly rapid (i.e., seven per cent annual) decrease during the Fourth Plan which would gradually stabilize to a relatively steady price level by the Sixth Plan when cropping patterns adjust. The medium growth path would result in a fairly gradual two to three per cent annual price decrease during the Fourth and Fifth Plans and a moderate decrease during the Sixth Plan.

Against this "logical" method of projecting prices, we have tested the projection usefulness of the three price equations by Mellor, Joshi, and Ray. Table 8 summarizes these projections based on the medium demand projection, the three alternative assumptions regarding supply, and two assumptions regarding growth in the money supply. The results of price projections over long periods of time with all three of these equations are puzzling.

As columns (2) and (3) show, if there were no change in the money supply, future foodgrain prices calculated by the Mellor and Joshi equations - given the medium supply and demand projections - would show

16/ T.N. Krishna, (1965) derived price elasticities of demand for foodgrains of -0.358 for rural and -0.0557 for urban population. The National Council of Applied Economic Research (1962) calculated a -0.32 elasticity (sig. at 5%) for foodgrains. If anything, 0.5 may be a bit high, thereby understating, the probable price decreases.

Table - 8

Price Projections

(Index numbers of wholesale prices of foodgrains; 1952-53 = 100)

	Medium Supply Projections				
	No M		6% M		
(1)	Mellor (2)	Joshi (3)	Mellor (4)	Joshi (5)	Ray (6)
1966-67 actual	200.7	178.5	200.7	178.5	178.5
1967-68 actual	204.4	222.8	204.4	222.8	222.8
1968-69	182.8	186.5	182.8	186.5	209.2
1973-74	183.8	148.4	223.9	192.4	221.9
1978-79	146.0	120.9	239.9	202.2	241.0
1983-84	125.8	102.1	291.6	219.2	347.4
	Low Metabolism				
1966-67 actual	200.7	178.5	200.7	178.5	178.5
1967-68 actual	204.4	222.8	204.4	222.8	222.8
1968-69	182.7	186.5	182.7	186.5	209.2
1973-74	188.0	161.8	228.2	210.3	273.4
1978-79	182.7	135.2	276.6	227.8	324.9
1983-84	180.8	115.9	346.6	251.5	458.6
	High Metabolism				
1966-67 actual	200.7	178.5	200.7	178.5	178.5
1967-68 actual	204.4	222.8	204.4	222.8	222.8
1968-69	182.7	186.5	182.7	186.7	209.2
1973-74	162.4	141.1	202.6	182.6	177.2
1978-79	122.3	114.0	216.2	189.7	188.0
1983-84	104.8	99.0	270.6	211.7	313.5

a steady decline. However, if we add back in growth in the money supply 17/ we project a rising price increase of about 3.2 per cent annually (from 1968-69 base) for the Mellor equation and 1.1 per cent annually for the Joshi formulation. The Ray equation projects an even more rapid price increase than the Mellor-Dar equation.

Basically, these results, lead us to the conclusion that the M (money supply) variable in the Mellor and Joshi equations serves as a proxy for other explanatory variables 18/ and that the weight on the per capita income variable in the Ray equation appears to be larger relative to the other variables than is reasonable 19/.

A second explanation for the apparently inconsistent results of projecting empirically derived price equations, is that there may be sufficient "friction" in the economy so that there is some built-in buoyancy to foodgrain prices.

A third explanation might be that these equations were fitted to a relatively slow supply and demand growth period while we are projecting into a period of more rapid change. In other words, there has been a structural break that also effects future price behavior.

17/ In this example we have assumed a 6 per cent increase in money supply which would be roughly consistent with past historical growth rates in money supply and future projected growth rates in national income (which are higher than past rates. This should be approximately what would be required to give a stable price level, other variables ceribus paribus.

18/ The money supply variable is included in both the Mellor-Dar and Joshi equations more because it "works" rather than because of satisfactory theoretical reasons.

19/ The implicit income elasticity of demand for foodgrains in the Ray equation exceeds 1.0.

Finally, there is the statistical possibility that some of the data, most particularly the price variable, are not accurate. 20/

In any case, we are faced with the conclusions that the empirically derived projections do not appear to be consistent with simple common sense projections. Obviously more work must be carried out to reconcile this problem.

In view of this situation, we are convinced that future prices will at worse maintain their present level if foodgrain production does grow at five per cent annually and, under very rapid production increases, experience steady declines.

2) Stability

Regarding the question of future price stability, similar mixed evidence is available.

1. The analysis by S.R. Sen suggests that price instability is proportion to the growth rate of agricultural production.

2. Louis Bean (1969) suggests that there are repetitive cycles in weather - i.e., that there will be periodic times of weather stability as well as instability. Significant trends in Indian rainfall have also been suggested by Blyn (1966) and Weaver (1967) (see Mellor, 1968a)

3. Minhas (1968) reports that analysis which will be reported in a forthcoming paper has shown that increasing levels of fertilization not only reduce inter-plot variation in yields during a particular year but also reduce the inter-year variation in mean yields. We assume this analysis has been confined to irrigated fields.

4. Presumably, future growth in irrigation coverage will tend to make production less sensitive to weather variations.

5. The development of a buffer stock - which will be discussed later in this section - should be able to smooth out some of the price fluctuations.

20/ I have begun some work to explore how faithfully the GOI index of wholesale foodgrains prices actually measure foodgrain price changes in the economy. My hunch is that these indices can be improved.

In sum, our guess would be that price instability in the future would be reduced but this, again, is a priority subject for careful study.

3. Technology in non-cereals

To my knowledge there are no dramatic breakthroughs in yield potential under farm conditions to report as yet in the non-cereals (Appendix I; India, 1969e)

1. Two new crops, soybeans and sugarbeet, are being tested and evaluated and may begin to fit significantly into cropping patterns during the next few years if processing and marketing problems are solved.

2. Some progress in selection of shorter duration pulses has been made.

3. Potato seed technology has shown significant improvement.

Therefore, we have decided to assume, for the time being, that the post-Independence rates of productivity change in non-cereals can be projected into the future (India, 1966a). These assumptions are summarized in Appendix M.

4. Projections of Cropping patterns and non-foodgrain Production

As a point of departure in order to begin to explore some of these implications, we have made one cropping pattern projection very roughly based on the five per cent foodgrain production growth rate, historical productivity growth rates in non-foodgrain, and the medium demand assumptions. 21/ (Appendix M) A key assumption to this exercise is that Indian cultivators, traders, and consumers do react

---

21/ One important point here is that we are assuming that non-foodgrain yields will increase at approximately the same rate as during the previous fifteen years. If there are technological changes in these crops also,the higher non-foodgrain yields would affect the rate and pattern of anticipated acreage changes.

to economic signals.22/

The cropping pattern projections are shown in Table 9, and the corresponding supply and demand results of this combination are shown in Table 10.

In summary, the results of this exercise are:

1. A slowly increasing cereals acreage but very large acreage shifts within the cereals from coarse grains to wheat and rice within wheat and rice, from local to high yielding varieties. The coarse cereals, such as millets and sorghum will be forced to the drier areas where they will be grown primarily for subsistence food or animal feed. Pulses will continue to scrounge for marginal acreage.

2. Sugar, oilseeds, and cotton - all with high income elasticities of demand but moderate recent yield increases - increase their relative acreage.

3. Yet overall, crop shifts are moderate.

This interpretation brings out an interesting point - that the growth in effective demand is a limiting and shaping force in future Indian agricultural development. The five per cent foodgrain growth rate provides more than sufficient foodgrains to satisfy demand at the rate of income growth which appears to be consistent with the five per cent foodgrain growth rate. The obvious ways to increase demand further would be through

1. increasing non-agricultural income growth,

2. changing spending (taste) patterns, or

3. redistributing income so that those in lower income brackets who have higher income elasticities of demand would purchase more.

Unless, one or the other of these changes takes place, a faster growth in foodgrain yields, e.g., that in "high metabolism" case, would lead to:

22/ Appendix N lists a summary of the estimated price elasticities of acreage of specified crops in India, pre and post Partition.

Table - 9

Projected - Acreage Allocations
First Exercise

(million acres)

Gross total acreage allocated to:	1952/53	1964/65	1967/68	1968/69	1973/74	1978/79	1983/84	% Change 52/53 to 64/65	% Change 68/69 to 83/84
Cereals	203.1	231.5	244.1	240.0	245.0	245.0	250.0	1.1	0.3
Rice - HYV	-	-	4.4	9.1	25.0	39.6	48.4	1.6	0.6
local	74.0	89.8	86.3	79.7	70.0	57.9	49.1		
Wheat - HYV	-	-	7.3	10.9	15.0	25.2	30.8	2.6	2.1
local	24.3	33.2	29.6	25.1	23.0	17.3	14.2		
Coarse - HYV	-	-	3.1	7.6	20.0	25.2	30.8	0.3	0.5
local	104.8	108.5	113.4	107.6	97.0	84.8	76.7		
Pulses	49.0	58.8	56.0	55.0	56.0	60.0	60.0	1.5	0.6
Foodgrains	252.2	290.3	300.1	295.0	301.0	305.0	310.0	1.2	0.3
Sugar	4.3	6.3	5.0	6.5	7.0	7.5	8.5	3.2	1.8
Oilseeds - 5 major	27.6	37.3	36.6	36.0	40.0	45.0	52.0	2.5	2.5
Cotton	15.7	20.4	19.9	22.0	25.0	28.5	31.5	2.2	2.4
Jute & Mesta & Sannhemp	2.3	3.4	3.4	3.4	3.4	3.4	3.4	3.3	0.0
Other		33.0	27.5	31.3	34.2	40.0	39.9	-	-
Total		390.7	392.5	394.5	414.6	429.4	445.3		
Gross irrigated acreage allocated to:									
Cereals		53.2	55.0	56.8	71.5	90.0	110.0		
Pulses		5.6	5.5	5.5	5.5	5.5	5.5		
Foodgrains		58.8	60.5	62.3	77.0	95.5	115.5		
Sugar		4.1	4.1	6.5	7.0	7.5	8.0		
Oilseeds - 5 major		1.2	2.0	2.0	4.0	6.0	8.0		
Cotton		3.1	4.0	4.0	5.0	6.0	7.0		
Other		10.0	15.9	15.6	20.0	20.0	18.5		
Total		77.2	86.5	90.4	113.0	135.0	157.0		

NOTE: See Annex.

Table 10

Supply and Demand Comparisons of "First Exercise" Cropping Pattern Projections

(million tons)

	Supply 1/				Demand 2/			
	1968/69	1973/74	1978/79	1983/84	1968/69	1973/74	1978/79	1983/84
Cereals	87.6	116.1	150.3	187.4				
Pulses	10.2	13.0	13.6	14.3				
Foodgrains	97.8	129.1	163.9	201.7	-	129.4	153.2	183.0
Sugar (Gur)		15.3	18.0	22.4	9.4	12.2	15.5	21.7
Oilseeds - 5 major		9.0	11.8	13.9	6.8	8.5	10.5	13.6
Cotton		7.8	10.2	12.2	6.3	8.2	10.5	14.3
Jute and Mesta		10.5	10.9	11.4	-	-	-	-

1/ Supply projections:

1. Medium Projections - Five Per Cent Rate.
2. Non-foodgrains:
   a. Acreage from
   b. Yield changes from

2/ Demand projections are medium projections

1. Some further cropping pattern shifts from what our initial exercise would indicate, but also,

2. A fall in prices of foodgrains which in turn would serve as a self-correcting brake on the rate of foodgrain production unless further increases in technological change and adoption were induced, and

3. As these acreage shifts proceed, the downward price pressures should eventually extend to all agricultural commodities at which point the economic development resource transfer from the agricultural to non-agricultural sectors working via the price system should begin to operate.

On the other hand, cropping pattern shifts under the "slow metabolism" path would be more gradual with foodgrain acreage probably even increasing. The cropping pattern would then more likely resemble post-Independence pattern.

A final point that should be mentioned is that new crops, particularly soybeans during the kharif and sugar beets during the rabi period, may begin to assume some importance although the degree is unknown.

C. Inter-regional and Inter-personal Development Implications

1. Regional Growth Rates[23/]

The New Strategy of Agricultural Development is, in effect, a strategy to more intensively exploit the complementarity among water, fertilizer and high-yielding varieites of seeds to the maximum. Supplementary efforts will be made concurrently to direct research toward the special problems of dry areas and of the small farmers.

In order to determine the implications of a five per cent growth rate on relative agricultural growth by states during the Fourth Plan we have, as a first approximation, assumed that the near term growth is distributed among the states in proportion of the irrigated acreage in each state to the total all-India irrigated area at the beginning of the Fourth Plan (B. Sen, 1969). A comparison of these projected state growth rates with the post-Independence growth rates is shown in Table 11.

23/ This section borrows extensively from the research of W.E.Hendrix (1969) and B. Sen (1969).

Table 11

Comparison of Post-Independence and Projected Fourth Plan (Preliminary) Agricultural Growth Rates by States - Annual Compound Rates

Zone/State	Post Independence 1952/53 to 1964/65		Fourth Plan	
	%	Rank	%	Rank
North				
Punjab	4.6	1	9.6	1
Rajasthan	2.7	8	8.4 1/	2
Uttar Pradesh	1.7	14	6.7	4
Himachal Pradesh	3.4	5	2.0	15
East 2/				
Assam	1.2	15	3.8	8
Bihar	3.0	6	4.9	7
Orissa	2.5	11	5.0	6
West Bengal	2.0	13	2.8	11
West				
Gujarat	4.5	2	3.1	10
Madhya Pradesh	2.5	10	2.1	14
Maharashtra	2.9	7	2.5	12
South 2/				
Andhra Pradesh	2.7	9	7.5	3
Kerala	2.3	12	2.2	13
Tamil Nadu	4.2	3	5.6	5
Mysore	3.5	4	3.2	9
All-India	3.0		5.0	

1/ This sharp increase is primarily the result of the recent opening of the Rajasthan Canal.

2/ There is a relatively large proportion of tank and canal irrigation in these areas. These sources are dependent on monsoons for replenishment and present difficult management problems to users.

Sources: Post-Independence rates: India, 1962a; Fourth Plan: B. Sen.

Two implications of this preliminary exercise are of immediate interest:

a. There is a slight reordering of the states with regard to growth rates with Rajasthan, Andhra Pradesh, Assam and Uttar Pradesh improving their relative positions the most,while Punjab and Madras are assumed to continue their previous high growth rates.

b. The spread in growth rates among states widens, agricultural production in Punjab (9.6), Rajasthan (8.4), Andhra Pradesh (7.5) and Uttar Pradesh (6.7) are all projected to grow more rapidly than 6 per cent per year while in four states, Himachal Pradesh (2.0), Madhya Pradesh (2.1), Kerala (2.2), Maharashtra (2.5) are all projected to grow at 2.5 per cent or less annually. The low growth-potential states should cause particular concern.

Several adjustments to this table would probably be made on a second round in order to account for:

1. availability of assured rainfall (which can substitute for irrigation) (Appendix H),

2. development of irrigation during Fourth Plan,

3. Fertilizer consumption growth (Appendix O),

4. quality of irrigation (i.e., tubewells as compared to tanks) (Appendix F),

5. past growth success, especially with HYV, and

6. soil characteristics (Section II-A)

These would lead to downward adjustments to Rajasthan, Orissa and Andhra and upward adjustments to Kerala, West Bengal and possibly Mysore. 24/

24/ One very interesting implication of these projections is that the growth rates of the high performance states (and districts within states) must be very high - higher than few developed countries have ever sustained - in order to offset the slow growth states if a five per cent growth is to be attained.

The pattern that appears to emerge over the next five to ten years is that the north, which has an abundance of groundwater potential yet to develop, will continue its rapid growth rate;first wheat production and then through more multiple cropping. Punjab/Haryana could perhaps even develop into a major rice producing area.

The east and south will begin to increase their growth rates as minor irrigation develops and the initial problems in paddy production are overcome. The western states appear to be the poorest endowed with groundwater availabilities and manageable soils. Unless there is concerted attention to minor irrigation development and encouragement of mechanization to work the black cotton soils, this area may become the lagging agricultural growth area in the future.

If we look further into the future, the new technology is so adaptable that the present geographical location of crops is no assurance of what future crop locations, hence of regional comparative advantage, will be (Russell and Brinegar, 1969). Presumably wheat cannot be grown in the north during the kharif nor in the south during any season, and rice and maize could not be grown during the rabi period in the north. Aside from these few climatic restrictions, the future map of agricultural crop location could theoretically vary anywhere between one extreme where every district is self-sufficient to another extreme where even greater geographical concentration is found than at present. As long as all-India markets are encouraged, the country will probably reallocate its crop location based on new comparative advantages and inter-state trade will increase as regional taste preferences adjust. Therefore, development of irrigation potential in combination with soil characteristics plus the supply of necessary inputs, particularly fertilizer and mechanization, will be even more important in determining future inter-state growth rate differences. This is a pattern which is subject to policy influence. 25/

25/ This is the reason for the primary objection to the present system of foodgrain zones. Zones create a patch work of disconnected markets which can be implemented and disassembled at will. The over-all production advantages which potentially result from regional specialization on the basis of comparative advantage are seriously interrupted. This becomes especially a problem during rapid technological change when cropping patterns must be free to reattain a new equilibrium (Cummings, 1967b).

It appears from this brief analysis that a narrowing of state-wise growth rates is not a feasible target to realistically set - especially without risking the possibility of a significant decline in overall growth rate which would probably accompany the radical redirection of resources required to narrow the relative state agricultural growth rates. Therefore, we will settle for a minimum agricultural growth rate for any state - and arbitrarily set this at 2.5 per cent annual increase in agricultural production for the lowest growth state.

2. Inter-personal income distribution[26/]

There are only two years of experience and little documentation as yet, but some evidence is accumulating regarding inter-personal income distribution. For convenience, we might divide the rural economic groups into the following categories:

1. large farmers,[27/]
2. small viable and potentially viable farmers,
3. small, low-potential farmers (who might also supply labor to larger farms),
4. tenants and rentiers, and
5. landless laborers.

26/ Martin Billings and Barbara Zinker of USAID are studying this problem and will develop more detailed papers on the basis of their analyses.

27/ How to measure a large or small farm has occupied an inordinate space in the literature (ISAE, 1968a) Martin Billings has suggested the following classification of the viability of farms by level of water assuredness(and thus, degree of risk) as follows:

	Irrigated (low risk)	Rain assured (medium risk)	Dry land (high risk)
	(expressed in acres)		
Typically viable	above 10	above 20	above 30
Potentially viable	2.5-10	5 - 10	10 - 30
Typically unviable	less than 2.5	less than 5	less than 10

There does appear to be a consensus that the HYV reduce the size level of farm necessary to be viable (India, 1969b)

With regard to size-holding the initial experience with the high yielding varieties has been somewhat different in the wheat and rice areas. The PEO study of wheat in 1967 (India, 1967e) reported that a "significant" portion of the non-participants had small holdings; but a sizeable portion of big cultivators, even in Punjab, had not adopted the new varieties. Problems, when cited, in order of frequency of mention were unavailability of water, inputs not available on time, failure to obtain short-term credit, and consumer preference for the local variety.

With regard to rice, Malone (1965) has observed on the basis of several hundred farmers in Tanjore district, Madras, that the first year of the program (1966/67) focused on larger and progressive farmers. This was continued in kharif 1967 but smaller farmers were beginning to participate in increasing numbers during this second year. 28/ The study indicated that compared to the larger cultivators, these small-farmer participants averaged:

1. higher yields,
2. more labor leading to more intensive cultivation,
3. less fertilizer,
4. higher cash profits (lower cash outlays primarily because they used family rather than hired labor), and
5. larger proportion of total cultivated foodgrain acreage in HYV.

Several generalizations regarding the distribution of gains by size-holding are suggested by this evidence:

1. There are no apparent physical economies of scale necessary in the adoption of the new technology. Water is the possible (and, if so, very important) exception to this assertion. Private tubewells have an average command area of 15-20 acres.29/. The tubewell can still pay-off rapidly at smaller acreages or the owner can sell surplus water. The use of water also requires a substantial investment in land shaping. There is a gap in mechanization requirements between the 5-10 acre size, which usually is

---

28/ Over 50% of holders of less than 5 acres in Thanjavur, Kaira, Birbhum and Sibsagar districts were participants (India, 1969b)

29/ There are however, over a million open wells which serve smaller areas. Many of these use persian wheels but can be operated by electric or diesel motor to increase pumping capacity. However, they are generally located at shallow depths and can be greatly affected when the water table lowers a few feet because of drought or heavy pumping in the vicinity. When this occurs, the wells can be deepened to make them less vulnerable to minor changes in the water table.

adequately handled by one team of bullocks, and the 25 acre size, which is the minimum holding to economically employ a 35-horse power tractor. Once a tractor is available, the potentialities for land shaping, multiple-cropping, power connection for threshing (which might also be run from the tubewell power), etc. are available. However, bullocks generally provide sufficient power for smaller-holdings; if more is needed, custom-servicing operations should be encouraged to provide these services to the smaller units.30/

2. The small-holders, who have the resources, particularly water, do participate. The smaller holders may, however, lag behind the larger cultivators by a season in order to have better knowledge of the risk involved.

3. Less desirable grain quality, i.e., the red color and poor chappati quality of the early dwarf wheats and the brittle, chalky, poor length girth ratio of IR-8, have influenced most cultivators to retain some minimum amount of land for growing the preferred local varieties.

30/ The "lumpiness" of investment for irrigation and mechanization is a significant factor for further study. In order to house the pumpset, the bore of a tubewell must be of at least minimum size. Proper irrigation requires capital investment in drilling, leveling, constructing channels, etc. Mechanical threshing is a prerequisite to multiple cropping. Furthermore because of the advantages of hydrolic systems, there is a substantial scale factor in tractors giving a jump between the small tillers and a 35 horsepower size. With a tubewell costing Rs.6-8,000 and a tractor Rs.20,000, some scale factor must enter. These problems are often compounded by the progressive replacement of bullocks which are necessary to carry out some tasks but become less fully employed as pumpsets and tractors appear, and because the maintenance and capital costs of bullocks are spread increasingly thinly, become a very expensive "luxury". In summary, agricultural progress builds in many self-reinforcing factors virtually requiring custom servicing as a prerequisite for survival of the smaller cultivator.

4. At the bottom of the heap are those cultivators who will not benefit and may not be viable under any economic conditions. 31/ Their solution can only be found in tenancy or in the labor, rural or urban market.

Once we move on to tenants, attached laborers on farms, and landless laborers, our evidence becomes even more sketchy:

1. Rents have risen, tenancy is still not an assured year-to-year occupation, and rented or tenancy holdings are better served to develop supplemental (to other holdings) income rather than permanent increase in standards of living, 32/

2. Attached laborers on farms are most probably being squeezed out if they begin to demand higher wages, 33/ This often represents the free choice of the persons who are attracted to better employment in the surrounding agro-industries.

3. Landless laborers apparently are experiencing mixed picture. Wages have gone up, especially during peak periods such as during rice transplanting, harvesting, and threshing and wheat harvesting. Prices have risen also during these past few years. The number of days worked annually has probably decreased in the rice areas because of population pressures; in the northwest India, such as western UP and Punjab, days worked have probably increased due to multiple cropping, greater harvests, and urban/industrial employment alternatives.

If we look to the future, certain broad income distribution implications might be anticipated. 34/ The faster the growth rate

---

31/ We attempted to classify viability by size-holding previously. Our minimum definition of viability would be sufficient production for home consumption to support adequate nutritional standards plus enough extra output to provide minimum cash needs of the cultivator and family.

32/ Wolf Ladejinsky of the IBRD has studied the land tenure problems for many years and has written several study papers.

33/ This is Martin Billings' personal observation in the field.

34/ At this point the tenativeness of this section must be re-emphasized. This is for discussion primarily and definitely not for quotation.

in foodgrain production increases, the faster foodgrain prices will fall, and as a result, the faster individual cultivators must shift cropping patterns and adopt new cost-reducing technology if they are to gain maximum profits.

1. Owner-operators who have sufficient resources, particularly irrigation and mechanization, will be in the best positions to adjust rapidly to changing conditions and bear the risks of year-to-year income fluctuations which might result from the rapid changes, sometimes into new technologies.

2. This puts the larger operators at some advantage over smaller holders, particularly if latter are over-extended in capital purchasers of tubewells or tractors based on minimum scale operations. The need to buy in - particularly larger cast outlays - makes the small-scale group more vulnerable. The smaller operators can minimize fixed costs, and therefore increase flexibility and adaptability, by making use of custom servicing operations. The small uneconomic holdings and dry farms below 10-15 acres in low rainfall areas would definitely be subsistence holdings.

3. Rents will continue to rise and tenancy is likely to become a decreasing practice except in the areas of marginal productivity or under arrangements of share-cropping.

   One potential result is that higher land prices may tempt marginal smaller holders, particularly those in desperate straits, to sell their land which could lead to more concentration of size holdings in larger sizes. This in turn would affect the fate of the following group, the landless laborers.

4. The fate of rural landless laborers is dependent on the trends in intensity in cropping on the one hand and the introduction of labor-replacing mechanization on the other. The rural population is increasing rapidly. The result could be either higher incomes and lower prices or an out-migration <u>if</u> the non-agricultural sector is also growing rapidly. 35//This is a very vulnerable group to the economic currents

---

35/ The agricultural labor force is often considered as the "residual" employer and is almost certain to increase for some time. Using the formula

$$z = \frac{x - ay}{1 - a}$$

where: z = rate of growth of agricultural labor force
x = rate of growth of the total labor force
y = rate of growth of non-agricultural labor force
a = per cent of population in non-agricultural employment

presently developing. Either rising wages or instability in the rural labor market or increasing farm sizes could stimulate the trend toward mechanization - which in turn could create even more labor demand if greater cropping intensity were followed. The second side of the picture is the continual "push" from high birth rates among the rural laboring class.

5. However, to the brighter side is the probability of declining food prices.

In summary, a polarized agriculture could result, as in the U.S, which would consist of larger, commercially-oriented cultivators on the one hand and smaller-scale, unirrigated subsistence cultivators on the other. The economic problem then inter-plays with the more subtle problems of caste, class, etc., suggested in the previous section by Srinivas (1968).

These directions are not inevitable, but are certainly not infeasible - they are possibilities. They can be influenced by policy. The changes in the rural income distribution and resultant adjustments have far-reaching implications to both input and output demands, and society at large.

Under these circumstances, target setting for inter-personal income distribution becomes quite difficult. Agriculture can export its poverty problem to the urban areas - but probably not unless urban incomes, even though low, exceed those in agriculture. Therefore, narrowing relative income differences within the agricultural sector does not appear to be a feasible goal; the more realistic target is to upgrade the standard of living of the low-end poverty within agriculture by some annual amount, i.e., perhaps by one to two per cent per capita income in real income. Even this small change, which would only be noticeable by comparing one generation with the next, is a very large goal.

D. Agricultural and Non-Agricultural Sector Relationships

As suggested in the earlier general section, this target is the most difficult to define in quantitative terms. In practice

---

35 (contd.)

and for India, assuming that x = 2½%, y = 4% and a = 25%, then agricultural labor force can be expected to grow at approximately 2 per cent per year. The non-agricultural sector is sufficiently large to absorb much of the increase in the agricultural labor force. However, if the non-agricultural sector were larger, e.g., if x and y were the same and a = 50%, then the rate of growth in agricultural employment would fall to 1% (Dovring, 1959, Mellor, 1966)

the task of resource mobilization and transfer will be carried out in subtle methods via price decreases as well as (as well as manifested in) the more observable forms of taxation and capital accumulation. The results of capital formation brought about by price decreases generally would be more visible in the non-agricultural, where the resulting profits would appear, than in the agricultural sector. Therefore, for the time being this target might best be defined in terms of some overall measure of capital formation for the entire economy.

The feasible components might be:

1. An increase in cost reducing capital formation in the agricultural sector alone of u percent annually;

2. A decline of agricultural prices of u percent annually;

3. An increase of agricultural taxes (or more to the point a decline of net government investment minus taxes) of w percent annually;

4. An increase in agricultural deposits in financial institutions of x percent annually;

5. An increase transfer of labor from the agricultural to the non-agricultural sector of y per cent annually; and

6. An increase in agricultural exports of z per cent annually.

These components could be added in some "best" combination to achieve the target rate of resource mobilization and transfer.

IV. TARGETS (SUMMARY) AND INSTRUMENTS (INTRODUCTION) - A TRANSITION

A. Targets (A Summary)

We have tentatively settled on the following four categories of targets:

1. A five per cent annual growth rate in aggregate agricultural production. A higher growth rate is probably desirable, especially in order to induce the cropping pattern changes necessary to improve human nutrition, to provide lower cost rate materials to industry, to encourage exports to greater potential, and to result in declining agricultural prices. The five per cent rate appears to be a feasible longer term prospect if adequate government support is given.

2. A minimum annual agricultural growth rate for any state of two per cent. A narrowing of the differences in inter-regional agricultural growth rates would be desirable. However, the high potential growth states promise to grow much more rapidly than the lower potential states. The two per cent rate is almost double the Post-Independence growth rate of the slowest growing state (Assam) and also higher than that achieved by two other states (Uttar Pradesh, West Bengal) between 1952-53 and 1964-65. A two and one half per cent minimum rate might be a politically more attractive target.

3. A minimum annual increase in per capita real income of one to two per cent in the low-end rural poverty group. A narrowing of inter-personal income differences would be desirable. The agricultural sector cannot be evaluated in isolation of the rest of the economy; transfer of the poverty problem to the non-agricultural sector is not a desirable total economic development target. A relative income target will be the more difficult, if not impossible, to achieve, the higher the aggregate growth rate that is generated.

4. An increase in the rate of capital formation in the total economy but as supplemented by examination of changes in such agriculturally identifiable components as agricultural capital formation, agricultural prices, taxes, labor transfer, deposits in financial institutions and exports. This target

is presently defined too generally to be of operational guidance. This reflects the undesirable state of information regarding rural resource mobilization and the interaction of the agricultural and non-agricultural sectors in the growth process.

These targets fall into two broad categories:

..... economic objectives which are considered necessary measures of achieving desired growth and development

..... political objectives which are considered necessary in order to hold the body politic together.

With a given level of resources, these objectives must be considered to be competing at least in part. We must have a better understanding of the interaction among the targets in the growth process. For example, we could almost certainly achieve perfect income distribution equality - but probably at a low or even negative aggregate growth rate - merely by an outright mass redistribution of resources or punitive wealth or income tax.

Secondly, we have discussed targets in terms of desirable and feasible criteria based on requirements. We assume benefits exceed costs relative to other target priorities at these levels. However, we have not gone beyond this point to evaluate, for example, the costs and benefits of setting a 7½ or 10 per cent agricultural growth rate as a target. It may be that our "terms of reference" are too conservative.

The obvious benefits of a faster growth rate would be:

..... increased possibility of obtaining nutrition norms by a wide range of the population

..... greater resource transfer from the agricultural to the non-agricultural sector via agricultural price decreases.

Intermediate between benefits and costs, would be the effects of falling agricultural prices depending upon whether

..... an incentive was created to induce further technological change, or

..... the price squeeze chokes off the incentive to expand output because the additional output is offset by declining prices resulting in only marginal income increases (if technological change is slow)

The difficult aspects of the higher agricultural growth rate are

..... the adjustment problems in terms of inter-personal dislocations and inter-regional growth rate differences will be widened, and

..... the investment costs for inputs, infrastructure, etc. will be increased.

This latter point brings us to ask to what extent - in the Indian economy - government policy can control the growth rate, equity, etc. In other words, to what degree is a "natural physical growth rhythm" built into the Indian economy and to what extent can we actually specify instrument/objective relationships.

B. Instruments (An Introduction)

The basic fact of Indian agricultural development is that the operational production and marketing decisions are made by millions of individual cultivators.

Coordination and order is brought to the individual decisions by:

..... The institutional, social, and political environments which have conditioned these cultivators in the past and which will shape their receptivity to new ideas in the future;

..... The economic environment reflecting changing forces of supply and demand expressed through the price system; and

..... Government policies and programs (instruments).

It is the government policy role focused to attain the objectives broadly defined in the previous section - either expressed directly through government participation or indirectly through providing an environment to influence private decisions - that we focus on in this section.

In this policy role, one would wish to be able to make specific recommendations regarding how much of one instrument relative to another should be used; a proper policy mix is important. However, we must admit that, at this time, we do not know that much about the agricultural sector in India; even if we did, Indian agriculture is changing so rapidly that by the time new data were accumulated and analyzed, they would be outdated. In fact, one of the primary objectives of LRAAA is to improve this information base. With these thoughts in mind, therefore, we shall attempt to lay out the major issues and cite the quantitative evidence which we know to exist.

For purposes of discussion, we have divided the policy packages (instruments) as influencing the following broad categories:

V. Input Availabilities

VI. Input and Output Distribution - Including Marketing, Storage, Transportation, and Rural Centering

VII. Prices, Taxes, Credit, and Administrative Measure which we might lump together under "Economic Policy"

VIII. Research and Technology

IX. Welfare of groups only normally marginally within economic matrix.

Without specifying a one-to-one relationship, we visualize generally that:

..... economic policy and improving input/output distribution permit the economy to get to the production function (as also infrastructure)

..... investment policy to increase input availability permits the economy to move up the production function

..... research, education, and extension would lead to an upward shift in the function, and

..... welfare policies would be directed toward seeing that those ordinarily outside the economic matrix participate in some of the gains.

One of the primary reasons for examining the problem in this manner is so that we can keep the growth policies separate from the welfare policies - while we consider both important, the trade-off from moving from one focus to another should enter into the decision-making process explicitly.

We have omitted a discussion of general economic policy - and its effect on agricultural development - because we do not have adequate time to develop this topic.

INSTRUMENTS

V. PRODUCTION INPUT REQUIREMENTS

The primary production inputs are fertilizer, water (irrigation), plant protection, energy, and seeds. Each of these are internal to the production function.

The output projections in section III were made from a synthetic production function based on arbitrary - although what appeared to be reasonable - input combinations. An implicit assumption in this technique is that there is perfect substitution among inputs and that there are constant returns to each input (as identified in certain packages) individually. The result is that several different combinations of inputs could produce a given output.

These assumptions may be fairly reasonable in the short-run, i.e., with the given amount of change which might be expected over one or two years. Even over the longer run, given certain technological changes, the assumptions might hold. But to use this technique for longer run planning purposes would require a careful and explicit specification of the nature of the technological changes required.

There have been several production function studies of agricultural growth during the pre-New Strategy period (R.Krishna, 1965a; C.H.H.Rao, 1965; India 1966d).1/ However, the new technology introduces a structural break in the production process. The past is not necessarily a very helpful guide to the future.

It is too early to expect adequate data to be available for very sophisticated analysis regarding the new production service. The surveys which are available (India, 1967d; India 1967e; India 1968g; ISAE, 1968b; India 1969b) suggest that input costs per acre of the HYV are much higher than for local varieties. We can assume from this that the marginal productivities of almost all factors, especially chemical fertilizers, irrigation, and mechanization, are higher than previously.2/ However, we cannot go much further than this - nor should we on the basis of the very preliminary information now available.

1/ Shukla (1965) develops a historical accounting of traditional forms of Capital in Indian agriculture before the introduction of the new technology.

2/ The basic economic rule determining level of input use is that each input will be used up to the point where marginal cost equals marginal return, i.e., up to that point where the marginal input still returns an incremental profit. Therefore, at the same level of output prices for HYV and local varieties, higher levels of input use would correspond to higher marginal productivities of these inputs for HYV is local varieties at comparable input levels.

Prices are determined largely outside the individual production but have a great influence on production decisions. We have assumed declining output prices - at least for foodgrains, assuming a five per cent or better growth rate is achieved - in the future. The increased yields may be somewhat offset by lower prices giving an increase in revenues which is less than proportionate to increases in productivity. However, we have projected a range of possible price movements - this in turn would indicate a range of possible derived input demands.

Therefore, in view of the need for further research to improve both methodology as well as information necessary to derive a production function for the new technology, we are forced to use the simple, but explicit, methodology which we developed in section III. Fertilizer and irrigation requirements can be estimated directly from the projections. The range of projections will be interpreted to derive a range of input requirements for these two inputs. We will discuss supply implications for the other inputs only in general terms. More specific point estimates may be derived later on the basis of more detailed economic analysis.

After we determine input demands, the policy question then is how to satisfy these demands, taking into consideration the range of public and private resources actually or potentially available.

A. Fertilizer

1. Demand

Fertilizer demand should continue to grow rapidly for two reasons:

..... dosage on all areas, whether high yielding varieties, local cereals, or non-cereals, is generally below optimal dosages.3/

..... the optimal dosages for HYV are at least double these for local varieties and the coming years will witness a large conversion of land from local to HYV.

3/We have assumed a 70 lb/acre NPK dosage on HYV for 1968-69 as compared to recommended dosages of 130-200 lbs/acre. These levels leave substantial room for exapnsion; for example based on nitrogen response data for Lerma Rojo wheat (Cummings, Herdt and Ray 1968):

(1) 70 lbs/acre dosage gives an average response of 22.88 and at a 3.5 to 1 fertilizer/foodgrain price ratio, a return of 554% on fertilizer. Even at the optimal dosage, the average return is 383% (but a higher total profit).

(2) Even if we double the fertilizer/foodgrain price ratio to account for falling foodgrain prices, the optimal N dosage falls from 127 lbs/acre only to 111 lbs/acre.

(3) A third factor which enters is that technological change will shift the response function outward (i.e., Figure 5).

We have not studied the fertilizer response data widely enough to know whether the very steeply falling marginal response curves which we have fitted for dwarf wheat - which imply that marginal changes in prices are not very important determinant of demand - appear to other foodgrains and to under lower-quality irrigated and rainfed conditions. A quick glance at some studies suggests caution - this will be the basis for future work.

A second factor which must be studied is the risk factor in growing HYV, most particularly water availability. Only private tubewells provide "assured" irrigation. Key irrigation timings for dwarf wheat have been identified in agronomic trials and the research is now being extended to other foodgrains.

Hopefully, a study proposed by the Indian Statistical Institute will give us more information in these areas (Minhas, 1968). A third factor, which we have not considered in this analysis, is the future trend in input prices. For example, such changes as the recent rapid changes in nitrogen technology (Sahota, 1965; Sahota, 1968) or the Rajasthan finds of rock phosphate could lead to declining fertilizer prices in India.

Fertilizer requirements for the three growth scenarios are given in Table 12. The method used in these estimates is unsatisfactory but explicit. The requirements for cereals are aggregated directly from Table 6 and 7.

One additional assumption must be noted in the calculations of fertilizer requirements. We have not made independent non-cereal supply projections with the detail that we have used for the cereals. Hopefully, more analytical attention in economics will be paid to these crops in the future. In order to be consistent with the technological assumptions and cropping pattern projections in section III, we have assumed that non-cereal fertilizer requirements are proportionate to the requirements for cereals and have arbitrarily increased the derived cereal fertilizer requirements by 40, 33 and 33 per cents respectively for the slow metabolism, medium and fast metabolism paths to account for non-cereal requirements.4/

$N:P_2O_5:K_2O$ can be assumed to be required in a 4:2:1 ratio which will mean an accelerated growth of P_2O_5 and K_2O consumption compared to present use (Appendix 0). This is a reasonable assumption since there are often sufficient natural deposits of P_2O_5 and K_2O in the soil to satisfy low level needs; however, as nitrogen dosage increases, the plants utilize correspondingly more of the other two elements and they must eventually be replaced.

These estimated requirements are based on actual consumption for the given production year. In order to have required amounts actually available for consumption, orders (whether for imports or domestic production) must be placed ahead of time, and fertilizer production during the year 1973-74 would, therefore, be based on the requirements in part for 1973-74 and in part for 1974-75 consumption.

Furthermore, additional amounts of fertilizer must be added to account for:

1. waste

2. inventory build-up - presumably in some proportion to requirements. If the distribution system were improved, inventory requirements would be reduced.

4/ We have discussed the basis for assuming that 75 per cent of total fertilizer was used on foodgrains during 1967-68 and 1968-69 in section I.

Table - 12

Fertilizer Requirements

	Base	Low Metabolism			Medium Metabolism			High Metabolism		
	1968/69	1973/74	1978/79	1983/84	1973/74	1978/79	1983/84	1973/74	1978/79	1983/84
HYV, irrigated	668	1400	2864	4500	1932	4091	6000	2727	5398	7500
Local, irrigated	456	459	135	-	440	-	-	348	-	-
Unirrigated	366	625	704	764	710	730	891	556	511	477
Total cereals	1490	2484	3703	5264	3082	4821	6891	3631	5909	7977
Non-cereals	492	994	1481	2106	1017	1591	2274	1198	1950	2632
Total requirement	1982	3478	5184	7370	4099	6412	9165	4829	7859	10609
Compound annual (%)	-	11.9	8.3	7.3	15.6	9.4	7.4	19.5	10.1	6.2
Average increase	-	299	341	437	423	463	551	569	606	550
Estimated supply	5378	4174	6221	8844	4919	7694	10998	5795	9431	12731
Average increase		359	410	525	508	555	661	683	727	660

The percentage waste will probably decrease as the proportion of domestic production to total supply increases. Arbitrarily, we might assign a five per cent figure to waste.5/ If we also arbitrarily assume that inventories (carry-over) must be four months supply and grow proportionately to consumption, then this would add another five to ten per cent to requirements. Finally since orders must be placed four to six months in advance in order to have adequate supply available at the beginning of the foodgrain production period, we must add another five to ten per cent (one half of the annual growth rate). These three adjustments would add approximately fifteen to twenty per cent to 1973-74 requirements or bring the total amount of fertilizer that must actually be produced - domestically or by imports - in 1973-74 (for medium projections) to somewhere between 4.7 and 5.0 million tons.

The fertilizer requirement derived from these projections is one of the more interesting results and deserves further study. The requirements are well below GOI targets based on a series of previous studies.6/ However, following qualifications should be noted:

..... Our results should be interpreted as requirements and not as demand. Although supply and demand were projected independently, the supply projections do assume a "reasonable" growth rate. In other words, our results say that 4.7 to 5.0 million tons of nutrients plus other assumed inputs are required to produce 129 million tons of foodgrains plus an assumed quantity of non-foodgrains. If prices and technology are sufficiently favorable, cultivators may demand more fertilizers to produce more foodgrains.

..... We have assumed a 13.5 to 1 fertilizer response ratio and have assumed this response to be maintained at increasingly higher dosages. Both the initial ratio and the assumed changes in technology should be carefully evaluated. We would submit however that an average response ratio of much below 13.5 to 1 would probably imply a marginal response of less than the fertilizer/foodgrain price ratio.

5/ GOI estimates are two per cent loss at port and approximately another one per cent additional loss to the cultivator.

6/ These previous studies are reviewed briefly in Annexure L. To these we should add Parikh 196 - and Brown 196, unfortunately neither of which have we had time to review.

..... We hold no brief for our non-foodgrain fertilizer demand figure and we are not aware of any satisfactory explicit treatment of this component (Donahue, 1966).

In sum, for the time being, we are satisfied with these results but invite challenge.7/

2. Supply

If these requirement figures are approximately correct, then India's foreign exchange requirements for fertilizer imports do not appear quite as menacing as often anticipated.8/

The GOI is trying to increase domestic production of fertilizer by construction of public sector plants and by grants of special concessions to investors in private sector plants. It has eight major government-owned plants in operation, four under construction and four in the planning stage. Private sector plants now in operation include three

---

7/ The Fertilizer Association of India is sponsoring what is expected to be a significantly more comprehensive study of fertilizer demand than previously carried out. This overall study will include individual research studies on:

1. optimal demand based on an econometric analysis of acreage patterns, irrigation availability, fertilizer response functions, and input/output prices on a disaggregated level carried out by the Indian Statistical Institute (Minhas, 1968).
2. factors influencing the actual level of use based on analysis of survey work carried out by the National Council of Applied Economic Research.
3. additional work on determinants of the actual rate of use based on analysis of several years of previous research carried out by the Institute of Agricultural Research Statistics; and
4. marketing and distribution based on analysis of survey work carried out by the Fertilizer Association of India.

The total study will take three years to complete but preliminary results may begin to appear in one to one and a half years.

8/ Annex Q gives USAID projections of expected domestic fertilizer production over the next five year period.

large units - Coromandel, Gujarat State Fertilizer and MCM's plant at Kotah plus a large number (30-40) of small units. In addition, as a result of major policy changes made by the GOI to encourage private foreign investment in fertilizer projects, two foreign companies (one U.S. and one British) are participating in the ownership and management of large fertilizer plants now under construction, and five other foreign firms are involved in fertilizer projects which have been issued letters of intent.

The government's attempts to create significant private sector N production will have an important effect by 1970-71 during which the private sector should produce 464,000 MT of N or 43% of the country's total production.

Evaluation of Indian efforts to attract private investors and responses to those efforts indicate two conclusions. First, the context - the combination of government attitudes and procedures, site locations, market potential, local partners, available financing and the opportunity to use fertilizer projects as entrees to attractive crude, ammonia and phosphoric acid supply contracts - is attractive enough to interest a reasonable number of prospective investors - eight collaborations involving major Western fertilizer producers have sought industrial licenses since January 1, 1967 and four had received licenses prior to that date. The Indian situation is also attractive enough to maintain the commitment of a high proportion of those investors once they have decided to apply for a license. Of the eleven propositions active in April 1969 nine continue active: one is in operation, two are under construction, three are completing engineering or financial arrangements and three are still negotiating with the government.

At the same time, it is now apparent that prior estimates of the time which it is reasonable to expect will be consumed between application to the government and beginning construction, even if conservative, have not been conservative enough. Different factors obviously affect different projects. To varying degrees, however, implementation of most projects is conditioned by two sets of difficult considerations: Indian economic and political sensitivities on the one hand, and on the other, the wide range of project raw materials, processes, products and locations which the private investor must sort through before committing itself to the $60-100 million investment required by a modern, Indian fertilizer plant.9/

9/ For an analytical discussion of plant location, see the study by Erlenkotter and Manne (1967).

The Government of India has a legitimate interest in many dimensions of fertilizer projects. It must provide the foreign exchange to service loans, pay profits and procure raw materials and spare parts.10/ It must locate and time-phase new refineries and public sector plants. It must administer systems designed to insure that plant equipment which can be procured in India will be procured in India. It must be in a position to take maximum advantage of bilateral trading agreements. It must worry about the fiscal consequences of financing plans and the economic consequences of private size and process decisions. It must worry about the concentration of private economic power and its own relationship to the states. And it must do all of this in a manner which in its concept will make it least vulnerable to political accountability, in and outside of Parliament.

Imports in the earlier years were restricted both on account of cultivators' requirements not keeping pace with the Plan targets and the difficult foreign exchange situation. Since 1966-67, however, foreign exchange has been released more liberally. Sizeable non-project loan assistance for import of fertilizers has enabled GOI to plan for substantial imports. The present position is that there are adequate stocks of all types of fertilizers available throughout most of the country. In the future, if the fertilizer supply and requirements projections in this paper are approximately accurate, domestic production will account for an increasing proportion of total fertilizer use.

B. Irrigation

Irrigation, which contributes to higher yields as well as enables multiple cropping, is a second input which clearly has high returns and continuing aggressive future demand.

The problem is summarized by Russell and Brinegar (1969) as follows:

"The basic strategy of water management for maximum agricultural production is to balance for the maximum length of time the supply of water available in the rooting zone with the evapotranspiration demands of the crop. Since the latter is largely a temperature dependent parameter, it exhibits pronounced seasonality in India and is markedly out of phase with the highly seasonal distribution of rainfall. Characteristically the water supply equals or exceeds crop demands during some or all of the monsoon season. For the remainder of the

---

10/ Fertilizer technology, particularly in the production of nitrogen has changed rapidly in recent years. For an analysis of the economics of these changes, see the papers by Foster and Wood (1967) and Erlenkotter and Manne (1967).

year however the evapotranspiration exceeds the precipitation. During the latter period the growing crop is dependent on soil moisture stored in the root zone. It is clear therefore that the capacity of the soil to store water and the depth to which plant roots can penetrate to exploit that reservoic are important factors influencing agricultural water management. When the amount of available water from incident rainfall that can be stored in the root zone is insufficient to meet crop needs, additional water in the form of irrigation is required."

The interaction of water with the other factors of production is extremely important in making efficient use of other inputs recommended for high yields. Modern water management takes into account the proper relationship between the water supply system, the kind of crops, the soil type, methods of cropping, drainage requirements, farm machinery, disease and pest control, fertilizer, climate, and related influences on food and fiber production.

In assessing future irrigation requirements, we must ask, "how much", "where", and "what kind".11/

The requirements derived in our medium projection run at an annual rate of four and one-half to five million acres. This is substantially above previous rates - but irrigation has higher pay-offs than previously. Related to these higher payoffs is our assumption that a substantial part of additional irrigated acreage will result from new multiple cropping.12/

The "where" is related to "how much"and "what kind". The data on undeveloped irrigation potential by states is given in Annex J. Major and medium irrigation are developed by public sources while minor irrigation development is carried out by private decisions.

There are several alternatives, certainly complementary in part, for future irrigation development policy:

11/ Marglin (1962) gives a general framework for water development analysis which provides a good starting point for policy planing. The Revelle Report (1964) is perhaps the most comprehensive published survey in this general framework for this part of the world

12/ As Annex K shows, multiple cropping on rainfed lands has been almost as high as that on irrigated areas in the past. This situation probably reflects both the quality of irrigation as well as economic incentives for more intensive water use.

1. Finishing off major development previously begun but decelerated during the recent tight resource period.[13]

To make any assessment of the desirability of changing the development of any or all of the decelerated projects or any other projects, information is needed on the costs and benefits for different schemes of development for each project, or, at least, for the projects in which different patterns are being considered.[14] In each case, the relevant question is whether additional or more rapid gains from accelerated completion justify the additional or more rapid incremental expenditure pattern required. Past expenditures are irrecoverable and therefore, irrelevant, though certainly the rate of return for incremental investment needed to finish a project should be much higher than for a complete new project. Gains must be measured in terms of additional actual utilization and net agricultural returns therefrom, not from potential alone. This might consider the gains in completed projects from additional investment to improve utilization. It may take several years beyond the two or so years for completion to achieve full utilization of potential - pay-off is more rapid compared to a new irrigation project but not so fast compared to other projects.

On the basis of past history, returns to major irrigation have been low.[15] The primary reasons fall into two main categories: (1) canal irrigation often is dependent upon rainfall which is not an assured source of water, and (2) the distribution has never been carried out satisfactorily to the cultivator level.

This distribution problem in irrigation cannot be discussed separately from supply as in the other input areas. Quite often the alternatives are discussed in terms of "intensive" vs. "extensive" strategies. A serious analysis of alternative distribution strategies is only just beginning to emerge.[16]

13/ A recent listing of the stage of completion of major irrigation projects is given in Annex R.

14/ These comments were written in another context by Don Erlenkotter.

15/ For a sample of these studies see K.N. Raj, 1960; Sovani and Rath, 1960; Anand, 1960; Agro-Economic Research Center, Madras, 1960; Epstein, 1962; Basu and Mukherjee, 1963; Sonachalam, 1963; and Anagal, 1969.

16/ For example, see Weaver, 1967 and 1968; and Anagol, 1969.

At this point, however, we should point out that this issue has special and added significance under the new technology. To quote from the observation of W. David Hopper (1969) after an extended survey of Asian agriculture:

> "The component singled out by the Survey Team as being perhaps the most critical element for the future of Asian agriculture was the degree to which cultivators can control the water available to their crops on their own individual fields. This conclusion does not reflect the Team's view alone, Asian farmers know it and wherever possible have invested personal capital in water lifting and spreading devices to provide better moisture control on their fields. But farmer action alone or with neighbours, cannot effect the construction of a system of ditches to remove excess water from river drainage areas, nor can it result in the building of a network of channels to bring water from canals and large reserviors to individual fields. These are tasks that must be undertaken by government.
>
> In much of the Region, irrigation is in the early stages of development. And of the older water systems, many are poorly maintained or managed. Again, the needs are obvious: the development of irrigation and drainage facilities where this can be done; the repair and better maintenance of works that are dilapidated; improved programmes of water management where these are needed. Not so obvious, however, is the need to alter the predominant pattern throughout Asia of flowing irrigation water from inlet channel to drainage outlet, field to field, down and across a terraced slope. Under this system of water delivery the farmer has little or no control over the moisture that comes to, or leaves his field, a condition that may have been marginally satisfactory for traditional agriculture but which is far from satisfactory for the sophisticated crop management required in modern intensive farming. Control at each field commanded by a major water system depends on the construction of a terminal network of interlocking supply channels and drains serving fields that have been levelled and shaped to permit a uniform water distribution to all their parts. Such networks are not cheap to build. But water control is the major barrier that Asian agriculture must hurdle if it is to fulfill its promise of abundance.

The return to an investment in farm water control at the terminal point of a properly designed irrigation system can be very high. It will not come alone from the increased yield of a single crop that obtained from precision irrigation and proper drainage, but far more from the capability it gives the cultivator to grow two or three crops per year. Water control at the farmer's field focuses attention on the yield per hectare per day, a concern that can be much more rewarding than the narrower stress on yield per hectare of a single crop."

2. Public Tubewells

Arguments pro and con would be as follows:[17/]

a. Presumably they can supply assured water at lower cost than smaller wells;

b. They are drilled deeper than private wells thereby less vulnerable to a lowering of the water table;

c. They would permit better overall management of available groundwater resources;

d. There is a scale problem in private tubewell development which basically means that the minimum size holding is approximately 10-20 acres (this should be taken as a very rough estimate for present) in order to justify investment unless surplus water can be sold. Public tubewells can give small-holders the advantages of assured water without having to invest the sunk costs of private wells; but

e. The distribution problems are similar to those - although in a microcosm - of canals and hence actual cost is generally considerably above potential.

3. Private Tubewell Development

Perhaps one of the clearest indications of the changing priorities in Indian agriculture is the increased attention to minor irrigation.

17/ The public vs. private tubewell development issue has received much greater attention in Pakistani development studies than in India (Mohammad, 1965; Gotsch, 1966). T.V. Moorti (1969) has put together some interesting data for Aligarh district U.P., which give some insights into this issue under Indian conditions. See also Burt, 1966.

The government has encouraged the private sector to produce pumpsets (diesel and electric). It is providing drilling units to punch down new wells. It is encouraging commercial banks to move into long-term rural loan activities necessary to help finance tubewell construction. Also very importantly, it is fostering a very ambitious rural electrification program.[18]

The reasons for the recent private tubewell boom are not difficult to determine:

a. They have a very short gestation period,
b. They provide assured water which is easily managed, leading to maximum yields and multiple cropping, and
c. As a result, they pay out under current conditions in two-three years.[19]

Given the fact that requirements are 4½ to 5 million gross acres per year, we should be able to find minimum cost schemes for meeting these targets by selecting an appropriate mix of project development schemes. Such factors as political constraints on minimum development rates for various projects and the desirability of tapping rural savings must eventually play a key role in this analysis.

18/ In 1951 only 1.5% of Indian villages had electric connections. By 1966-67 10% (61,000 out of 570,000) had been electrified. The target for 1971 is 110,000 villages (about 20%). In one state, Madras, over half the villages have electric power supplies. With this availability the electrification of pumpsets is now proceeding at an all-India estimated rate of about 140,000 annually. A measure of demand is that applications for electric connections are backlogged six months.

19/ A very interesting problem which appears in private tubewells development is the choice between diesel and electric power which in turn affects agro-industries and rural electrification. At present the choice is clearly toward electricity if it is available. The primary reason is the low cost of rural electricity which is heavily subsidized. Very preliminary estimates indicate that electricity rates may even be doubled - which would approach the breakeven distribution cost point - and still be competitive with diesel power. This is a complex problem which involves a broader look at electricity developmemt strategy, differential pricing (to handle peak load problems), and many related matters. Hopefully, some useful information on rural electrification pricing will be generated at the 1969 ISAE meetings during which one session will be focused on this topic.

In terms of investment, irrigation requirements would cover a multitude of activities such as well drilling, pumpsets, land shaping, and drainage. The assumed additional coverage for the medium projection runs at an annual rate of four and one-half to five million acres which, if we add half again that much to account for supplemental benefits and depreciation and assume a command area on a multiple-crop basis of about 25 acres for a 1/2 cusec well, means about 300,000 new wells per year. However, a large portion of multiple cropping will come on previously irrigated land. Some increment to irrigation will be from major and medium projections. So we are more realistically talking about 100-150,000 new wells per year. The demands for drilling rigs, pumpsets (the division between electric and diesel sets, as best we can tell, is largely a function of the availability and cost of rural electricity), electrical connections, fuel oil, pipe, etc. and the other capital inputs can be derived from these figures.

c. Plant Protection

As the HYV covers greater acreage the ecological balance (in the short-run at least) will shift as to provide ideal conditions for the growth of pests and diseases. The FAO reports that pesticides have replaced or rival fertilizers as the major input in value terms with the HYV now in use in South East Asia and the Far East (IR-8, TN-1, etc.). This experience suggests that plant protection may become a priority input second only to irrigation as the acreage under HYV increase.[20]

The government appears to recognize the need for a plant protection program and is making an effort to offset the threat to the new crops by obtaining large quantities of protection materials. The area treated with these materials has increased greatly, from 16 million acres in 1961 to 124 million acres in 1967-68. By 1971, it is hoped to be able to treat over 200 million acres annually. It is organizing spraying units, developing an aerial spray potential, encouraging the manufacture of hand applicators, and training personnel in methods of application. An early warning surveillance system has been set to spot attacks of pests and plant diseases.

20/ To quote Hopper (1968): "Large plant populations lead directly to greater insect populations, and provide an ideal environment for the spread of diseases. With traditional materials, systematic plant protection measures of prophylactic nature were only marginally profitable, if profitable at all. Relative to cost there seemed little to be gained by adding ten per cent to a 1,500 pound per acre yield. But a similar ten per cent on a 4,000 pound crop can pay for a comprehensive plant protection programme and leave a substantial and attractive residual."

Because of the low level of current use and the heterogeneity of the product, demand estimates for plant protection products and services would be hazardous. It would not be presumptuous, however, to predict that this will be a major future growth agro-industry in India.

d. Energy [21]

The traditional sources of energy in rural areas have been human labor and bullocks. These gradually have been supplemented by 50,000 tractors, several hundred thousand pumpsets, and an assortment of power driven implements.

The new technology will place additional demands on energy requirements. The HYV require careful preparation precise planting depths and fertilizer placement, frequent interculturing and irrigation, and mechanical threshers to thresh the higher yields.[22] The characteristics of shorter field duration and photo insensitivity of some of the HYV can be taken full advantage of though more timely operations. Finally, the dry lands can be more effectively brought into higher agricultural production most effectively through increased energy supply, particularly with regard to land preparation.

The technical argument for mechanization appears to be rather straight-forward.[23] India has one of the lowest horsepower per acre ratios in the world and also one of the lowest yields. Increases in manpower and bullocks will be gradual, therefore, mechanization must be encouraged. Budgeting studies indicate that mechanization does provide low cost power and proves to be profitable on viable economic size units (Pradhan: India 1967f;

21/ Bhattarcharjee gives a good basic review of the relevant issues.

22/ These requirements are determined from agronomic tests included in the all-India coordinated yield trials. The surveys of HYV (India, 1967d, 1967e, 1968g, and 1969b) show that there are actual increases in energy inputs by the cultivators. See also Billings and Singh (1969).

23/ Mechanization is drawing quite a bit of heat in the Pakistan development literature. The "straw man" article by an agricultural engineer was written by Giles (1967). In response, Bose and Clark (1968) and Kaneda (1969) have attempted to refute the argument. However, they use few figures and pose on "either - or" argument which has more pedantic than policy value.

Kahlon and Gill, 1967). Furthermore, the land released from growing fodder to feed draft bullocks can be used to grow other crops.

The counter argument is based on the present availability of both men and bullocks, the likely rates of increase of these sources of energy supply in the future,[24] and the presumably low social costs of labor in the Indian economy (see references in section on Socially Oriented Investments). Generally this argument is accompanied by technical studies which demonstrate large potential increases in power output from these traditional energy sources as a result of combination of numerous small innovations, i.e. such as a more efficient harness, which while when taken separately provide only marginal increases, when taken in combination can increase angery supply by as much as double present outputs. The policy recommendation is to encourage development and use of these various innovations.[25]

A comprehensive economic analysis would base evaluation on social costs and benefits. Energy units might be evaluated in terms of their contributions either to (1) increasing yields, (2) increasing cropping intensity, or (3) decreasing waste as opposed to the costs to society of labor replacement. What this means is that the big question for future expansion is government policy, which must weigh the foreign exchange and labor displacement implications (i.e., social costs and benefits) against the cultivator's demands (based on private costs and benefits). It is assumed that those machines which can be justified on the basis of increasing yields, increasing cropping intensity, or lowering losses while having minimum labor displacement will receive greatest encouragement.

24/ The fact that draft bullocks are a commercial proposition and that their rate of increase can be controlled are often overlooked. Between 1961 and 1966, the cattle population of India increased only 0.2 per cent as compared to a 2.2 per cent increase in total livestock (India, 1969f).

25/ Aside from the technical merits, this argument overlooks the basic fact that Indian cultivators do not readily adopt new practices which promise only marginal returns.

Three types of energization pumpsets, tractors, and combines, illustrate the issues in this analysis.

The pumpset enables a larger flow of water from a dug well than the bucket or Persian wheel method and can deliver water from much greater depths than the 25 to 30 foot unit of the traditional methods. Moreover, the replacement of men and bullocks of substituting pumpset for Persian wheel is more than made up for in terms of employment creation and extra production due to more intensive cropping as shown by this example in the Punjab provided by Martin Billings.

Water source	Crop Intensity	Av. man days for all crops per acre*	
		Pumping	All other activities
1. Rain	125%	-	21
2. Well (Persian wheel)	150%	19	39
3. Pump set 1/	200%	5	52
Net change 1-3	60%	+ 5	+31
Net change 2-3	33%	-14	+13

1/ A pump set typically discharges two-three times as much water as a Persian wheel, depending upon its size, with half the labor force.

* Man-day is equivalent to 8 hours.

On land formerly irrigated by Persian wheels (and growing local varieties) some net loss in labor demand is sustained by energization. However, with HYV of wheat and maize, the demand for labor from all other activities, and especially harvesting, is likely to increase. An educated guess is that total extra labor requirements per acre is on the order of 50% for these crops.

The mechanization of pumping and threshing will free farmers for activities with a high opportunity cost (most notably in October-November and April-May). Women and children are mainly employed in light work such as interculture, cotton picking, corn-cob extraction, millet ear removing and cane stripping. In South India, pumping has always required adult men only. Their opportunity costs too, are likely to be high.

The demand for tractors is rising faster than supply. Tractor production has risen from 1600 units in 1962 to about 11,500 expected in 1968. Future demand for such equipment is reflected by the estimated backlog of 20-30,000 orders. Tractors are not subsidized and their production is left to the private sector (although a public sector plan is under consideration). Government has actively encouraged production levels to increase and is promoting tractor mechanization where farmers are prepared to pay for it.26/

Again in this case further development of tractors appears to be a sound economic proposition. Presumably tractors provide better seed-bed preparation on all soils and are almost essential for adequate preparation of some of the heavier types such as the black cotton soils. The labor displacement can be offset through more intensive cropping; in some of the areas where labor pressures are most intense such as the delta paddy areas, tractors are not easily adaptable to the small, irregular fields which cover a significant proportion of the holdings. Furthermore, the tractor provides a portable power source which is available for a multitude of tasks from threshing to drainage pumping.

The two primary issues in tractor demand appear to be the size of unit and the actual quantity demanded. The economic size categories appear to fall into three categories: power tillers, 35-horsepower, and 50 horsepower and bigger.27/ The quantity of

---

26/ This represents a reversal from former policy which favored bullock implements.

27/ Apparently there is limited economic justification for a size between the power tiller and 35 horsepower. The primary reason is that the frame for a 35 hp. tractor costs little more than that for a 20 hp. unit but the larger motor is big enough to operate hydraulic system which opens wide opportunities for a wide range of implements. The 50 hp. unit might be necessary for some of the heavier soils in addition to providing power to operate a wider range of implement in sum, it would be a more versatile power unit.

tractors demanded is obviously well above the 12,000 per year which are currently being made available. The actual number would be a function of a series of variables including tractors price, output yields and prices distribution of size holdings[28] cropping instensity, credit availability and the development of custom servicing.

The combine presents a more difficult policy choice. Its obvious advantages lie in faster reaping and threshing. It does cut the straw into bhusa: These advantages would be substantially higher if multiple cropping would follow where previously it did not or if harvested crops were saved which otherwise would fall victim to monsoon rains. A second claimed advantage of the combine is that it reduces field losses during harvesting. The major disadvantage is the labor displacement which may not be offset by increased cropping intensity. This might be especially a problem in the paddy producing areas, less so in the wheat areas.[29]

Some mechanization of Indian agriculture is inevitable.[30] The production of diesel engines and electric motors have each increased at the rate of approximately 20% per year since 1960. Current annual production of irrigation pumps is estimated at 250,000 sets. Production of spray-motors for plant protection equipment have increased to about 30,000 annually from none in 1964. In the

---

28/ A team of bullocks can provide sufficient power for 5-10 acres depending on soil type and cropping intensity. The minimum economic size for a 35 hp. tractor is approximately 20-25 acres with 30-35 acres approaching a more optimal economic unit.

29/ Probably the ultimate threat for labor displacement would be the rice transplanter if an economically viable model is developed.

30/ Mechanization does account for a significant role in productive savings mechanization and investment generation in rural India which might otherwise go into hoards.

intensive wheat growing areas, more than 50% of the wheat is threshed by machine. An estimated 10,000 threshers have been produced and sold from the workshops in Ludhiana district (Punjab). The increased demand for agricultural machinery throughout India is stimulating investment and expansion of producing units.

The potential for custom servicing of mechanization requirements would appear to be an important agro-economic research need. The new technology will place an increasing premium of timely operations and full and efficient use of resources. Custom servicing would be a particularly promising means of enabling small cultivators to obtain necessary services for land shaping, plant protection, harvesting and threshing.

The probable difference between private net returns as compared to social net returns means that the government may decide to intervene in the market in order to control the pace and direction of mechanization. If this must be the case, then selective pricing, as excise taxes to those individuals who have the means to pay, would appear preferable to quantitative controls.

e. Seeds

Hybrid seeds and improved varieties are the basis of the new technology. However, it is an input area on which very little published research has appeared (Desai and Patel, 1968).

There is little to add here other than that much more research must be carried out if development of the seed industry is to proceed at a steady pace.

f. Concluding comments

Given the technology, the growth rate is a function of input consumption. Therefore, input availability is a primary growth rate determinant. However, in the absence of a production function fitted to the new agricultural conditions, we can only guess about the growth trade-off among factors, the returns to individual factors and to scale, the costs of too much of one input vs.

too little of another, the basis for choice among techniques (A.K.Sen, 1959) and the cost/benefit of various investments in agriculture vs. those in other sectors. As a general rule, with the possible exception of the very large fixed investments in the modern fertilizer plants, which do require some time phasing and careful location decisions (however, projections of domestic supply show little chance of overtaking even our conservative requirement figures), we would hazard a guess that aggressive expansion in all input areas should be encouraged.

Basically we are not dealing with an expensive technology but one with high pay-offs. Pricing projections will be discussed in a following section but at this time it is fair to say that so long as the agricultural economy is left reasonably unrestrained to adjust acreages to changing profit prospects, declining agricultural prices do not appear to pose a longterm constraint to aggressive input use. The agricultural sector is largely privately owned and private capital investments are perhaps one of the easiest means of tapping rural savings - transferring some of the gains of the New Technology to the non-agricultural sectors.[31]

If we do accept the conclusion that an aggressive expansion in production inputs development should be encouraged - and as we will argue in the following section, this policy would also require aggressive expansion and development of input distribution - the policy decision is then now to carry out this decision, i.e., whether public investment or encouragement of private initiative should be pursued. Needless to say, the fitting of a production function and cost/benefit studies to individual factors are priority research needs for input investment planning over the future.[32]

31/ To quote from results of a socio-economic survey conducted by Hindustan Lever to determine how disposable income from the new agricultural technology was spent in 1968-69 (Hindustan, 1968): "A generally similar pattern emerged. The first change was understandably more and better food, and in the four survey districts this took up about a sixth to a quarter of the additional cash income. The largest share in all districts, however, varying from 60 per cent in Junagadh to 25 per cent in Shahabad, was devoted to farm inputs - tubewells, pumping sets, fertilizers, new or better implements, hybrid seeds, grain storage, etc. and housing."

32/ One of the subjects selected for the 29th Annual Conference of the Indian Society of Agricultural Economics is "Capital Formation in Indian Agriculture" which would include estimates of regional changes, types of investment, sources of finance, future investment demands, and suggestions for future policy.

VI. DISTRIBUTION OF INPUTS AND OUTPUTS

Future development of the distribution system is at the same time undoubtedly one of the most important as well as one of the most difficult policy areas to project. Market development is an enabling investment, outside the production function of the cultivator, which importantly affects production decisions by:

1. enabling the delivery of inputs at the time, place, and quantity needed in order to permit full benefit of production technology to be utilized by the cultivator, and

2. enabling the cultivator to pass on the gains of his production activities at higher profits to himself but also at lowest prices to consumers.

From the previous sections, we have projections of the rapid expansion of input use and output supply which can be generated by the new technology. Therefore, it is obvious that the distribution system will be under mounting pressure to effectively fulfill its role. However, market development planning is complicated by the facts that:

1. The new technology will require fundamental organizational changes in the marketing system which involves large investments of fixed capital, and

2. Future regional cropping patterns and growth rates can only be approximately projected.

A complete look at this policy area includes examination of storage, transportation, and market planning for both inputs and outputs. We will begin with descriptions of the input and output marketing systems then discuss the issues in storage and transportation planning, the

concept of "rural centering" in market development planning, and finally make concluding comments.1/

1/ The following observation by Schultz (1968) on the timing of institutional reforms (for which he cites Hopper, 1968b) which he feels to be one of the four key unsettled economic problems for a research agenda is pertinent here:

> "The question here is the optimum sequence in undertaking such reforms. In planning for the modernization of Asian agriculture, there has been much controversy with regard to this issue. There is the view that major institutional reforms are a precondition and that these reforms are sources of considerable additional agricultural production. The small increases in production and weak dynamics associated with institutional reforms that have been undertaken would appear not to support this view. Nevertheless, the established institutions of traditional agriculture in Asia and elsewhere are not adequate in terms of economic efficiency once modernization is underway. Accordingly, the modernization process gives rise to a demand for institutional changes and the institutional lags can be observed. Therefore, in view of the agricultural dynamics in many parts of Asia brought about by the availability of new varieties, relatively cheap fertilizer and tubewells, I would advance the following hypotheses: (1) whereas Asian farmers have shown little interest in credit reforms, they will now demand a larger supply of credit including better terms than they have had; and they will demand legal authorization and technical assistance to help them organize cooperatives for this purpose, (2) They will demand changes in tenancy contracts including land reform, (3) They will cooperate among themselves to acquire tubewells and to undertake minor investments to improve the supply of water, (4) They will, also, use whatever political influence they have to induce the government to provide more and better large scale irrigation and drainage facilities. These are all testable propositions."

A. Distribution of Inputs[2/]

Perhaps the most striking observation regarding the informational basis for planning input market development is the absence of analytical economic studies of input marketing and even the small number of descriptive studies of this very important area.

For this reason - even though it may detract from the continuity of development in this annex - we will give brief descriptions of the marketing systems for four categories of inputs and hope that analytical studies necessary for future planning can be developed.

1. Fertilizer

In order to ensure equitable distribution of available supplies and uniform prices in the country GOI set up a Central Fertilizer Pool in 1944-45. The Pool took over, at agreed ex-factory prices, the entire indigenous production of straight nitrogenous fertilizers and imported both straight nitrogenous and complex fertilizers. Ammonium chloride, complex fertilizers and superphosphate produced in the country were and continue to be marketed by the manufacturers through private dealers and cooperatives. Potash imports are canalised through STC and sales effected through Indian Potash Supply Agency.

In the beginning when fertilizer consumption was low, cooperatives were the main agency for distribution. Out of nearly 61,000 fertilizer depots in 1964 as many as 47,000 were in the cooperative sector.

Problems exist at all levels of distribution in this system: unloading of ships, shortages of rail wagons, bottlenecks at inter-gauge transit points, storage, etc. However, even if these problems are solved, weakness in management at all levels of distribution is likely to remain a constraint upon the efficiency of fertilizer movement in the cooperative system for some time. For example, in north-west India only 16% of the cooperative retail outlets have full-time staff. Few persons at any level in the cooperative distribution system are trained in sales, retailing or marketing. Moreover, cooperatives do not provide sales incentives to their retail personnel either in the form of commission or recognition.

2/ Distribution of water was discussed in the previous section. Credit will be discussed in the following section on Economic Policies.

Although the cooperative system has coped reasonably well with the volume of fertilizers it has been called upon to move in the past, the rate of growth of the system will be a limiting factor on its ability to handle the much larger volumes envisioned over the coming years.

One important reform that is being carried out is to consolidate the cooperatives into units which are large enough to be economically viable and afford full-time, trained staffs. However, private distribution must assume an increasingly larger share of the distribution, and the industry is rapidly moving in this direction where not restrained by discriminatory licensing.

As the demand for fertilizers increased and it became necessary to push up their consumption to match the plan targets GOI suggested to the state governments that they allow private trade to supplement the cooperatives, wherever this was considered desirable in the interest of increased fertilizer use. The new fertilizer plants that came to be established also wanted to have freedom to appoint their own distributors - private as well as cooperative.

Therefore, with a view to attracting foreign capital and know-how for the fertilizer industry, GOI announced a liberalized policy in December 1965. According to it, new fertilizer plants (licensed before 31 December 1967) were promised complete freedom to price their products and sell them through agencies of their choice. The existing factories were also allowed marketing freedom in stages. While most of the state governments have fallen in line with the policy of GOI some of the state governments notably, Punjab, Haryana, Rajasthan, and Madhya Pradesh continue to favor employment of only the cooperative agency. Development of the private distribution system is a requisite to being able to handle the volumes to be moved during the future.

The present position is that all indigenous production, whether of straight or complex fertilizers, is marketed directly by the producers. The Central Fertilizer Pool now handles only the imported fertilizers. The imported quantities are, however, still very large. This situation is likely to continue for some more years. The Pool can thus effectively correct any imbalance in supplies in any part of the country.

Perhaps the greatest future need is for the development of an inventory reporting system which enables the government to know what is available at each place at each time. Such information in juxtaposition with expected needs, would greatly facilitate prompt and efficient allocation of fertilizers.

2. Seeds[3/]

Seeds are distributed (sold) to producers by government, cooperatives and private dealers, including farmer sales. Most of the improved varieties and hybrids move through government and cooperative channels since the varieties have been developed almost totally by government agencies. The National Seeds Corporation has the responsibility for the production and distribution of hybrids. Thus, hybrids generally move from the NSC through the State Departments of Agriculture which in turn makes sales to cooperatives and panchayats or directly to producers through their own seed stores. In Tamil Nadu, most of the seed trade is in the private sector; this, however, is not typical. The NSC is establishing retail stores and also marketing through private agents. Private sector seedsmen produce and market seed within the limits of their resources. Currently there are more than 125 fairly sizeable seed firms in India and the numbers are increasing. There are at least 28 prominent companies in Maharashtra state, 22 in Uttar Pradesh, and 14 in Rajasthan. The Central Government is officially supporting the growth of the private sector and is taking positive steps in support of this policy. It has encouraged the development of the India Crop Improvement Association and arranged participant training programs for private producers.

The supply of hybrid seed does not appear to be a problem, but certification, processing, storage, and distribution may become bottlenecks. The lack of trained personnel, inadequate processing equipment and storage facilities and limited marketing arrangements for increasing quantities of seed may collectively thwart the timely distribution of certified seed to producers. The states, hampered by the lack of personnel and facilities and enabling legislation, are responsible for seed production to achieve state targets and for local enforcement of standards and quality controls. Performance of the states has been variable; shortfalls and inadequacies to date have been covered generally by close, effective support of the National Seeds Corporation; however, current and future production requirements are likely to strain the NSC's capabilities. Much of the seed will be distributed through the cooperative system where the same problems will be encountered as for fertilizer.

3. Pesticides

The supply of pesticides in all states is arranged through private manufacturers or formulators. Many of the manufacturers/formulators have their own agents located in important cities and towns. In some

---

3/ See the study on hybrid bajra by D.K. Desai and D.A. Patel (1968) and the Report of the Seed Review Team (India, 1968j).

states like Mysore, Maharashtra, and Gujarat, the cooperatives are also given the agencies or dealerships of private manufacturers for distribution. These are arranged on the basis of tenders from the private suppliers. The distribution arrangement varies from state to state. For example, certain regional units of the Central Government sometimes arrange to supply chemicals to state departmental units and individual cultivators. In a few states, U.P., Punjab, Rajasthan and Orissa, arrangements exist for stocking chemicals at the state level. In Mysore, the State Marketing Society has undertaken the distribution of chemicals.

At the district level, the District Agriculture Officer (DAO) is an important agency for stocking pesticides. In nine states, arrangements exist for stocking chemicals at the district through the DAO. In Mysore, Bihar and Gujarat, private firms attend to this work at the district level. In U.P., the Plant Protection Service Centers hold stocks at the Regional level and have sub-centers at the district level.

At the village level, the Village Level Worker (VLW) is the most important agency for distribution of pesticides in at least six states. Village stocks are replenished from stocks at the block or district level at regular intervals according to seasonal needs. In at least five states there are no regular arrangements for village supply (Punjab, Bihar, Andhra Pradesh, Madras and Kerala). In these states, chemicals are obtained from outside the village with the help of the VLW and others. Generalizing, the pattern of distribution at the village level is as follows: In about half of the villages, pesticides are obtained through government agencies and the VLW; in about a fourth, village institutions such as the cooperatives and panchayats provide for distribution; in the remainder, manufacturers and private merchants provide the service.

In a recent move, the GOI removed subsidies from pesticide pricing. Concurrent with this has been increasing pressure on private producers to market their own products rather than depend primarily upon government efforts. As a result, the rate of growth in the distribution of pesticides levelled off during 1968-69. Future efforts must combine effective delivery with extension efforts to publicize use at the cultivator level. Once the distribution problems - which presently are a major bottleneck to demand - are overcome, consumption should pick up rapidly. Pesticide use is closely connected with mechanization so this makes for a natural transition to the next section.

4. Farm Machinery[4/]

Farm machinery is distributed through a mixed system. The private sector has the major responsibility for distribution and practically all of the manufacturing capacity. The Block Development Officers and cooperatives have phased out of machinery distribution except for the limited quantity of Grain-Fertilizer drills distributed by subsidies and some items of plant protection equipment. Agro-Industries Corporations have recently been set up to distribute and finance the sale of the imported tractors and locally made machinery implements. Agro-Industries Corporation also have a variety of other projects for equipment manufacturing and sales service under consideration.

Ninety-five per cent of the tractor production comes from four private-sector manufacturing units and is distributed through independent nation-wide systems of franchised dealers. These dealers often handle other agricultural inputs and services through their sales/service stores, but the bulk of their business is in the single item of agricultural tractors. A similar pattern of large scale manufacture and franchised dealers handle pumpsets and plant protection equipment.

Threshers, tractor implements and improved bullock implements are produced by many small scale units for local cash sale direct to the farmer. The small scale units have limited capital for seasonal inventory building, have limited design and production expertise, and undertake little or no demonstration or sales activity. While the advertised prices are very low, these units are not able to expand their markets or improve quality and often are not able to supply the seasonal peak markets. The typical small scale manufacturer has the capacity to produce 100-300 machines in the 3-4 month period prior to use of the machine and is set up to produce only 4-5 different items.

Many machine tool and other manufacturing units (in the wheat area) are now introducing agricultural machines to utilize their manufacturing plants. These units are having difficulty organizing a marketing network because of inexperience with consumer sales and with rural marketing. These difficulties are considered to be temporary and it appears that there will be many sources of machinery in the near future.

As production of tractors, pump engines, implements and spraying equipment increases, the need to improve sales and service facilities as well as organize production facilities, and train management becomes increasingly important. This system is also undergoing transition but promises to expand aggressively.

4/ John Balis and Tom Farley of USAID are attempting to carry out a survey of the farm machinery distribution system from raw material to consumer in order to identify alternative routes and recommend most effective combinations.

B. Output Marketing

Basically the output marketing system performs three major functions:

..... procures commodities from producers

..... distributes the given amount of procured commodity to consumers who did not produce it (but who produce other commodities and services instead) over time and space, and

..... provides signals of the supply-demand relationship of the production to be corrected by producers (and consumers) in the next period.

The Indian agricultural marketing system has proven sufficiently supple to cope with gradually increasing volumes of relatively predictable commodity composition. Generally, it has functioned reasonably well under normal production conditions.

From the past research, and keeping in mind the wide diversity of experience among states and crops, we know that:5/

1. Marketed surplus as a percentage of production varies from as low as 10-20 per cent for pulses and coarse cereals to over 90 per cent in some cash commodities like cotton or tobacco (India, 1963). The percentage for the same crop varies considerably from state to state; for example marketable surplus of wheat is 28 per cent in Uttar Pradesh and 44 per cent in Rajasthan.

2. Marketed surplus appears to be positively correlated with price (R.Krishna, 1962; Dandekar, 1964; Krishnan, 1965)6/ and with level of production (R. Krishna, 1965b). Methods of direct estimation of the price elasticity of marketed supply are confronted with difficult problems of definition of variables. R. Krishna, (1965b) used an indirect method by estimating the output elasticity directly and deriving the

---

5/ For a review of marketing research in particular crops see UPAU, 1969b for wheat; UPAU, 1969c for paddy; JNKVV, 1969 for oilseeds; and UPAU, 1969d for animal products.

6/ Mathur and Ezekiel (1961) concluded that marketed surplus was inversely correlated with price but their analysis was challenged by Dandekar (1964).

price elasticity (R. Krishna 1967c). Using the formula

$$e = bE_{MQ}$$

where e = price elasticity of marketed supply

b = price elasticity of output

E_{MQ} = output elasticity of market supply

The output elasticity of market supply of wheat was found to be between 1.04 and 1.6 (Krishna, 1965b). If the marginal price elasticity of output is 0.1 to 0.2, then the price elasticity of market supply would be between 0.104 and 0.32. The policy implication of these coefficients is "if output increases in response to any price increase, sales may be expected to increase more than proportionately with output; but if output falls for any reason, market supply will fall more than proportionately" (R. Krishna, 1967c). In other words, the food supply to urban markets fluctuates more than output.

3. Market arrivals follow a generally predictable seasonal pattern which can, however, change due to government policy or production estimates (Cummings, 1967a; India, 1959). For example, the first quarter of marketings for wheat accounts for between one half and three quarters of the eventual total for the year; the greatest variability from one quarter to the next is found in the final quarter.

4. Generally cultivators will market less-preferred, high yielding varieties and hold higher quality wheats for home consumption. Prices influence the decision of which type of foodgrain to market and which to consume (Cummings, 1967a; India, 1959).

5. Arrivals come to market in all manners from head load to lorries. Certain areas, such as the Punjab, have much higher proportion of production delivered by tractors and in bulk than other states such as West Bengal (Cummings, 1967a; Gill, 1969; Neal, et. al, 1965; Bhattacharjee, 1960; Jasdanwalla, 1966; C.H. Shah, 1965; Kahlon, 1968).

6. The role of intermediaries varies from almost no purchasing of wheat in Punjab to a very substantial portion of rice purchases in some parts of West Bengal. Such factors as presence of

regulation of markets, convenience of transportation, distance from market, and density of production influence this behavior (Cummings, 1967a; India, 1963).

7. Cultivators have some history of shifting from one market to another to take advantage of better prices. Factors which influence this behavior include commodity, quality of roads, distances of market, and type of transportation available (Bhattacharjee, 1960; Jasdanwalla, 1966; C.H. Shah, 1965).

8. The one cross-section study of marketed surplus indicates that marketed surplus by size-holding exhibits a U-shaped behavior; the highest percentages are by very small holders, presumably caused by "distress sales" (although there was no check on whether these cultivators later repurchased foodgrains after financial pressures were relieved), and larger holders, responding to economic incentives (Narain, 1961).

9. Generally, internal market operations have been adequate to effectively handle the volumes delivered. Regulation is perhaps the most effective means of ensuring fair treatment (Cummings, 1967a; Lele, 1968; Mathur and Kulkarni, 1965).

10. During normal periods there is effective spatial and temporal distribution as measured by correspondence of spatial prices with movement costs (Cummings, 1967a; Lele, 1967; Herrman, 1966; Kulkarni, 1965; Chaudhri, 1961; Lakshmanan, 1967; Singh, 1965; Lele, 1968) and seasonal prices with holding costs (Cummings, 1967a; Lele, 1967, Herrman, 1966; Venkataramanan, 1965; Kahlon, 1968; Lele, 1968).

11. Government intervention is justified to supplement private market operation but more often than not in the past, has been of an *ad hoc* nature which has had an unsettling effect on future market development (Cummings, 1967a; India, 1959).

The conditions and demands on the system have now changed. The 1967-68 wheat crop gives one example (Gill, 1969). Production was 20-30 per cent above previous records, red wheat was marketed in areas where the amber varieties are highly preferred. The government entered the market as the major purchaser carrying out a price support program in cooperation with cooperatives and private traders. The Punjab markets were swamped. In some markets operations almost came to standstill

because of the accumulation of bagged wheat. Over 100,000 bags were stored in the open market yard at Khanna mandi alone. Grain was stored under tarps and in schools. It was all under cover when the monsoons arrived - but the marketing system must change if this scene is to be avoided in the future.

The 1967 and 1968 ADT-27 rice crops in Tanjore are a second example of need for change. The ADT-27 crop, a short-duration variety, which enables double-cropping of the Tanjore delta, is harvested during the height of north-east monsoon. This variety has no dormancy period - that is, it will sprout within 24-48 hours of harvest unless dried. The traditional methods of drying under the sun on available roads, etc. therefore, had to be supplemented by artificial driers. Thirty new driers were put up in 1967 in Tanjore district to handle this problem.

Other types of problems are also emerging. For example, the absence of a processing industry is one of the major factors holding up the spread of soybeans and sugar beets. Dairying is another activity whose expansion depends on marketing development (Nightingale, 1969).

These changing marketing conditions will spread to other crops as technology takes hold or acreages increase rapidly. The question that must be asked now is where will the future bottlenecks - whether dealing with market operations or economic incentives - appear and what can be done to see that they do not interfere with the orderly flow of production to consumers.7/

This is a question of major importance on which only limited research and planning - whether by government or private industry - has been carried out.8/

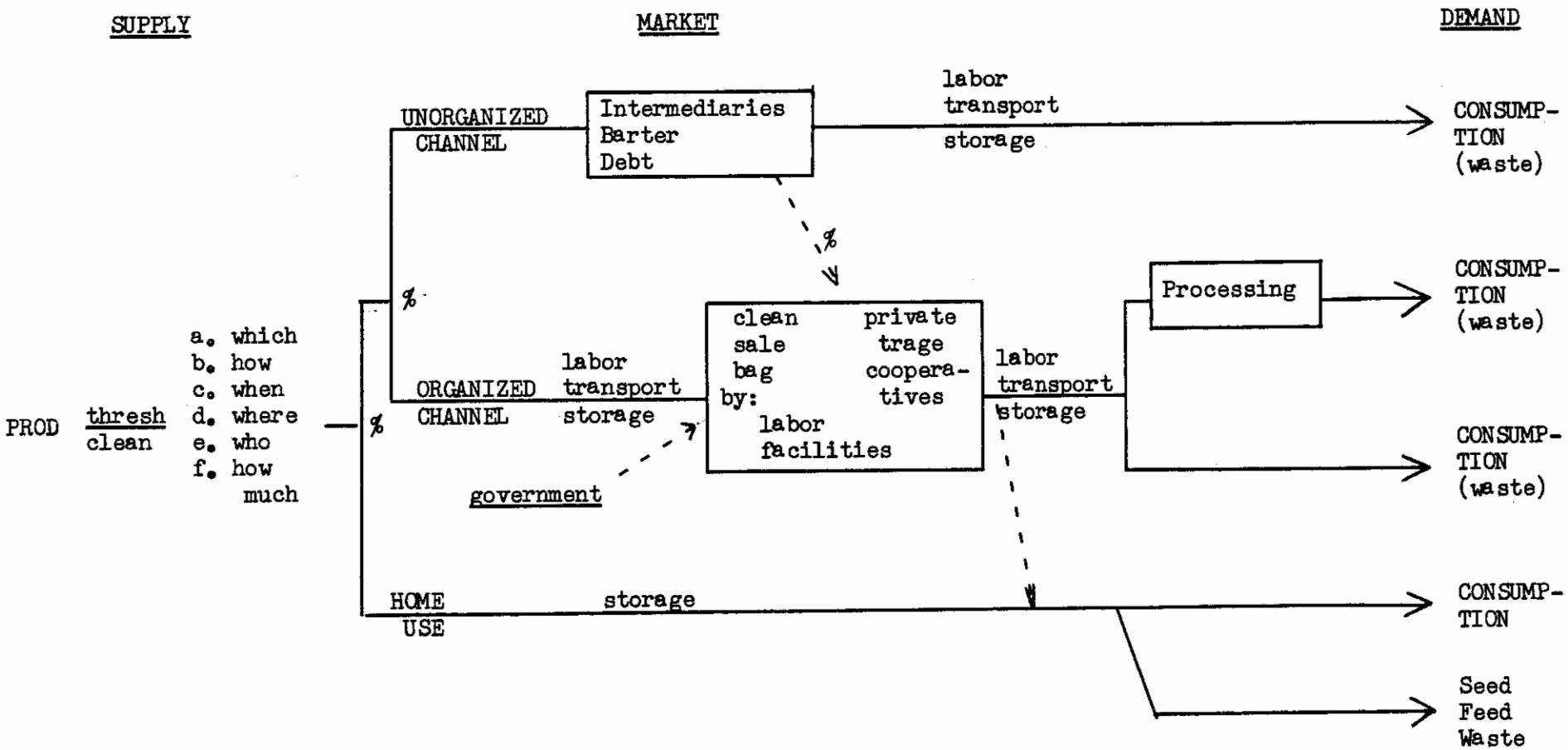
7/ One can be more specific for wheat: In 10-15 years, India will have bulk handling and all-India grading. Now it has bag handling and private grading. How does it get from the present to the future?

8/ Figure 6 presents a flow diagram of the marketing process by which to organize such a study. The basic question to be asked could be: if we project increasing volumes of agricultural commodities through the present marketing structure, where would bottlenecks appear? For example, for wheat, one would estimate how the pattern of marketed surplus would change, what the dimensions of the demands on the organized channels would be and what changes (i.e., cleaning and stacking in the market yard) need to be made in the short and longer run to adjust to these new demands. However, the short-run changes must be made within a longer-run context in order to avoid building practices which, once adopted, would interfere with handling double the volume presently handled.

continued

F-134A

Figure 6
THE MARKETING SYSTEM - FLOW DIAGRAM



C. Transportation and Storage

Two major infrastructure investment categories directly affecting distribution are transportation and storage. The characteristics of transportation and of public storage which separate them from most categories previously discussed are the external economies inherent in their development.

1. Transportation

The following broad view of the Indian transportation system taken from the Summary of the Final Report of the Committee on Transport Policy and Coordination (India, 1966f) gives the dimensions of the Indian transportation system:

"The internal transport system of India is a vast and complex network comprising 36,000 miles of railways, 470,000 miles of roads, 8,438 miles of inland waterways in addition to coastal shipping along the 3,125 miles coastline of India and an air traffic network connecting 69 cities and towns in the country.

* The government-owned railways dominate the transport system carrying about 80 per cent of all goods traffic and 50 per cent of the passenger traffic in the country.

* Mechanized road transport comes next in importance to railways and carries annually a goods traffic of 19 billion tonne miles and a passenger traffic of 48 billion passenger miles, compared with 67 billion and 59 billion respectively for the railways. The public sector accounts for close on two thirds of the road passenger transport but the operation of goods transport by road is entirely in the hands of the private sector except in the states of Jammu and Kashmir and Himachal Pradesh. This is easily the fastest expanding mode of transport currently, having grown 465 per cent in terms of goods traffic and 230 per cent in terms of passenger traffic over the 1950-51 levels; the corresponding figures for the railways are 142 per cent and 41 per cent.

Public procurement and distribution programs which are complementary to private trade operations, but which force reforms, might hasten this transition. The paddy drying plants put up by the FCI in Tanjore during 1967-68 are one example. The very large volumes of wheat in the Punjab provide another opportunity perhaps even encouraging some functions (such as cleaning and assembling) to be carried out in the villages then delivering to market in larger lots. The incentives for on-farm scientific storage suggested earlier are a third possibility (Cummings, 1968b).

Previous Page Blank

* Some 12 million bullock carts in the countryside still account for the greater proportion of the local traffic in and around the rural market centres.

* Inland water transport is most important in the north-eastern region where it accounts for 40 per cent of all traffic. It is of importance also in the regional economy of Kerala, and offers considerable potential for development in Goa, Maharashtra, Gujarat, Orissa, West Bengal, Andhra Pradesh and Madras.

* Coastal shipping, predominantly in the hands of private companies, is mainly employed in the bulk movement of coal, cement, oil, salt and foodgrains.

* The seven major ports and the 170 or so intermediate and minor ports in the country between them handled 57 million tonnes of cargo in 1964-65, twice as much as in 1950-51; much of the expansion in traffic has been in petroleum products, machinery, fertilizer and foodgrains.

* Internal air traffic in both goods and passengers has more than doubled since the nationalization of air services in 1953. External air services, operated under a separate management, have expanded almost eight-fold.

The three five-year plans have devoted Rs.4,243 crores - 20 per cent of their total investment outlay - to investment on transport. These investments have augmented considerably the capacities of rail, road and other transport media, but transport demands have generally been growing faster. During the middle of the First Plan period and again in the closing years of the Second Plan, the imbalances between demands and available capacities for transport developed to crisis proportions, tending to reflect adversely on developmental efforts in the industrial and mining sectors.

Coexistent with the general shortage of transport capacity has been the phenomenon of close competition between railways and mechanized road transport for long-distance movement of higher-valued commodities. Over the years, road transport has attracted to itself an increasing proportion of the traffic in these higher-priced items on which the railways depend for the bulk of their freight earnings. In passenger traffic too, the railways have been yielding to competition from road transport

on secondary routes for short and medium distances. Increasingly, resort has been taken to the taxation and regulation of road transport to protect the revenue position of the railways.

Altogether, in recent years, transport requirements have been observed to grow faster than economic activity at large and this trend will continue in the context of the growth and greater urbanization of population and commercialization of economic activity. Development of transport to meet these demands will entail heavy and long-range investment, much of it devoted to creation of basic facilities such as railway tracks, roads, ports, air terminals, ship repairing yards, ect. If waste of resources is to be avoided, and bottlenecks in some sections and spare capacities in others are not to develop, an over-all view has to be taken of the transport system. The various modes of transport should be developed as complementary services and effectively coordinated to function as an integrated network. Also, efforts need to be made to build into the transport system a measure of flexibility and responsiveness to unanticipated changes in demands for transportation arising from short-term shifts in production."

The importance of the transportation system both for getting inputs from industry to cultivators and outputs from cultivators to consumers has been the subject of some research already. The availability and quality of transportation is positively correlated with:

1. rate of adoption (Fliegel, et al, 1968)

2. level of input use (Fliegel, et al, 1968)

3. percentage of land in cash crops and vegetables (Jasdanwalla, 1966; C.H. Shah, 1965)

4. proportion of marketed surplus (Jasdanwalla, 1966, C.H. Shah, 1965)

5. spatial and temporal market integration (Cummings, 1967a; Lele, 1967)

However, there appears to be very little literature available on transportation planning, particularly with regard to Indian agricultural

development.9/ We would suggest that the first step is to establish the nature of the need, for example, where and how much farm-to-market and market-to-market roads need to be constructed. There is some school of thought which argues that if the former do have economic justification, they will be built by the villagers themselves. At first blush, this rationale has considerable merit although the cooperative ability of villages to organize is an implicit assumption that must be tested. There are situations, however, such as parts of central India which require high bunding or delta areas such as in West Bengal where there is need to collect jute quickly in order to effectively process it to export quality. The marketing of highly perishable fruits and vegetables is a similar situation.

The growing volume of inputs and outputs will require large expansion of mileage and quality of market-to-market transportation. Market-to-market roads or rails are clearly a government responsibility. At this point, the second step of deciding the alternative means, i.e., road or rail, to establish these linkages must be analyzed.

In essence what we rapidly conclude is that transportation for agriculture is integrally bound up with overall economic development and must be evaluated accordingly. As such it becomes subject of cost/benefit studies in order that these public investments can be weighed against competing financial needs.

2. Storage

Storage investment planning is in better shape. Storage serves as an intermediate stage between production and consumption of outputs or inputs. Since input consumption and output availability are concentrated at very specific points in time, adequate storage helps ensure that inputs and outputs are available at time, place, and quantity needed and that seasonal price fluctuations are moderated.

While there is often a tendency to do so, storage requirements cannot be analyzed as a homogeneous investment. Higher quality construction is needed for foodgrains than for fertilizers and pesticides and foodgrains cannot be stored in the same facilities because of the danger in contaminating the foodgrains.

9/ The review by Wharton (1968) gives a brief listing of studies in other countries. Studies of farm to market flows have been made by Gill (1966), Lakshmanan (1966) and Neale, et al (1965). Lakshmanan (1967) has made studies of inter-state movements.

Two commodities, fertilizer and foodgrains, dominate, the storage scene. In both cases, both public and private investments are involved.

Fertilizer storage is required by the fact that domestic production and imports (because of port capacities) run smoothly over the year while use is concentrated primarily at sowing time or in two fairly concentrated doses during the year. If fertilizer is not at the time, place, and quantity needed, it will not be used. Furthermore, a large portion of the public stocks are still arriving via imports. Unless adequate public storage is available, there may be a tendency to dump the public fertilizer even during tight markets thereby creating difficult competition for private distribution.10/

Assuming that approximately four to five million nutrient tons of NPK will be required in 1973-74 and that these nutrients are distributed in 40-50% mixtures, then approximately 10 million bulk tonnes will be moving through the system in five years. Approximately two-thirds of this must be available at the beginning of the kharif season which means five to seven million tons of some sort of cover must be available for stocking. Cultivators will purchase supplies before the season, so a substantial portion of this will be under the roofs of cultivators. Furthermore, fertilizer storage need that be of highest quality, primarily enough cover to keep out moisture, so costs are lower than for a ton of foodgrains. Still the magnitude is great and needs to be evaluated in the context of a transportation model.

Public foodgrain storage must be built for buffer stocks and welfare distribution.

It was estimated that (Cummings, 1968b):

a. the basic public distribution would approximate seven million tonnes per year,

b. the upper level of buffer stocks would be seven million tonnes.

If foodgrain availability were low, buffer would be drawn down but distribution would increase (and the opposite when foodgrain availability were high). Therefore, somewhere on the initial order of 14 million tonnes of foodgrains would pass through storage during the course of a year.

10/ This competition may actually be the best means of forcing private producers to aggressively market their material - but there are probably other more compatible means to accomplish this.

Eventually, approximately two-thirds of storage needs would come from kharif harvest and one-third from rabi. A normal seasonal pattern distributes about one-half to two-thirds of arrivals during the first quarter after harvest with the remaining third to half coming to market during the remaining nine months. Procurement would focus on the peak marketing period (when prices are also generally lowest) and possibly during the final months of the marketing season if prospects for the succeeding crop are bright. The pattern of purchases would change somewhat from year-to-year depending on the relative success of rabi and kharif crops and the distribution needs.

Taking into account the seasonal bunching of procurement and the expected friction in distribution, a preliminary estimate of total public storage requirements for distribution and buffer stocks would be approximately ten million tonnes.11/ The quantity and location of public storage is given in Table 13. A vigorous storage building program is indicated.

At present approximately two-thirds of public storage is located in the five states of Andhra, Gujarat, Tamil Nadu, Maharashtra, and West Bengal where the major ports are located. This location was dictated by the previous dependence on PL 480 imports.

Under the buffer stock operation, supply will shift from imports to domestic procurement and distribution will focus on low income and price stabilization programs. The total volume of storage must increase and the important question is where to locate the new storage.

If the storage is located in the producing areas, procured stocks can be rapidly put into weather, insect, and rodent-protected godowns in quick response to favorable procurement prices (i.e., lower market prices). More importantly, procurement-centered storage location introduces flexibility in the system (reducing intermediate storage) to move grain in one move to the point where it will be consumed. The disadvantage of rural located storage is that the reaction time to get grain to urban areas in response to sharply rising prices is lengthened. However, if the rural-located storage is on good transport facilities,

---

11/ Another important question is whether the new storage should be constructed for bag or bulk. The FCI estimates that bag storage can be maintained a maximum of 12-18 months; in the U.S., grain is stored in bulk for up to 3-5 years. Therefore, if the entire stock cannot be turned over every 12-18 months, there is an argument for constructing some bulk storage even though there are extra costs of bag handling before and after storage (See Khusro, 1963b, 1969 for a careful analysis of this issue).

Table - 13

Location of Public Storage

('000 tons)

State	FCI			Food Department			CWC	SWC	State Govt.	Total
	Owned	Hired	Total	Owned	Hired	Total				
Andhra	146.90	18.60	165.50	-	18.00	18.00	302.50	58.20	87.00	631.20
Assam	-	10.00	10.00	40.30	9.80	50.10	5.80	19.50	NA	85.40
Bihar	-	-	-	215.50	12.50	228.00	2.20	20.50	135.00	385.70
Delhi	114.00	-	114.00	-	-	-	-	-	-	114.00
Gujarat	-	-	-	73.20	146.00	219.20	8.80	196.00	158.00	582.00
Kerala	140.20	39.40	179.60	-	-	-	17.00	18.60	18.00	233.20
Madras	195.03	6.70	201.73	-	39.20	39.20	210.50	33.00	525.00	1009.43
M.P.	65.20	24.50	89.70	-	-	-	15.60	43.10	NA	148.40
Maharashtra	-	-	-	574.80	106.20	681.00	23.10	72.85	160.00	936.95
Mysore	46.00	-	46.00	-	-	-	19.40	47.30	NA	112.70
Orissa	17.20	1.10	18.30	-	-	-	6.80	15.20	39.20	79.50
Punjab & Haryana	53.20	-	53.20	-	-	-	10.00	97.90	-	161.10
Rajasthan	74.50	-	74.50	-	-	-	18.10	21.25	NA	113.85
U.P.	296.10	14.40	310.50	-	-	-	20.00	39.80	NA	370.30
West Bengal	-	371.20	371.20	242.80	110.50	353.30	6.50	32.00	NA	763.00
	1148.33	(487.75)	1636.08	1146.60	(442.20)	1588.80	666.30	715.20	1122.20	4798.63 (929.95)
	1083.00	(103.00)	1186.00	1219.40	(441.00)	1660.40	579.80 (175.00)	176.50 (704.00)	1239.50 (331.00)	4298.20 (1753.00)

Note: ( ) indicate hired storage.
Last row corresponds to figures obtained from a different source.

Source: Collected from various unofficial sources during 1968.

presumably both rail and road, and if the godown levels are constantly inventoried and reported to the central coordinating group, this should not be a serious problem. A final important consideration to the placement of storage is the question on whether state-imposed restrictions on movement of government stocks will be continued.

The general rules that these observations suggest are that:

1. Storage for operational stocks should be concentrated near the primary deficit consuming centers;

2. Future buffer storage should be built inland rather than at the ports;12/ presumably some large portion in the producing areas;

3. While some storage should be located in the larger villages and cities, the bulk should be located at the larger surplus markets in the country.13/

A spatial and temporal study of storage requirements is a basic pre-requisite for future public construction.

The public storage will, of course, supplement private storage. However, what the future balance will be is a very open question. I am not aware of even any rough guesses of present capacity, especially by quality of storage, of private off-farm foodgrain storage capacity.

12/ In the only quantitative study to come to my attention, A.M. Khusro (1963) has used Kenyesian monetary theory as an analytical model by which to determine storage requirements. According to these calculations - which are based on an estimated 1970-71 storage of 5,200,000 tonnes for wheat and rice only - present capacity is overbuilt in the states of Andhra, Tamil Nadu, Gujarat and Maharashtra - four of the five states where major ports are located.

Doubling Khusro's volume to ten million tonnes which we suggest will be required for 1968-69 introduced analytical problems which are more complex than simple extrapolations of Khusro's figures.

A second problem in using Khusro's scheme for our purposes is that his "buffer" storage is concentrated in deficit states - states where there would be large distribution but small procurement.

13/ The 1967-68 wheat crop is a good illustration of the advantage of having large storage located in the producing area. "Over-building" in Punjab and Western Rajasthan would have the additional advantage that the very arid weather during a large part of the year would reduce storage losses.

Furthermore, with the very aggressive entrance into the market of the FCI and the repeated threats which are raised regarding the future of the private trade - which we feel to be grossly unwarranted - private traders probably do not see a large economic pay-off in storage construction. Past returns from private seasonal storage have apparently been no more than normally profitable (Cummings, 1967a; Lele, 1967; Kahlon, 1968). The larger the availability of public storage and the economic threat that it carries, the less incentive will be for private construction.

However, the fact remains that the foodgrain crop must go under cover - public or private - somewhere. If foodgrain production grows at five per cent and marketed surplus increases with production, then storage requirements will grow at faster than a five per cent rate and will be a major future investment requirement.

D. Market Building and Rural Centering

One final area which has not received nearly the required attention necessary is the role of the market - both in terms of location and function - in the agricultural development process. Proper location can increase the marketed surplus of cultivators and the supplies to consumers. If both input and output marketing functions are combined at the same location, probably also integrated with the credit mechanism, again the convenience to cultivators is greatly increased. Basically, this whole concept - which links up the input demands and output supplies - as it affects agro-industries, cultivators, and ultimate consumers - should be carefully researched and must be listed as a priority agro-economic research need for agro-industries collectively.

Actually, this attempt to integrate a spatial aspect into rural development strategy could have far-reaching implications. To quote J.P. Lewis (1963):

> "....by maximizing the average proximity of agriculture to concentrations of industrial and commercial activity, a pattern of comparatively (but no unrealistically) dispersed industrialization would help to provide the kind of market environment that..... agricultural development so urgently needs. Indeed, town-centered development would supply the necessary frame for the whole network of development sequences, linkages, and feedbacks upon which the successful transformation of the Indian country-side so largely depends. To a degree that would be quite impossible in larger cities, for example, town-centering could marshal many of the rural unemployed - part-time as well as full-time - to the tasks of urban construction without dislodging them from villages. While metropolitan construction also employs idle labor, of course, it cannot

> do so until workers from villages already have been converted into geographic migrants, and its skill requirements, on average, may be somewhat higher. By contrast town-centered building would make a more direct attack on the problem of creating idle rural manpower, would do so at a lower social cost, and by putting a much larger number of less roundabout multiplier processes to work at once would be apt to have a greater expansive effect, especially on local industries not significantly dependent on imported and other scarce equipment and materials."

Schultz (1953), Nichols (19), and Tang (19) have documented the close relationship of agricultural development with proximity to towns and industrialization in the United States. Ludhiana and Coimbatore, although obviously not planned for such a purpose, are private enterprise examples of this same process in India.

Investment patterns and economic policies can have an important role in influencing future Indian regional growth pattern. This is an especially important consideration to grasp and act on now since the New Technology has set loose forces which give no guarantee that future regional cropping patterns will resemble present patterns (Russell and Brinegar, 1969). In theory the new pattern of agricultural location could vary anywhere between every district being self-sufficient in every crop to a pattern of regional specialization of important. Generally, the developed countries have followed the latter path. There are certain, scale advantages on both the input and output sides in large markets and price stabilization, extension information, research and similar policy oriented programs may be easier to organize if the beneficiaries are relatively concentrated geographically. "The major savings from a geographical decentralization of agricultural production are likely to flow from a reduction in transportation costs and some types of risk and uncertainty associated with weather." India must decide which path, if either, to follow.

There are a series of policy measures that can be taken to influence spatial location of agricultural development including transportation rates; import and export tariffs and subsidies; urbanization policy; price support programs; input investment location such as irrigation, transportation, storage or processing (i.e., sugar mills); or even research focus. For example, the railway rate structures were quite important in determing the ultimate concentration of foodgrain acreages in the U.S. The large number of sugar crushing mills in north India

almost ensures that a substantial proportion of refined sugar will continue to come from the north in the future. Future location of starch industries can influence maize location and oilseed solvent plants can influence future soybean concentrations.

In sum, this whole policy of market and investment locational policy begs for serious analysis if a potentially powerful development tool is not be neglected.14/

14/ For a general attempt to identify this problem see the study by E.A. J. Johnson (1965).

VII. ECONOMIC POLICY

Economics is the study of the allocation of scarce resources to alternative ends. Economic policy focuses on manipulating certain tools to indirectly influence the allocation of inputs, the distribution system, research and technology, etc. in different combinations to achieve the agricultural development targets. In this section, we will discuss four general policy sub-areas which might be included in economic policy:

..... Prices

..... Taxes

..... Credit

..... Administrative Measures

We will examine each in turn.

A. Prices[1/]

Prices play a manifold role in an economy.

For the producer, prices affect his variable input allocations in the short-run, his investment decisions over the longer-run, and his marketing decisions.

For the consumer, relative prices influence the relative amounts of commodities demanded and the level of prices affects the real income which the consumer has for spending and saving.

For the trader, prices influence buying and selling decisions over time and space.

For the economy as a whole, the price system provides a substitute for millions of small otherwise administrative decisions allocating scarce resources among competing uses in the short-run, inducing capital

---

1/ For general discussions of the role of prices and price policy in agricultural development see the articles by R. Krishna (1967c) and Mellor (1968b). See also the discussion of empirical studies of the effects of prices on production, marketing, and consumption decisions in Section III.

accumulation and technological change over the longer run, and directing the transfer of resources from one activity to another and from one sector to another.

The basic ingredients of price policy should include attention to:

..... the general level of aggregate agricultural prices, or more accurately, the terms of trade of agriculture, which would influence input/output price relationships on production side and consumer's real income on the consumption side,

..... relative prices among agricultural commodities which influence the allocation of land and other inputs among crops, and

..... stability of prices which influences risk.

1. Input vs. Output Prices

The net income of the producer which is the difference between sales and costs or between output prices and input prices times technology is the key determinant of production decisions. Raj Krishna very effectively summarizes the arguments regarding whether input or output prices should be influenced (1967a):

"When we consider the growth of the overall level of agricultural output rather than the output of individual crops, it is clear that the price ratio of outputs to inputs is as important as the relative prices of outputs, if not more so. Price ratios more favorable to cultivators can be brought about both by raising output prices and by lowering the prices of inputs to the farmer. Each course of action has its positive as well as its negative features."

"The outstanding advantage of subsidizing purchasable inputs like fertilizers, pesticides, equipment, and livestock rather than raising product prices is that the cost of the subsidy program is directly related to the utilization of practices that increase productivity. The cost to the economy as a whole of increasing agricultural output is likely to be lower in the case of subsidies and can be borne through the tax system. More resources are available for development of the non-agricultural sectors of the economy as well as other purposes; the government can avoid the political consequences of higher food and fiber prices to the non-agricultural population; and, equally important, the cultivator must employ purchasable inputs to reap any advantage whatsoever from input

subsidies. By contrast higher product prices add to the income of both non-innovators and innovators. This windfall income may to some extent vitiate the incentive provided for increasing production by the improved ratio of product to input prices by increasing the marginal preference for leisure relative to labor of at least some farmers."

"The case for higher product prices can turn some of these very arguments to advantage. They very fact that a program of input subsidies costs less than a program of product price supports means that the agricultural sector derives a smaller income from the first program than from the second. This is an important consideration, for it can be argued that at current price relationships agriculture receives less than its "fair" share of the national income, and that a major obstacle to innovation in peasant agriculture is the lack of a capital cushion to absorb the added fluctuations in income produced by many innovations, such as fertilizer in areas dependent on variable weather. A second argument for higher product prices is that input subsidies are of no avail in situations in which increases in agricultural productivity come from additions of non-purchasable inputs that are not complementary with purchasable inputs - for example, the farmer's labor in better cultivation, weeding, clearing, and local irrigation and drainage channels. Third, if the use of purchasable inputs is already widespread, the costs of input subsidies mount. Moreover, since non-innovators as well as innovators benefit, the argument for input subsidies on the ground that they do not increase the preference for leisure is weakened. If, however, the use of improved inputs is not widespread, it is doubtful whether the mere cheapening of inputs will by itself induce more farmers to begin to use them."

"Thus it should be clear that a blanket preference cannot be given either to general price supports or to input subsidies. The relative efficacy of the two means of improving the price ratio of outputs to inputs depends on the existing level of input use, the technological character of the measures necessary to increase productivity, the relative importance of low cost and provision of a cushion for risk-taking to the cultivator, and a value judgement with respect to the distribution of incomes between the agricultural and non-agricultural sectors. All but the last-named aspect of the problem can be resolved by specific empirical research in each country facing the choice between price supports and input subsidies, and even the question of rural-urban income distribution can be illuminated by such research."

An examination of the specific circumstances of the Indian case suggests that government policy should concentrate its policy attention on output prices for two primary reasons:

..... practically all of the subsidy has already been removed from input prices (see Appendix S), and

..... input use is widespread and increasing, subsidies would be expensive and may not be necessary.

However, all would agree that continued pressure should be applied to reducing input costs through production and marketing efficiencies.

2. Output Prices

Government policy might influence output prices in three ways:

..... level

..... relative prices

..... stability

a. Price Level

The importance of this role depends very much on the state of agricultural development of the country. For example:

1) In the traditional agriculture where few inputs other than land, labor, bullocks, and seed are used, and where these inputs are characterized by inelastic supply, influencing the level of prices would have only limited scope in increasing production. 2/ Most probably, higher output prices would only lead to higher input prices.

2) In the present transitional situation in which India is moving from a traditional to a modernized agriculture based on high yielding seeds, inorganic fertilizer, irrigation, plant protection, and some degree of mechanization (inputs which are purchased and elastic in supply), the price level should be high enough to provide an economic incentive to use these inputs.

2/ We should be very careful to put out there that:
a) Price stability would still be important (price supports would be valuable) even in this environment.
b) even though aggregate supply response may be low, relative price changes would influence relative acreages.

At the minimum it should cover the risk of changing from the low income (but income-assured) method of production to one of higher returns. However, it should not necessarily be high enough to cover all costs of production including a reasonable profits, or if so, it should cover only those costs of the more efficient producers. In a shortage situation as India will be in during transition years, market prices themselves generally will be high enough to give remunerative returns. The support price would "bottom-out" those years of low prices; i.e., stabilize prices on the low side.

3) Once it is clear that the transition is past (that the new strategy is fully integrated into Indian agriculture), then the support price should be more directly related to risk insurance, covering only variable or cash costs of production. This policy might be followed for two reasons:

-- At this point, the situation would be one where potential supply is exceeding demand. More efficient production should lead to lower unit costs. Market prices should be given freedom to gradually fall in order to discourage excess production (i.e., so that efficiency and cost-reducing technological change is encouraged) and/or to permit exports.

-- The cost of continually "propping" up domestic agricultural prices would be an increasingly large procurement program and buffer build-up.

In summary, under certain conditions, it may be advisable to aggressively influence the level as well as the stability of prices. The present period when the new technology is being introduced is one of those times. However, as the agricultural production performance increases and imports are replaced, then world agricultural prices (combined with absence of import controls and active encouragement of exports) might be the proper terms of reference for domestic agricultural prices.

b. Relative Prices

The policy for relative prices of agricultural commodities is integrally tied to that of aggregate level and of stability. Several empirical studies document the facts that relative acreages (and presumably relative use of other inputs) are allocated in part due to relative prices. This trade-off takes in particular significance when competing crops, such as rice/jute or wheat/gram, experience different rates of yield change.

c. Price Stability

Price stability - both inter-year as well as intra-year - is desired in order to minimize economic waste from inefficient decisions. Price instability cum income instability, introduces uncertainty which causes private decision makers to stop short of the optimal marginal conditions in employing productive resources. Furthermore, it forces the government to follow conservative spending and investment programs in order to restrain inflation. In sum, price instability leads to under-utilized resources and sacrificed growth.

The support price provides the lower limit for prices. The upper limit is more difficult to determine.

Perhaps the safest thing that can be said regarding the upper level of harvest prices is that flexibility must be permitted. If a rigid upper limit is maintained for harvest prices (for example, the level of the previous year) and supply falls by 20 per cent, then incomes would fall by 20 per cent. By allowing harvest prices to rise by 20 per cent above the "normal" level, producer's incomes would be stabilized at the previous year's level; however, this would shift the whole burden on consumer whose real incomes would suffer. Furthermore, in the period of rising production, some of the gains of productivity should be passed on to consumers. Therefore, some trade-off between producer and consumer interests is required.

Given these considerations, stability of harvest prices can be defined as the absence of wide swings in the terms of trade of agriculture. A calculation based on factoral (relative prices adjusted for productivity), or income terms of trade based on the specific Indian conditions might be given serious consideration.

Seasonal prices must be allowed to rise above the harvest price at least enough to cover holding costs - storage, interest, etc. A sufficient risk factor should be added to these holding costs in the policy calculations (presumably the risk would be reduced as the buffer stock becomes operational). In the past traders have had a very difficult time estimating storage plans. Some years the seasonal price increases have not covered storage costs; stockists suffer losses (Lele, 1967; Cummings, 1968a; Kahlon, 1968). Therefore, they must balance these losses with larger-than-minimum profits in other years in order to establish a break-even income over time. Otherwise private traders will be driven from business and government will assume the distribution trade by default.

3. Buffer Stock

In order to create a favorable economic environment for the new technology, the government must develop a flexible program to moderate the short-term fluctuations in order that resources can be employed more efficiently to attain the long-term growth objectives in agricultural development. The buffer stock - an integration of several policy instruments - is a market-compatible program which can cope with short-term problems as well as allow economic signals to direct inter-crop and inter-spatial acreage and input allocations.

The basic idea of the buffer stock appears to be simple - to maintain a quantity of foodgrains to offset (buffer) the production irregularities by adding to private consumption availability (i.e., drawing down public stocks) during shortage and withdrawing from consumption availability (i.e., building up stocks) during relative abundance. If the policy is to be effective, the stock must be self-regenerating over time.

The compelling reason to seriously consider the buffer stock program is that the new technology may upset the optimal regional location of agricultural crops significantly during the next few years. If the adjustment mechanism (i.e., cultivators reallocating acreage and variable inputs to greatest returns) is allowed to operate freely, a new pattern of comparative advantage corresponding to the new technology can be attained whereby resources are used most efficiently (as directed by pricing signals) at all parts of the country. Building of an adequate buffer stock is a fundamental pre-requisite for the removal of foodgrain zones and the accompanying policies which presently interfere with these adjustments.3/

3/ The basic assumptions that underlie the argument for buffer stock policy should be made very clear; first, that prices do influence production, marketing, and consumption decisions in predictable, economically rational ways; second, that unless complete nationalization of the foodgrain distribution is desired, the private trade must carry a large responsibility for distribution - the trade must be permitted to make normal profits for the services - it performs.

At the same time two complementary points must be made equally clear. First, this position is not held in ignorance of the real and potential imperfections of the Indian price system. The price system is a positive force which should be utilized to the greatest extent feasible. The constructive role of government would be to moderate the excesses while allowing the price system to fulfill its basic allocative function. The buffer stock is specifically designed to supplement and reinforce the private market rather than to replace it.

Secondly, we should also make equally as explicit our view that a positive economic policy is a necessary but not a sufficient condition for accelerating agricultural development. The most successful price policy (at least as evaluated in the abstract) in the absence of continuing programs to develop and extend improved technology would have little impact. Therefore, strong programs of research, education, and extension and a commitment to provide the necessary inputs and infrastructure are also essential to accelerated agricultural growth.

Table - 14

Inter-relationship of Instruments in Buffer Stock

$$QD_t = Q(RFM)_t + Q(I \& M)_t + Q(FPS) + f(PM_t - P_t)$$

$$\text{min. turnover} \leq QD_t \leq QB_{t-1} + QP_t$$

$$QP_t = f(P_t - PS_t) + R$$

$$R \equiv QD_t - \lceil QB_{t-1} + f(P_t - PS_t) \rfloor$$

$$QB_t = \sum_{t=1}^{n} QP_t - \sum_{t=1}^{n} QD_t \qquad \begin{matrix} P_t \geq PS_t \\ L \leq QB_t \leq U \\ L \geq 0 \end{matrix}$$

QD_t	quantity distributed
Q(RFM)	quantity to roller flour mills
Q (I & M)	quantity to institutions and military
Q (FPS)	quantity to low-income groups (Fair Price Shops)
PM_t	maximum price
P_t	market price
QB_t	quantity in buffer stock
QP_t	quantity procured
PS_t	support price - minimum price
R	remainder to be procured (i.e. by open market purchases)
L	lower limit
U	upper limit

A buffer stock program to attain the desired objectives should be built explicitly around the following four instruments:

..... Distribution to low income persons through Fair Price Shops;

..... A mechanism to increase the volume of public distribution in response to foodgrain price increases;

..... Guaranteed procurement of all quantities delivered at support prices set at incentive levels announced prior to the sowing season; and

..... Selective procurement at open market prices.

The system as expressed in two functional and one definitional equations shown in Table 14 illustrates the inter-dependence of the separate instruments in the buffer stock program and provides a focus for the discussion of quantities and methods.

a. The public distribution program to low income sectors has an explicit welfare objective. The quantity distribution under this program is a function of the ration allotment, the price at which the public foodgrains are distributed in relation to market price, and the number of people who are eligible (This program will be discussed in Section X).

b. The quantity distributed under the price dampening policy is a function of the difference between market and the upper limit of allowable (i.e., maximum) prices - this instrument establishes stability at the upper limit of prices.

c. The price support program - procurement of all supplies delivered at the support price - is formulated to increase agricultural production by establishing a stable minimum price at incentive price levels. Depending upon the relationships between support price (established before sowing season) and market prices, the quantity procured under this system may range between zero and all of the marketed surplus.

d. The quantity procured by open market purchases closes out the system in the face of uncertainty and introducing operational flexibility to keep the system variable.4/

4/ Foodgrain imports are assumed to become increasingly less important in the future as India reaches "self-sufficiency". Concessional (PL-480) imports will be of major assistance in initiating the program but they should not be made a requirement of its continuance.

e. The buffer stock is the sum total of these four instruments. The operational problem is one of coordination.

In the absence of the buffer, prices will deviate from a norm of price stability with some probability of size and frequency. Therefore, the relevant analytical questions necessary to be answered in order to define operational rules are:

- What are the size and frequency of expected fluctuations?
- Within what limits are they to be controlled? and
- What are the costs and benefits of different sizes of buffer stocks in carrying this out with a given probability of success?5/ 6/

Or in practical operational terms:

1. What percentage of fluctuations do we wish to take out?, and
2. What size buffer stock will do this?7/

Very preliminary studies have suggested that the present target size of the buffer should be approximately seven million tons (Cummings, 1968b; Saran, 1968)and that future target size should grow in some relationship with growth in demand.8/

5/ In order to complete this analysis, the costs and benefits of the outlined buffer stock would have to be evaluated relative to the alternatives:
1. The present system of administrative controls which has the advantages of lower financial costs and having worked in the past but which also is not a growth-oriented policy;
2. Additional investment in research, irrigation, other variable inputs, and/or infrastructure;
3. Holding the "buffer" in foreign exchange (i.e., the cost of drawing down foreign exchange);
4. Some combination of these.

6/ Forward prices and future's trading were not considered in this analysis. They are an obvious theoretical possibility but are banned for foodgrains in India under the Essential Commodities Act.

7/ S.K. Ray will carry out research during 1969-70 in an effort to shed some light on these questions.

8/ A.M. Khusro (1969) comes up with a smaller total based on an analysis of wheat and rice alone. The targets should be considered as upper limits - the size of the buffer stock will actually vary between zero and this upper limit.

In summary, the buffer stock must be understood as an inter-related system of instruments coordinated to achieve pre-defined objectives. This scheme is projected to operate in India where foodgrain production is growing at five per cent annually, where there are no foodgrain zones, urban rationing, and compulsory procurement levies, and eventually where there are no foodgrain imports. The private trade is assumed to play a continuing important role in foodgrain distribution. The scheme also assumes that the politics of Center-State relationships in foodgrain policy (i.e., effective procurement, flexible movement of public stocks between states) are improved; if they are not, either a much larger (and much costlier) buffer must be considered or the old system of administrative controls must be reimposed.

The buffer stock scheme will be a complex program to operate. One key to the scheme is coordination. Some single group must have the authority to procure, transfer, stock, and distribute foodgrains as needs dictate. Continual ad hoc negotiations slow down mobilization and work against building up a capable, professional organization. Economies of scale enter in many areas such as market information, efficient use of storage and transportation, central and state organization, etc.9/ Therefore, some realignment of responsibilities among the presently involved public agencies will be required in order to effectively implement the system.

Secondly, a high premium will be placed on an adequate information system. A scheme must be developed to provide accurate pre-harvest production estimates and daily reporting of arrivals, dispatches, prices, transport, availabilities, and storage at key points over India.

Thirdly, the required investments in storage and transportation must be undertaken.

These are all solvable problems. The buffer stock is an expensive system to operate. However, the returns can be very high also. I suggest that the benefits of this system, as compared to its costs, are greater than alternative systems. India is entering into a potentially dynamic phase of agricultural development. The buffer stock, as outlined, can provide a positive economic environment to help translate potential into reality.

9/ Tentatively I suggest that the actual operation might best be decentralized to regional commodity areas with coordination supplied at the Center; this is a study topic in itself.

4. Support Prices[10/]

The program for public foodgrain distribution is discussed in Section X. Programs for open market procurement and price dampening distribution are discussed in more detail in another paper (Cummings, 1968b). We do, however, propose to discuss the concept of support prices, first in a general way, and then with more specific figures attempting in particular to evaluate the relative prices of wheat and rice.

We do wish to make one distinction before getting into this discussion. Much more attention has been given in India to "procurement" prices than to "support" prices. Procurement prices are announced at the beginning of each marketing season which is too late to influence production decisions. However, anticipation of expected procurement price levels does influence production decisions and therefore has caused the operational concept of the support price, which has been significantly lower, to lose relevance. We feel that this is an unfortunate situation. In our suggested scheme, support prices should be set high enough to at least be a potential source of procurement. However, if more public stocks are required, open market procurement would serve as the residual. The concept of a fixed "procurement price" would then lose its distinction.

a. General

Support prices can influence the production decision mechanism in two closely related ways:

- The fact that a minimum price is known before sowing decreases at least the price element of risk,
- The level at which the price is set can influence the amount of inputs, particularly fertilizers, that are used.

10/ The most comprehensive reviews of agricultural support price policy within the specific Indian policy context are by Dantwala (1966) and R. Krishna (1967c).

1) Risk[11/]

On the first aspect, there is little argument. If risk is decreased, one has more confidence to try to innovations and make bolder - and more efficient - allocation decisions.

The cultivator is being persuaded to change from a relatively secure, even if low-income, method of farming. He does not have large savings to fall back on in case of failure. The new technology requires increased input expenditures in early stages and because grain types are not preferred, HYV will sell at some discount. If the new technology is to be adopted in the first place, cultivators must be shown that the higher yields will also mean higher income - gross returns (quantity of output times price) must more than cover the cost of inputs.

There are three major sources of year to year variation in income (Wharton, 1968)

- yields
- costs
- output prices

Despite the significantly higher expected average yields from the new technology, the peasant cultivator may be much more concerned about the expected variance. For example, even though the average yield of HYV is double that of local varieties, if the variance is so high that the negative standard deviation is lower than the average for local varieties, this may cause problems.

11/ There is a growing literature on the influence of risk and uncertainty upon economic behavior including Davidson and Mighill 1963; Dutia, 1961; Gould, 1963; ISAE, 1963; Hsieh and Ruttan, 1967; R. Krishna, 1969; J. Krishna and Desai, 1967; Marglin, 1965; Myer, 1969; Porter, 1959; Tedford, 1964 and Wharton, 1968.

R. Barker has assembled the following data on average yields of IR-8 and local rice varieties in the Philippines (cited by Wharton, 1968, p 44):

(metric tons per hectare)

Dry Season	$-\sigma_x$	$\bar{x}$	$+\sigma_x$
IR-8	3.24	5.86	8.48
Binato	1.51	3.17	4.83
Wet Season			
IR-8	2.59	4.49	6.39
Binato	1.00	2.32	3.64

For both seasons, the negative standard deviation yields of IR-8 is higher than the average for the local varieties. Minhas (1968) has reported analysis on Indian data which "has shown that increasing levels of fertilization not only reduce inter-plot variation in yields during a particular year but also reduce the inter-year variation in mean yields." However Malone (in private correspondence) has suggested that the wide variety of yield in TN-1 in West Godavari has been a, if not the, major factor in the slow spread of HYV in this district even with the major promotional activity behind it. Certainly the potential importance of having information on yield variability of the HYV warrants a significantly greater empirical research effort in this area.[12/]

The second source of variability, cost, is also important. In particular, the higher the proportion of fixed costs, the more

---

12/ Diversification of crops within a growing season or multiple cropping - allowing for a successful crop to follow a setback - are methods of partially insuring against suffering the full costs of yield uncertainty in any single crop or season.

conservative the cultivator is likely to be in taking risks.[13/] The cash costs for HYV are almost invariably higher than for local varieties (Table 17).

Support prices directly insure against only the last of these sources of income stability. However, most of the HYV will be grown on irrigated or rain-assured acreages which do provide substantial insurance against yield uncertainty. Therefore, price supports do contribute to income certainty in a broad sense.

It should be emphasized, that the risks to be covered are those which are outside the production function - i.e., weather, input supply availability, or changes in market prices - which might discourage experimentation from safer, even if lower yielding, varieties not so dependent on inputs, especially water and fertilizer. Poor management, internal to the production function, should not be subsidized - this problem is more effectively attacked through an aggressive extension effort.

2) Input Response

The second potential advantage of a price support program is through the relationship of the level of the supports to the amounts of inputs used. Although the empirical relationships have yet to be established, the economic rationale is clear. Following on the marginal analysis, the producer will add inputs to the point where marginal cost just equals marginal revenue (Hopper, 1965a).

13/ Promoters of new innovations occasionally fail to recognize the double risks associated with much of the new technology. Where the new technology requires the purchase of a "package" of associated inputs to achieve maximum returns, the peasant farmer not only subjects himself to risks in production but also in costs which are of a much higher order of magnitude than he has previously experienced. If this action also reduces his ability to depend upon traditional forms of security (family or village) due to resentment at his innovative actions, the peasant faces a third form of risk. Any valuation and summation of all three often results in an extremely high risk factor.

Sadly, it is often hesitancy on the part of peasant farmers to incur the full costs required by the optimal "package of practices" to secure the full benefit of the new varieties which frequently leads to an actual loss. There are several cases where farmers have failed to apply fertilizer at the higher levels required with the result that traditional varieties outyield the new (Wharton, 1968).

The past situation where fertilizer responses, optimal doses, (and other input) availability were low is now changed. With HYV, optimal doses are much higher than before and fertilizer is available to satisfy these requirements. If output prices are raised, the break-even point for input use is at increased quantities of inputs which presumably lead to larger volumes of output. This is the crux of what is meant by "incentive prices".

In summary, the role of support prices - announced well in advance of the sowing season (in order that they may influence production decisions) and backed up by full government purchase at the announced price - is to provide the economic environment to make adoption and continued use of the new potential attractive (i.e., profitable). Price supports are therefore a necessary - although not sufficient - condition for Indian agricultural development.

Several additional points deserve mention.

While we are arguing for "high" prices (prices which are "high enough" to provide incentives to increase production through use of new technology and greater inputs), we are not arguing for prices which are too high. At the point beyond which input supplies are demanded, inflation may result. A valid justification for support prices up to this margin is to allow sufficient profits to enable the producer to invest in production - increasing capital such as land leveling, tubewells, etc. What the cultivator does with profits is an empirical problem which deserves serious investigation.14/

Secondly, the support prices would be set at the beginning of each sowing season, each kharif and rabi period, and maintained for the entire year. If supply begins to build up, this may be an economic signal for downward adjustment in support price; the reverse might be the reaction to a depletion of stocks. But any adjustments must be made for the next crop year, not during the present one.

Thirdly, the basic support price should be set on an all-India basis, allowances possibly being made for inter-state price difference limited by transportation costs. In this way, economic forces will be free to allocate acreages on the all-India basis of comparative advantage.

Fourth, the level at which support prices are set does impose restrictions. If it is too high, the government will buy all the foodgrains marketed; if it is set too low, the government will purchase none. This inflexibility means that the support price should be used

---

14/ At least two studies (Hindustan, 1968; UPAU, 1969) suggest that a significant proportion of the increased profits are reinvested in capital inputs.

primarily for production incentives and insurance and that another instrument is needed to insure that necessary volumes of foodgrains for distribution are procured.15/ Failure to make this distinction has led to some unwarranted frustration with the price support concept, some undue conservatism in the levels at which price supports are recommended, and a reliance on compulsory levies in order to procure the volumes of foodgrains required for public distribution. Reliance on procurement at support prices to supply the buffer - which actually means either very "high" support prices or "low" support prices backed up by compulsory levies - has serious weaknesses.16/

15/ This inflexibility poses certain responsibility on the government in establishing support price levels. For example, the procurement

If the objective of procurement is to tax, then explicit taxes are preferable. If some foodgrains are procured at the support price level - as was done in wheat during 1967-68 - this is commendable. However, in order to procure sufficient volume to replenish the buffer stocks, a more flexible instrument than support prices alone is required.

The other side of the issue, the desire to "prop" foodgrain prices above market price levels, must also be avoided. The potential costs of such a program can be guessed from the experience with wheat during 1967-68 and 1968-69. In this case, the results might be justified on the basis that (1) producer incentives necessary to ensure that a successful new technology is fully integrated into the system, and (2) the procured grains can be distributed through public outlets are not unbearable subsidy. Whether these conditions will be present in the future for other foodgrains is questionable.

Fifthly, support price policy should not be considered an either - or relationship to new technology. On the contrary, it is the new technology - with much higher yield potential dependent upon greater input use - which makes the support prices necessary. The last few years have been the beginning of a new ball game in Indian agriculture and play has to be adjusted accordingly.

Sixth, even given that the technology is adequate, support price policy is a necessary but not sufficient condition for increase in agricultural production. Institutional and credit arrangements should not be allowed to blunt the incentives. Furthermore, it is necessary that input supply be elastic in order that higher output prices induce greater quantities as opposed to higher prices of inputs; this condition appears to be satisfied at present.17/

Finally, before we go into an examination of some of the specific methods of calculating prices, we must admit that, thus far, we have little empirical evidence that aggregate foodgrain production does respond to changes in the terms of trade of agriculture.18/ The new technology and adequate level of input supplies have not been available in past years - this may be the primary reason. However, we are placing

---

17/ This is a primary reason why M.L. Dantwala (1967) and John Mellor (1968b) are very cautious in urging too much reliance on output prices as a means of stimulating output growth.

18/ We would call attention to the Ph.D. research of Robert Herdt on aggregate response of foodgrain production to the terms of trade of foodgrains in the Punjab which should become available in the fall of 1969.

relevance primarily on (1) western experience and a logical extension to the Indian situation, and (2) the apparent relationship between the rise in prices in 1964-65 and the rapid increase in tubewell development and continued high rate in fertilizer consumption growth during the succeeding years.

b. Specific Levels

If we can agree that support prices have a role to play in stimulating greater agricultural production (and that the minimal role would be to reduce output price uncertainty), the important next step is to calculate specific levels.

Ideally what should be done is to fit a production function relating input changes to output prices. The conceptual problems would be difficult acknowledging out present state of understanding the productinn process - but even if specification could be solved, who do not have long enough time series with adequate supplies of inputs and HYV. At this point, we can only point this out as a priority research problem area.

Short of this ideal, two simple methods, terms of trade and costs of production, are possibilities which have already been extensively discussed. We would not dismiss either of these methods as quickly as some others have. A third method, determination of support prices on the basis of synthetic farm budgets bears consideration. A fourth method, called a modified production function model also deserves much more serious study.

1) Terms of Trade

Perhaps the simplest concept, because it is workable (but at the same a concept which does not get directly at the (decision making) mechanism), is the terms of trade.

The basic rationale of the terms of trade or parity is that the producer compares his returns to costs. The implicit implication is that if the terms of trade are increasing, profitability is increasing, terms of trade decline, profitability does likewise, hence incentives are dampened.

a) Commodity Terms of Trade

The simples form of terms of trade, output prices divided by input prices, is called the commodity terms of trade. The parity operation in the U.S. is one application of this approach. Use of this concept is valid only as long as productivity is unchanged. 19/

The most obvious problem with this approach is the difficulty of calculating indices for the prices paid and prices received. Furthermore, gains in productivity - which are not taken into account in the simple

---

19/ This causes Dutia (1966) to term this method as "backward looking".

"parity" formulas - become windfalls.20/ It is possible to correct simple parity for productivity changes, but if these are costed out, this method is the same as an aggregated cost of production method.

We have tried to derive a series for terms of trade of wheat and rice from the available data that would approximate current conditions.

Prices received - An all-India producers price for a crop can be roughly determined by defining it as the average wholesale price during the specified peak-marketing period of the commodity. For example, market arrivals of rice begin immediately after the harvest at the end of south-west monsoon and continue throughout the year but record a peak during the months of January and February. The average of the all-India wholesale prices of rice during this two month-period of any year can be taken as an approximation to the producers' price of rice for that particular year. Similarly for wheat, the producers' price can be taken as the average of the wholesale prices during the months of May and June.

Prices paid - Ideally, the prices paid by the farmers can be obtained from a weighted average of the farmers' domestic expenditure and farm cultivation costs. In the absence of any information on these two items one might at best crudely approximate the prices paid by the farmers by considering the prices of some principal commodities generally purchased by the agriculturists. Six items have been taken into account here. These are fertilizers, iron and steel manufactures, cement, leather, cotton manufactures, and kerosene oil. A simple average of the index number of wholesale prices of these items is taken to represent the index of prices paid by the farmers, although a weighted average might have been a better choice.

Base - Base period should be recent enough so that the comparisons are meaningful. Moreover, it should be reasonably normal or average from the point of view of weather, agricultural production and agricultural prices. We have selected 1961 as base because this year recorded a minimum price fluctuation and a favorable weather over large parts of the country. Foodgrain production in 1961 was above 16 oz. per capita per day. Also, 1961, was the first year of the Third Plan and the parity comparisons will help to make assessment of the programs of agricultural development during the Third Plan.21/

Table 15 gives the parity prices of rice and wheat calculated on the assumptions just discussed.

20/ The "windfalls" would contribute to agricultural development if they were invested.

21/ 1961 base terms of trade does also approximates the input/output price relationships during 1956-59 period which served as the base for our demand projections.

Table 15

Parity Prices of Rice and Wheat

	Index of prices paid	Parity index	Parity Prices of Rice	Wheat
1961	122.3	100.0	50.28	42.33
1962	124.0	101.4	50.98	42.92
1963	131.6	107.6	54.10	45.55
1964	134.5	110.0	55.31	46.56
1965	140.2	114.7	57.67	48.55
1966	152.6	124.7	62.70	52.78
1967	164.4	134.4	67.58	56.89
1968	168.7	137.9	69.34	58.37

b) Corrections for Productivity Gains

Yield data indicate that productivity gains for the five primary cereals have been moderate. The annual change in productivity (yield) - compound rates - 1949-50 to 1964-65 - are as follows (India, 1966a):

Rice	2.09 per cent
Wheat	1.24 " "
Jowar	1.58 " "
Bajra	1.20 " "
Maize	1.13 " "

If there were no associated input costs with the productivity gains - if we could relate the productivity change to technology as opposed to inputs - we would infer that the cost of production had fallen and therefore make a correction in the price ratios. However, we have no evidence of this having happened so we leave this observation open to question and explore cost of cultivation in more detail in the next section.

c) New Technology

The New Technology does represent a change in technology which is only partially offset by higher costs. As yet we have not carried out the calculations to test out parity concept (factoral terms of trade) on the HYV.

2) Costs of Production

a) Local Varieties

A second method is to compare the prices received by the farmers with the costs of production.

The studies in economics of farm management conducted by the Directorate of Economics and Statistics since 1954-55 (India, 1966d) give base line data on the costs of cultivation of principal food crops in several regions of India. These studies all treat local varieties. The Farm Management Survey covered only a small number

of sampled farms in the selected regions (200 holdings under the cost accounting method and 400 holdings under the survey method) and does not represent complete coverage of all States.22/ Nevertheless one might inflate these physical input data to derive the costs of cultivation in the surveyed regions and thus obtain some guidelines to determine present farm costs.

An attempt was made to derive the costs of cultivation of paddy and wheat in 1966-67 in the regions covered by the 1954-57 Farm Management Surveys of the Directorate. Costs were obtained by inflating the various physical components as given in the farm management studies. The inflators used are very crude and can in no way be considered as ideal.

The principal components of the factor costs considered in the farm management studies were: (1) human labor, (2) bullock labor, (3) seed, (4) manure and fertilizers, (5) depreciation, (6) land revenue, (7) rent on leased land, (8) irrigation charges, and (9) interest on crop loans and owned capital. The contribution of these to the total cost show a wide variation from crop to crop and region to region (India, 1966d). However, for almost all crops in all regions human and bullock labor, seed, manure and fertilizers and rent on land had accounted for a major share of the total costs. For the sake of simplicity we have therefore assumed here that the minor components viz. depreciation, land revenue, irrigation charges, interest paid on crop loans and on owned fixed capital and miscellaneous item, to remain at the same absolute level as given in farm management studies. Since our procedure consists only of estimating the various components of the factor costs at 1966-67 prices without altering the proportions of input-mix as given in the base line data, the output figures are assumed to remain as constants.23/ In other words, ceretis paribus, our attempt is to estimate the average cost of cultivation at 1966-67 prices for those farms which were covered by the farm management studies.24/

Following this procedure, the costs per hectare for the cultivation of paddy and wheat have been worked out and shown in Appendix T. The costs per quintal of paddy range from Rs.34.80 (Bihar aman season) to

---

22/ The Farm Management Surveys have been extended to additional states but only a limited amount of this more recent data has been published.

23/ This, of course, may be a very weak assumption for local varieties and would weaken this method considerably as being applicable to HYV.

24/ The inflated cost data look particularly suspicious with regard to costs of land and bullocks.

Rs.57.77 (Tamil Nadu, season I)[25] and of wheat range from Rs.42.42 (Punjab, Rohtak unirrigated) to Rs.133.63 (Maharashtra, unirrigated). Even within the Punjab State, four samples give an average cost from low of Rs.42.42 to high of Rs.71.89. It should be emphasized that these are:

a) average costs

b) calculated on the "C" basis of farm accounting.[26]

These data suggest that procurement prices fail to cover total costs of the average producer of paddy only in Tamil Nadu and Andhra - which happen to be two very important paddy states from which a large proportion of paddy was to be procured. Procurement prices for wheat appear to be "low" relative to cost of production in U.P., Rajasthan, and Maharashtra (which is not an important wheat state). It is not clear why the cost of unirrigated wheat is so much higher than irrigated wheat in U.P.

It is obvious that inter-state market prices do not differ by a factor of two or three when zones are not in effect - and zones were not in effect when these studies were carried out. The private market does an effective job in keeping spatial price differences within transportation costs.[27] Furthermore, these studies report average costs; half of the wheat cost more than the reported figures to produce

---

25/ Which are equivalent to rice prices of approximately Rs.57.80 to Rs.95.90 per quintal.

26/ Cost A_1 includes hired human labor, bullock labor, value of seed, value of manures and fertilizers, depreciation, irrigation charges, land revenue, interest paid on crop loan,
Cost A_2 includes Cost A_1 + rent paid for leased-in land,
Cost B includes Cost A_2 + rental value of owned land, interest on owned fixed capital and working capital,
Cost C includes Cost B + imputed value of family labor.

27/ If output prices are in fact constrained within transportation costs, presumably the cost of production data could be checked either through comparison of land values or acreage allocations (high cost crops in one state compared to another would occupy smaller acreages).

in four of the eleven samples, the average cost per quintal of wheat exceeds Rs. 100.28/

For these reasons, we are suspicious of the data from any of three aspects:

(1) Cost figures - particularly the physical input data for family labor and rent,

(2) The inflators used, or

(3) The yields.

Unless more research is carried out, at best, cost of production appear to be valuable only as a check to other methods.29/ With this in mind, we introduce these calculations primarily in order to provoke criticism and further debate.

b) High Yielding Varieties

Presumably if the new technology is actually an improved technology, the per unit costs should be lower than for local varieties.

Very limited data are available to empirically test this hypothesis. The studies which have been located thus far are summarized in Table 16.30/ In most cases, the HYV were lower cost technology.

28/ There has been a sustained discussion in the literature regarding "what costs" and "whose costs" need to be considered. R. Krishna (1967c) argues for complete average cost on a bulkline basis - the minimum cost which covers the actual average costs of farmers using package cultivation producing a major part of the output. Dantwala (1966) suggests that the guaranteed price should cover the cost of cultivation of the bulk of the more efficient farmers. Dutia (1966) also accepts this view - but with the reservation that marginal costs of production rather than average costs should be covered. He then argues that the entire concept is "backward looking" and presents his modified production function approach as a means of relating supply response to price stimuli. In sum, these arguments while dwelling on the possible practical advantages of the method also bring to the fore the theoretical weaknesses of a cost of production approach.

29/ In all fairness the farm management surveys were not originally designed for this purpose and hence should not be strictly evaluated against this norm of usefulness.

30/ These recent data for cost of production of local varieties can be compared with the inflated data in the previous sub-section.

Table 16

Cost of Production of Local and High Yielding Varieties

Study	Crop	Local	HYV
K. Singh and Sharma, 1967	Wheat - U.P.	58.60	35.70
Shingarey and Waghmare, 1968	Paddy (TN-1) Maharashtra (Cost C)	33.34	35.00
Lavania and Dixit, 1968	Wheat (Cost C)	59.43	36.83
	Corn (Cost C)	48.55	35.96
	Millets (Cost C)	47.72	27.08
Sisodia, 1968	Wheat S-64	-	73.30
	LR	-	66.47
	S 227	-	49.53
	Average	-	61.21
	Local-part.	67.05	-
	Local-non Part.	66.28	-
Venkataram and Ramana, 1968	(Prob. A_1)	22.83	31.58

Studies carried out by the Agro-Economic Centers during kharif 1966-67 were restricted to cash costs because the major purpose of these surveys was to provide basis for credit recommendations. These data do confirm the obvious fact that cash costs of HYV are higher than for local varieties (Table 17).

3) Synthetic Budgets

This method is a compromise between what we would ideally want to do and what we are able to do. The procedure is to "construct or to synthesize, representative ....farms from available data, then compute the unit costs of production for those synthesized farms" (Pandey and Cochrane, 1969).

The following excerpts from a preliminary study by V.K. Pandey and W.W. Cochrane (1969) for different villages in Muzaffarnagar, U.P. is instructive:

"Unit costs of producing wheat were derived for two multiple-enterprise crop farm situations (a small farm operating 4 hectares of land, and a large farm operating 15 hectares of land). These farms were synthesized from farm management records collected in the field on behalf of the Directorate of Economics and Statistics of the Ministry of Food and Agriculture. Each representative farm, large and small, was synthesized from a smaple of 10 farms, where information was available on each farm with respect to land use, labor inputs, animal power, farm implements and buildings, irrigation structures, and cropping patterns. In synthesizing the two farms under consideration, the characteristics of each farm were not derived from simple arithmetic averages; the characteristics of each farm may be more properly described as modal averages where extreme conditions in the sample data were eliminated. Finally, each representative farm may be viewed as an internally consistent operation, representative of its size group for the area involved.

At present, there is not much difference in the technological status of large and small farms, but the large farms have taken the lead in the use of chemical fertilizers and improved implements. The small farms, on the other hand, are using labor more intensively, mostly family labor, to increase wheat output. The largest share of fertilizers used by the farmers in this area goes to the sugarcane crop. This may explain the small difference in the per hectare yields of wheat on the two size groups of farms. There appears to be adequate water supplies for each farm size group in this area. The use of plant protection chemicals was not observed as a common practice on these farms. Farmers, both large and small, have started experimenting with the high yielding varieties of wheat on their fields, but these varieties have yet to command a major area in the farmer's cropping pattern.

Table 17

Data Taken from GOI Report on High Yielding Varieties Programme, Kharif, 1966-67

District	Crop	Cash Cost per Acre (Rs.)	Sale Price (Rs./Quintal)	Gross Value per Acre (Rs.)	Yield (Kg/Acre)	Cash Cost (Rs./Quintal)
Paddy						
Thanjavur	ADT-27	138.94	43.50	534	1228	11.31
	Local	117.98	44.75	345	770	15.32
	Dif.	20.96		+ 189	146%	
Cuttack	TN-1	295.73	54.00	942	1744	16.96
	Local	82.08	54.00	459	850	9.66
	Dif.	213.65		+ 483	205%	
Karnal	TN-1	113.19	45.60	604	1324	8.55
	Local	54.32	45.60	402	886	6.13
	Dif.	58.87		+ 202	149%	
Kolaba	TN-1	129.73	54.94	262	476	27.25
	Local	68.95	57.36	338	585	11.79
	Dif.	60.78		- 76	81%	
Krishna	TN-1	202.23	40.21	684	1701	11.89
	Local	101.15	41.66	666	1599	6.33
	Dif.	101.08		+ 18	106%	
Ernakulam	Tainan-3	365.11	80.06	1057	1321	27.64
	Local	225.74	98.87	1018	1030	21.92
	Dif.	139.37		+ 39	128%	
Bajra						
Mahasana	HB-115	174.58	74.50	362	486	35.92
	Local	93.20	75.00	214	285	32.70
	Dif.	81.38		+ 148	171%	
Maize						
Aligarh	Ganga 101	256.77	66.64	335	496	51.77
	Local	118.72	63.37	345	497	23.89
	Dif.	138.05		- 10	-	

Source: India, 1967

The total unit cost of producing a quintal of wheat on the small representative farm is Rs.67.27 and on the large representative farm is Rs.60.45. These unit costs compare with the announced procurement price for common white wheat of Rs.76.00 per quintal in 1967-68 and a minimum support price for the same variety and area of Rs.56.00 per quintal."

4) Modified Production Function Model

B.P. Dutia (1966) described the general outlines of the modified production function approach and the model was then specified mathematically and fitted to data by Jai Krishna (1968).

A production function of standard form is fitted each for traditional and improved technology. Furthermore, it is assumed that "the average Indian farmer " will be willing to bring about a change in the production process if and only if he is sure of realizing a certain net income plus a margin for risk and uncertainty arising out of the adoption of improved technology. If we then divide the output level corresponding to the levels of inputs as contained in the "package of practices," we get the estimate of a break-even price, which may more appropriately be called an "incentive price."

This model has the advantages of taking into consideration technical input/output relationships, risk, and technological change. On the negative side the estimational problems particularly with regard to the technical coefficients and the assumption of an "optimal mix" of inputs which correspond to the package of packages, the fact that the model gives only a point estimate, and the sensitivity of the results to the level of the assumed risk and uncertainty margin all require more careful study.

Demonstration data from IADP districts were fitted to the modified production function model by Krishna. The incentive price (P_{y1}) was then calculated as the sum of net income per acre under local practices (Z_{L1}) plus risk and uncertainty margin (K) + cost of package per acre (C_1) divided by output under demonstration plot per acre (Y_1):

$$\frac{Z_{L1} + K + C_1}{Y_1} = P_{y1}$$

Risk margins of 20%, 33%, and 50% of net income under traditional technology were applied. The results are summarized in Appendix U.

In comparison to the Jha Committee recommendations for support prices in 1964-65, the calculated incentive prices required were fairly close for paddy (Rs.30.70 to Rs.44.85), jowar (Rs.39.08), maize (Rs.27.57 to 29.81), and wheat Rs.33.38 to Rs.79.89), particularly in major producing areas. However, it should be recognized that the operational costs reported in this study are much lower than were reported in the previous three sub-sections. This may reflect the optimal input/output assumptions or the unrepresentative conditions in the IADP district.

In summary, this method appears promising and deserves more careful study.

5) Concluding Comments

The purpose of this section is to argue that the support price level must be established on the basis of explicit criteria regarding what production effect - and we include both relative crop as well as aggregate production changes - might be expected in response to that price level, if it is truly to be termed an "incentive price." The present approach of predicting price trends and then attempting to set support prices well below that expected market price level will not stand up to this rigorous test. In some cases, the support price calculated on the present approach (for example, the procurement price level for wheat) probably, in practice does accomplish this role; however, in order to follow this approach, the GOI has been forced to await the marketing period to announce such prices; the "incentive" element can only come via cultivator expectations into which must be added the risk factor which the support price policy is employed to eliminate.

The key role of a support price policy will be emphasized even more strongly during the future when market prices of most agricultural commodities are expected to decline. Production incentives may be eroded by these declining prices. However, the more vulnerable groups in the economy, the high cost producers, particularly those on dry lands and small under-capitalized farms, will suffer the most serious income squeezes.

Certainly a closer look at this very important policy area is required.

5. World Prices

Over the long run, the aggregate of prices as well as the relative prices among crops are determined by basic supply and demand forces. As India ceases to import and becomes a potential exporter of agricultural commodities, the terms of reference for domestic agricultural prices would be world prices. The basic rational for using world prices is that, presumably, they reflect the economic value placed on the use of resources on a world-wide or free-trade basis of comparative advantage; thereby they are a guide to efficient domestic resource allocation in the wider international setting.

Any comparison of domestic with world prices is fraught with difficulties regarding:

..... what the "world" price actually represents,

..... what exchange rate should be used, and

..... what varieties or grain types should be compared.

Many of the world commodity markets are organized through artifical agreements in which prices are kept within specified limits. Furthermore, it is a common practice to subsidize exports. However, in the absence of an independent effort to research this problem, we will make the assumption for the time being that world prices do reflect international scarcity values.

The official exchange rate would be the easiest means of converting rupees to dollars which is the international unit of exchange most often quoted. However, generally, it is assumed that the official Indian exchange rate of Rs.7.50/$1 is over-valued and that an economic shadow rate would more likely approach Rs.9-10/$1. We will make our convertions at a rate of Rs.7.50/$1.

Finally, it should be noted that foodgrains are very heterogeneous commodities. Rice is the clearest example; the spread between low-quality and high quality rice may be as much as 2 to 1. Furthermore, India does not export rice on the world market so we do not know specific price/grade relationships for the Indian varieties.

The results of these comparisons of Indian prices with international prices are shown in Table 18. It appears that Indian rice prices are

Table 18

Comparison of Indian prices for wheat, maize and rice with prices in other countries

						Prices[1]		Domestic Prices India		
						$	Rs.[2]	Support (1967-68)	Procurement (1968-69)	Market
Wheat	USA	Chicago	New Contract	Bushel (60 lbs)	25.4.69	1.3275	36.58	52.00 to 63.00	71.00 to 83.00	68.50 to 95.00 (2.5.69)
					4.1.68	1.479	40.75			
	Canada	Winnipeg	In store wheat-Fort William port Arthur Manitoba No.1	"	25.4.69	1.899	48.65[3]			
					4.1.68	1.916	48.69[3]			
	U.K.	London	Transhipped U.K. Ports	Ton	25.4.69	£28.17.6	51.14			
					4.1.68	£28.15.0	50.92			
Maize	USA	Chicago	No.2(Yellow) Cash	Bushel (56 lbs)	24.4.69	1.26	36.20	42.00	47.00 to 55.00	57.00 to 70.00
					4.1.68	1.126	33.25			
Rice	Thailand	Bangkok	White Broken Rice A1 Superior	Metric ton	23.5.69	£45.10.0	81.90	63.00	72.69 to 76.15	
			White rice special Qual.(Grade A.)	"	23.1.68		117.00	66.00	99.00	128.60 (2.5.69)
					23.5.69	£60.0.0	108.00			
			White Rice 15% Broken	"	23.1.68		151.20			
					23.5.69	£75.0.0	135.00			
			White rice 100% 3rd Grade	"	23.1.68		153.00			
					23.5.69	£82.10.0	148.50			
							165.60			

1/ Prices in foreign countries refer to those applicable to the country concerned. They are exclusive of freight and other incidental charges and are not the landed prices in India.

2/ Equivalent prices in Indian currency, i.e. in rupees per quintal except where otherwise stated.

3/ Converted at the free market rate of Canadian dollar ruling as on 29-11-68 (Canada $2.55 7/8 to 2.56 dollars = £1 sterling).

Source: Various issues of GOI, Bulletin of Agricultural Prices, Economic and Statistical Advisor, MFA.

roughly comparable with world prices[31] while Indian wheat and maize prices are well above world levels.

6. Relative Rice/Wheat Prices

The relationship of rice and wheat prices which presently exists in India raise some interesting price policy questions particularly in the context of the relative progress of the HYV of rice and wheat.

Part of the reason for the present situation can be explained:

1. Rice is the major foodgrain in India and consumed primarily in the south and east which are the most politically volatile and sensitive of the Indian states. Recent food policy, which has been faced with the problem of obtaining supplies of rice for public distribution but which has been unable to obtain these supplies at acceptable prices on world market, has chosen to set procurement prices at below-market levels which, when in combination with a system of zones, enables the GOI to procure rice at "low" prices. Furthermore, a substantial amount of PL 480 wheat has been channeled into the traditional rice-consuming areas in an effort to keep rice prices down.

2. The present level of rice prices leaves India in a competitive position to enter world trade as an exporter once the domestic rice production picks up.

3. There is a clear relationship between relative rice/jute prices and acreage (Stern, 1962). The technological changes in rice already give rice some profit advantage over jute, assuming that relative rice/jute prices are unchanged. Jute is a major foreign exchange earner and higher rice prices would either drive jute prices up or acreage down; either force would decrease India's foreign exchange earnings in a very price competitive market.[32]

31/ With the increased rice production anticipated in South Asia and the Far East and the thin export market, it is probable that world rice prices may decline further.

32/ The acreage of jute and rice in the important jute producing states is follows (1967-68, thousand acres):

	Jute	Rice
Assam	146.0	2102.5
Bihar	157.9	5247.6
Orissa	50.4	4308.1
U.P.	22.9	4359.1
West Bengal	496.0	4719.6
Tripura	12.1	251.6
All India	885.3	

4. There has been some considered opinion that raising rice prices would not necessarily lead to increases in rice yields.[33/] The HYV of rice have encountered some problems, particularly with regard to water management, in the initial stages of introduction (Hopper and Freeman, 1969). Yield variations have been wide and TN-1 has been found to have sufficient susceptability to bacterial leaf blight during the kharif period so that some cultivators who tried it have been discouraged. In some areas the uncertainty during the initial periods has been sufficiently great that higher rice prices may not be expected to induce increased input use to increase yields; furthermore, in this environment, the increased profit may not be expected to be reinvested in agricultural capital improvements.

   We might accept this reasoning as being applicable to the recent past but will argue later that the future price policy should be reconsidered in the context of production potential.

5. The question regarding whether wheat prices (or overall food-grain) prices have been depressed by PL 480 shipments (S.R. Sen, 1960; Schultz, 1960; Witt, 1960; Olson, 1960; Manne, 1967; Khathate, 1962 and 1963; Falcon, 1963; Rath and Patvardhan, 1967; Srivastava, 1969) has been made irrelevant with the very rapid price increases during the two drought years while wheat prices have decreased from their very high 1965-66 levels, they are presently held up by above-market procurement prices.

6. Indian wheat prices are so high relative to world prices that there is little prospect for wheat exports.

7. There is clear evidence that the higher wheat prices are a significant cause of the success of the HYV of wheat and that a significant portion of the increased profits are being reinvested into capital improvements in agriculture (UPAU, 1969; Hindustan, 1968).

8. So long as the concessional PL 480 wheat imports were available, these wheats could be pooled and distributed through the public distribution system at an average price which brings the overall subsidy into acceptable limits.

33/ The GOI study of kharif 1967 (India, 1969b) concluded that there has been some question regarding the profitability of T (N)-1 vs. local varieties. However, the profitability of growing ADT-27 and IR-8 is clearly favorable in areas of adaptability as it is evident from the increase in acreage under these two varieties.

9. The relationship between relative wheat/sugarcane and wheat/gram prices to relative acreage adjustments is significant (R. Krishna, 1963b; Falcon, 1962; J. Krishna and Rao, 1968). However, India exports sugar at significant subsidy even at present; higher domestic sugar prices probably would not be translated into higher Indian export prices.

In summary, in the past as well as presently, market rice prices have been higher than market wheat prices in India. However, current procurement price levels for wheat and rice are approximately equal.34/ In essence foodgrain price policy has resulted in a subsidy to wheat production in the north and a tax on rice production in the south.

The future presents a somewhat different environment in which to set price policy.

1. If foodgrain prices do begin to decline, maintenance of the present level of procurement-cum-support prices will put an increasing financial burden on the government. Concessional foodgrain imports will be determinated in the future; this lower priced supply will not be available to offset the prices paid for domestic foodgrains in order to hold down the distribution price.

   At current procurement price levels, the HYV are clearly profitable. Presumably the new technology where adaptable for wheat is cost-reducing; pressure should continue to be applied to lower production costs. Therefore future wheat price supports might be lowered, in an environment of rising general price level, not raised appreciably.

   The preferable price policy might be to set support prices which would be below anticipated level of market prices by x per cent. If market price falls to the support price level, the government procures at that level; if not, the government procures at market prices. However, explicit in this policy must be a more empirical attempt to relate price/production response and commitment not to change support price levels up and down repeatedly.

   A positive side effect of this policy may be to encourage pulse production.

   On the negative side, the cash incomes of marginal producers may decline; without resources to enable them to adopt, they might be squeezed considerably.

34/ Wheat is procured at Rs.76-81 and rice at Rs.72.69 to Rs.86.00 (A.P., Tamil Nadu, Maharashtra, Punjab, M.P., Orissa and Haryana) in the primary production areas.

2. Now may be time to rethink the rice price policy. The technological problems appear to be on the verge of being solved. A higher support price announced well in advance of the sowing period and combined with credit and input supply policies may be warranted. However, this should be applied only to certain varieties of rice such as ADT-27, IR-8, Padma, Jaya, etc. which promise production successes.35/ In essence, we are arguing that the Agricultural Prices Commission step up the research component of its activities, begin to interact more closely with the scientists and production specialists, and evolve an explicit price policy for rice based on price/response information. Whether rice prices should be raised or not is an empirical question which must be researched; the present policy of restraining rice prices through a compulsory levy at below market prices can be costly if in fact, it is a disincentive to the adoption and optimal development of the new varieties.

The companion problem of jute prices must also be considered. A policy must be evolved, however, whereby jute prices are not used as an excuse to hold down rice prices; or if they are used as an excuse, the cost/benefits of the price policy must be calculated.

7. Concluding Comments

The conclusions of this section fall into two categories. First, assuming that the new technology can be integrated into Indian agriculture, Indian price policy must be empirically based on twin

---

35/ The levy procurement price for ADT-27, a medium grade rice is Rs.42-48 per quintal of paddy. Cheap rice for Tamil Nadu city is a major electoral plank for the DMK party. In the delta districts of Andhra, the pcocurement price for IR-8 was only Rs.45/quintal of paddy until May 1969 when it was raised to Rs.50/quintal. Both areas are zoned even at the district level. The market prices - and even world prices - stand at significantly higher levels. The implications of these policies for investments in water and use of variable inputs must be studied seriously.

objectives of encouraging the adoption and spread of the new technology while at the same time, putting the overall agricultural price structure in a position which moves more closely in parity with world prices. This means that: (1) selective output pricing based on appreciation of technological possibilities and price/production, i.e., price/variety-input, responses must be followed: (2) bold decisions must be made on both the level and relative prices; (3) better price projection equations must be developed in order that the relationship between support and market prices can be predicted in advance; (4) the differential effects of future price trends on different production groups in the agricultural sector must be empirically determined so that the social implications - of both the price level to smaller holders as well as of urban consumers - are fully understood, and (5) finally, the relationship between agricultural prices and industrial wage and raw material costs, i,e., inflation, must be determined.

The second category of conclusions is that price policy - to be affective - must take into consideration:

1. The elasticity of input supply in order that higher output prices are translated into higher input use rather than higher input prices

2. There must be an effective market for outputs where production can be sold normally on the open market at competitive prices and where the price support mechanism can move in when needed without undue disruptions, and

3. Investment in information, transport, and storage must all be carefully planned and implemented.

In sum, this is an area which cries for serious empirical research. Data are rapidly becoming available to carry this research out.

Table 19

Incidence of Direct Taxes on Indian Agriculture*

Year	Direct Taxes: Land Revenue[1]	Direct Taxes: Agricultural income tax	Direct Taxes: Total	Net National Output From Agriculture[2] (in million rupees)	Gross Area Sown[2] (in mil. hectares)	Land Revenue per ha. (in rupees)	Agricultural Income Tax per Hectare (in rupees)	Direct Taxes per Hectare (in rupees)	Direct Taxes as Percentage of Net National Output from Agriculture
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1950-51	452.4	31.2	483.6	47800	131.9	3.51	0.16	3.67	1.0
1951-52	508.7	43.3	552.0	49100	133.2	3.81	0.33	4.14	1.1
1952-53	578.4	40.6	619.0	47100	137.7	4.20	0.29	4.49	1.3
1953-54	714.9	57.7	752.6	52000	142.5	5.02	0.26	5.28	1.5
1954-55	730.3	47.7	778.0	42300	144.1	5.07	0.33	5.40	1.8
1955-56	788.9	76.7	865.6	43900	147.3	5.38	0.52	5.88	2.0
1956-57	932.0	77.3	1009.3	53800	149.5	6.25	0.52	6.75	1.9
1957-58	880.7	78.0	958.7	51300	145.8	6.04	0.53	6.57	1.9
1958-59	923.8	84.2	1008.0	60800	151.6	6.09	0.56	6.65	1.7
1959-60	957.5	89.2	1046.7	60900	152.8	6.27	0.58	6.85	1.7
1960-61	977.8	94.9	1072.7	66800	152.7	6.40	0.62	7.02	1.6
1961-62	957.9	94.4	1052.3	67700	156.1	6.14	0.60	6.74	1.6
1962-63	1206.5	95.9	1302.4	67900	156.8	7.69	0.62	8.31	1.9
1963-64	1237.0	92.6	1329.6	79400	156.8	7.89	0.60	8.49	1.7
1964-65	1198.5	107.3	1306.8	101600	157.4	7.61	0.69	8.30	1.3
1965-66	1120.5	102.4	1223.0	106000	158.3	7.08	0.65	7.73	1.2
1966-67 (RE)	880.5	105.7	967.1	116000	158.9	5.54	0.64	6.18	0.8

* The revenues from betterment levy are not included here as annual data on the yield from this tax are not readily available. This, however, will not make any material change in the total incidence of direct taxes on Indian agriculture.

1 Reports on Currency and Finance (Annual, Reserve Bank of India). The data on land revenue relate to receipts of the State Governments and Centre from the Union Territories.

2 Statistical Abstract of India (Annual, Central Statistical Organization).

Source: Gandhi, 1969.

B. Taxation[36]

In one sense, the primary reason to tax is to hold down inflation. The government can print money to finance development expenditures but because of the gestation period involved this would increase demand relative to supply and lead to increasing prices.

While we would hold that some deficit spending is justified in the development process, other means of mobilizing financial resources must also be examined. Taxation is a logical means of mobilizing these financial resources either to be used for public investment in the agricultural sector or non-agricultural activities.[37]

Most analyses conclude that the agricultural sector is bearing a relative low "net fiscal burden" in India. Gandhi (1966, 1968) suggests that the system of agricultural taxes fails to meet objective tests of revenue raised, equity on basis of both inter-sectoral and inter-class comparisons, and coordination of policies. The effect of agricultural taxes, even at the very low level, on productivity must be researched further (Gandhi, 1966).

1. In 1950-51, the agricultural sector paid only Rs. 186 crores in direct and indirect taxes. By 1961-62, this revenue had increased only to Rs. 381 crores. During this interval, revenue from the non-agricultural sector tripled. Table 19 lists the incidence of direct taxes in Indian agriculture.

2. In 1961-62, the agricultural sector paid 5.9% of its income in taxes compared to 13.2% for the non-agricultural sector. These percentages increased from 3.6 and 8.8% respectively in 1950-51, but the 2 to 1 ratio still holds. The inter-sectoral inequity also stands whether tested on per capital or wealth.

36/ An alternative means of transferring resources from the agricultural to non-agricultural sectors is via declining agricultural prices (Owen, 1966; Mellor, 1967b). Because of this potential, the effects of taxes on agricultural productivity must be carefully evaluated. Opinions differ in the literature between those who would place priroty reliance on mobilizing agricultural resources via agricultural taxation as a a means of financing public investments (Dantwala, 1967; Mellor, 1968b) as opposed to those who argue for an "incentive price" policy as a means of encouraging private investment(Schultz, 1967).

37/ This section is based largely on the papers by Ved Gandhi (1966, 1968, 1969) and Stephen R. Lewis (1967).

Table 20

Open and Concealed Taxes on and Subsidies Given to Indian Agriculture

(In Million Rupees)

Year	Taxes				Subsidies							Subsidy as a Proportion of Taxes
	Open	Concealed		Total	Open	Concealed					Total	
		Procurement	Fertilizer Pricing			Fertilizer Pricing	Govt. Loans	Agricultural Credit	Irrigation Water Rates	Electricity Rates		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1960-61	1,073	40*	74	1,187	40*	-	8	20	139	-	207	0.17
1961-62	1,052	40*	95	1,187	50*	-	9	23	197	-	279	0.23
1962-63	1,302	37	85	1,424	60*	-	9	25	328	-	422	0.30
1963-64	1,330	60	51	1,441	75	-	10	29	324	-	438	0.30
1964-65	1,307	170	4	1,481	92	-	9	30	366	-	497	0.33
1965-66	1,223	694	-	1,917	116	15	9	36	387	-	563	0.30
1966-67	967	104	-	1,071	112	407	10	40*	415	8	990	0.93

* Trend-fitted.

Source: Gandhi, 1969.

3. The inter-class comparisons indicate that the total agricultural tax take may be regressive.

4. Furthermore, subsidies given to agriculture averaged about 30 percent as a portion of taxes during 1962-63 through 1965-66 (Table 20).

If one looks over the tax possibilities, the reasons for this behavior are obvious.

1. The land revenue is the major direct tax but it is facing strong political pressures in the states. In actual fact, it is regressive to acreage - a result which works against production efficiency overall.

2. The take from agricultural income and betterment taxes are almost negligible.

Because of these problems of raising revenue from direct taxes - which are the responsibility of the respective states - the Center has resorted to such indirect fiscal measures as:

1. Compulsory procurement of foodgrains at below market prices.

2. Taking "pool" profits in the pricing of fertilizers.

3. Excise taxing of inputs such as fertilizer and pumpsets. 38/

Input subsidies have been reduced substantially in the last year or two but there still remain substantial subsidies in low interest government loans (i.e., taccavi rate varies between $4\frac{1}{2}$ to 7 percent and the coop. rate between $6\frac{1}{2}$ to 9 percent) above market procurement prices for wheat, low irrigation water rates (S. Singh, 1968) and subsidy in rural electricity rates.

The net result of this is that agricultural taxation has become a political issue, first and last; the States generally are not anxious to increase revenues from these sources and the Center has only a few options - which can be blocked by agricultural interests in Parliament - some of which have probable disincentive effects on agricultural development, i.e., compulsory procurement.

38/ While one might favor these taxes because of the desire to mobilize some of the financial resources in agriculture for public purposes, the disincentive effect on productivity, particularly during this early stage of the new technology must be carefully weighed. An opportunity to test the incentive effects of excise taxes has recently been provided. From March 1, 1969, the GOI imposed a 10% tex on all chemical fertilizers. It is estimated that the net income from this levy will be approximately Rs. 26 crores in 1969-70.

In sum, the potential is large but probability of much higher agricultural taxation is limited. It is more a political than an economic issue and must be evaluated in this broader context. The empirical work in agricultural taxation is limited, the research opportunities are great.[39/]

C. Credit[40/]

Credit enables the cultivator to enjoy the production benefits of new technology now and to defer the payment until after the results are obtained. In this function, credit can open the advantages of the new technology to a wider group - those who do not have previously accummulated earnings saved to finance necessary investments.

Institutional credit now available to agricultural producers is primarily supplied through the cooperative credit systems which, at present is supplying about 30% of the estimated total of 16,000 to 17,000 million rupees. Short and medium term credit available from the cooperative credit systems currently amounts to about Rs. 4,500 million and long term credit available from the Land Mortgage Banks primarily for land development, irrigation, wells, pumpsets and tractors amounts to about Rs. 900 million. Additional

---

39/ Gandhi (1969) gives one set of priority research topics at the end of his paper. Other studies which might be reviewed include Kaldor, 1956; IJAE, 1960; Alagh, 1961; Groves and Madhavan, 1962; Mitra, 1963; Khan, 1963; Reserve Bank, 1963; and Khusro, 1963.

40/ Two factors make it difficult to write this section at the present time: (1) The All-India Rural Credit Review Committee (Venkatappiah) Report - India, 1969a- which is due to be released in the summer of 1969, will provide a thorough review of the rural credit situation which may out-of-date our brief discussion; and (2) the bank nationalization, which is too recent to analyze, should have a significant future effect.

credit of about Rs. 350 million will be available for development projects from the Agricultural Refinance Corporation. Money lenders are supplying the bulk of the remaining 70 percent.41/

At the present time, the availability of capital does not appear to be as serious a problem as does the ability of institutions to funnel this capital to the cultivator, as credit, in an adequate and timely manner.42/

Cooperatives provide the principal institutional source of credit to agriculture in India. This credit flows through two credit systems viz., The Cooperative Credit System providing short and medium term credit and the Land Development Banks providing long-term credit.

The Cooperative Credit System provides credit to cultivators through some 180,000 credit societies at interest rates varying from 8½% to 11%. The volume of short and medium term credit from this source is estimated at Rs. 450 crores for FY 1968. This represents about 30% of this type credit being used. There is a great variance between states as to availability depending on the development of the system in given states. Legislation has been passed for the establishment of credit corporations in Bihar, West Bengal, Orissa, Assam, and Rajasthan where cooperatives are very weak.

41/ The money-lenders, like the trader, are a much maligned economic group. They provide interest for high-risk demands for which there are not alternative sources. The All-India Rural Credit Survey in 1957 shows the following frequency of loans at specified interest rates (India, 1957):

Interest (%)	Percentage of loans
less than 10	18
10-12.5	25
12.5-18	9
18-25	29
25-35	9
over 35	6
not specified	4
	100

Given the risks involved, the economic cost of capital in India, and the flexibility of administration of the money-lenders, these may not be excessive interest rates. Quite obviously more understanding of the informal money market in India is required.

42/ We must note that cooperatives do show demonstrated favoritism to caste and economic groups, a policy which does exclude a large group from their potential services. We will discuss this problem in section IX Socially Oriented Programs.

Progress is being made in three areas that should make the cooperative system more effective.

1. A revitalization of the primary credit structure by amalgamation of weak societies and the liquidation of dormant societies in order to establish viable units at the base is rapidly being carried forward. Emphasis is being placed on improved management by placing a full-time, well trained secretary in each viable society.

2. A crop loan system is being adopted. Under this system the credit needs of the cultivators are determined based on requirements of production in respect to different crops, credit limits for individual cultivators being fixed subject to their repaying capacity. Credit to be provided partly in cash and partly in kind on the basis of three components:

   a. A cash component to take care of the outlay on cultivation according to traditional methods;

   b. A kind component - inputs like fertilizer, pesticides, seeds, implements, etc. for improved cultivation; and

   c. A further component in cash for cash outlay on account of use of inputs provided for in (b), this component being conditional on the extent of use made for component (b).

3. The Reserve Bank of India, State Governments, and the Cooperative Credit System have taken steps to liberalize credit policies and assure a smooth flow of loan funds to High Yielding Varieties Program and the Intensive Agriculture District Program.

The Land Development Banks with coverage in all states will extend in the vicinity of Rs. 90 crores of credit to cultivators in FY 1968. Loans are made for up to twenty years at 8½ percent interest with varying loan making fees in addition. In addition to their own resources, capital is obtained by selling debentures. Government institutions and commercial banks are the primary subscribers to these debentures.

Land development and irrigation accounts for about 80% of the capital use provided by these long-term loans.

The Agricultural Refinance Corporation, established in 1963, provides a source of capital to cooperative and commercial banks for the financing of project-oriented schemes of agricultural development. On June 1, 1968 the Corporation had sanctioned 128 special development schemes amounting to approximately Rs. 100 crores. Major types of schemes sanctioned were minor irrigation, land reclamation, and plantations. The Corporation will have at least Rs.35 crores for refinance purposes in the current year.

Commercial banks have, in the past, played an insignificant role in financing agriculture. However, due to a change in GOI policy by social control of banks it was expected that the commercial banks would gradually assume a significant role. Thirty five commercial banks formed the Agricultural Finance Corporation. The Corporation had two important functions to perform namely, financing of important priority projects contributing to agricultural development, and promoting commercial banks' advances to worthwhile agricultural projects. This situation has now been changed due to the bank nationalization.

The formation of two new corporations for special types of financing is in the formative stage by the GOI. One would supply a source of finance to cooperatives and State Electricity Boards for the extension of electric distribution systems to rural areas and the other would provide a source of refinance and guarantee to banking institutions financing wholesalers and retailers of agricultural inputs.

Although non-institution lending (money-lenders and relatives) is still a major supplier of agricultural credit, it is expected that institutional development now underway will gradually provide a source of credit to more nearly meet the demands of the developing agricultural economy.

As we mentioned in the beginning, a discussion of the future needs for credit would be premature until the Vankatappiah report is released. We would only summarize two projections at the present time:

The first is that the future credit requirements will increase more rapidly in the future as agriculture becomes increasingly commercialized.[43/]

The second is that if agriculture does grow rapidly, prices do fall, new technological changes are forthcoming, and innovation and flexibility become the key determinants of economic viability, credit policy will assume an increasingly important role in ensuring equity among cultivators as well as support for sustaining and reinforcing the aggregate growth rate.

43/ An imaginative approach to estimating aggregate credit requirements was used by Khan (1963) in which he used a production function analysis to estimate needs. He concluded that requirements as a percent of output were 14-15% in Pakistan and total credit requirements averaged Rs. 1,953 million during 1959-65.

D. Institutional Measures - Zones

Procurement, statutory rationing, and foodgrain zones would all fall within this category. Procurement policy has been discussed at several points earlier in this section. The arguments regarding statutory rationing are inter-related with private marketing, procurement, and Fair Price Shop public distribution - these are also discussed elsewhere. Foodgrain zones do require discussion in this section.

Foodgrain zones have been an intermittent policy in India even since the British period. They were mostly recently imposed in 1964 and cover most of the major foodgrains. Wheat zones, which have applied to individual states, have been substantially enlarged in 1968-69. However, in some states, paddy movement has been zoned even down to the district level. When zones are in effect, only the government can move foodgrains from one zone to another; inter-zone private trade is banned.

The justifications of zones are primarily on two fronts (India, 1965e):

1. Zones make it easier for the government to procure foodgrains to move from surplus to deficit areas, and

2. Zones protect the poorer rural groups from the higher buying power of the cities.

Careful examination casts serious doubt on the validity of either of these arguments in support of zones. More importantly, critical analysis suggests that continuation of zones will impede the attainment of "self-sufficiency".

In the first place, it is not clear that the government can procure and move greater volumes of foodgrains from surplus to deficit areas than can the private trade, operating in response to price difference. Government procurement did increase substantially during 1964-67 compared to previous years (but commitments increased even more). However, the degree to which zones themselves were responsible for increased procurement as compared to other causes (for example, great government commitment) is not clear. Furthermore, the amounts procured have not been large. During the Second and Third Plan, only three to six percent of marketed production was procured. The procured proportion of production did not increase much above this level in either 1965-66 or 1966-67 when food was short and zones were strictly enforced. Imported wheats have accounted for 75 percent of wheat moved inter-state by government.44/

44/ In 1966, of the approximately 14 million tons of foodgrains distributed by the Central and State Governments, more than 10 million tons consisted of imported foodgrains. These same proportions continued in 1967.

A "conventional wisdom" prevades the whole question of foodgrain distribution, namely that private traders are parasites without a basic productive function - opportunists who hoard stocks to bid up prices to weaker members of society during times of scarcity. Although there may be specific cases of "anti-social" speculators, the charge on any general basis has not stood up to serious enquiry. On the contrary, our limited evidence suggests that during normal times, the private foodgrain trade does an effective job of allocating foodgrains over time and space making only a normal profit in the process. The private trade is not able to carry out the entire job of distribution during times of shortages when private stocks are not available to move in response to price difference. However, there is no evidence to show that monopoly government distribution is a superior alternative. The most desirable government intervention - and this principle applies to each of the policy areas discussed - would be to supplement and reinforce the private market rather than to circumvent or replace it.

Secondly, zones are not necessary for procurement. In fact, states which are using a levy at the producer or trader level (i.e., in most states) or which are procuring through purchase at market prices (i.e, Punjab for wheat) may not be aided in actual procurement by the zones, as such. The zone does serve to depress prices in the surplus areas thereby appearing to make the cost lower for the government. However, while zones may minimize cost per unit procured, they also may inhibit the volume arriving in the market for several reasons - ie., if either the cultivators substitute sales of (for example) gram for wheat (consuming the latter on the farms) or anticipate that zones may be lifted and higher prices will follow or sell to the black market. Any policy which discourages market sales increase foodgrains waste since storage conditions are probably poorer on farms than with traders.45/

Thirdly, the charge that the high per capita purchasing power of the cities "sucks" the grain from the rural areas is based more on one or two specific historical instances, which may not bear close relationship to the present situation, rather than on any systematic research.

Finally, any price-depressing result may work to the cost rather than to the benefit of the non-producing poor. Cultivators

---

45/ This is another area that badly needs empirical investigation. The lack of reliable information on the marketing behavior of cultivators (especially including storage at the producer level) poses a major unknown for policy determination.

in the surplus states receive lower prices, hence lower incomes. They can afford to spend less money to hire rural labor. Other expenditures which might result in income for landless are also limited. If these poorer rural groups could be identified, they could still be supplied food from the Fair Price Shops through extended coverage. The higher prices for indigenous foodgrains generated by the urban consumers should be treated as what they are - the value these wealthier consumers place on particular type of food. Basically, the imported and indigenous wheats have comparable food values. If welfare (i.e., food value) is an objective of policy, the non-producing poor can be fed from government stocks without disrupting the private market and introducing the attendant inefficiencies.

The primary implication of the zones for agricultural development is that it creates a patchwork of disconnected markets which can be implemented and disassembled at will. The overall production advantages which potentially result from regional specialization on the basis of comparative advantage are seriously interrupted. Wheat prices are raised in a normally low-productivity state such as U.P. and depressed in a high-productivity state such as Punjab compared to what might be expected if there were no zones. 46/ This appears to reward inefficiency to the penalty of progress. Furthermore, when zones apply only to selected crops, the prices of unrestricted crops are raised (in surplus zones) relative to the zoned foodgrains resulting in acreage being diverted to the temporarily more profitable crop. Black market operations, whether carried out or not, are certainly encouraged. Finally, because zones have been used only during times of shortage, there is expectation that they will be lifted or altered eventually. Government policy becomes an additional element of uncertainty which benefits neither cultivators, trader, or consumer in planning decisions.

The zones have not accomplished what they were intended to accomplish regarding procurement and distribution. In the future, zones will be a more obvious liability with regard to accelerating agricultural productivity. The costs of this system in terms of budget, of economic inefficiency, and of government time and effort are very great. Free private inter-state movement reinforced, rather than replaced, by government distribution is a more promising alternative. In the interests

---

46/ At the level of foodgrain prices prevailing in 1966-67 this probably is not serious. For example, the market prices for wheat appeared to be amply high to provide incentives even in the Punjab. However, these inter-state price discrepancies would be serious at less favorable all-India levels.

of both inter-state harmony as well as sound long-term agricultural development, zones should be lifted. The buffer stock would then become the primary policy focus to promote agricultural production and distribution.

E. Concluding Comments

In actual practice, economic policy (which is a misnomer for an assorted bag of programs) is the most flexible of all policy areas, perhaps because:

1. the relationship between these instruments and broad objectives are only very approximately quantified, and

2. the costs of these policies are seldomly explicitly spelled out.

As a result, arguments for and against particular policies, i.e., "high" prices or "low" prices, can be presented with almost equal merit. "Ignorance is bliss".

With the introduction of the New Technology to Indian agriculture, economic policy takes on a different role. Prices are the economic signalling mechanism and price policy, taxation, credit, and administrative measures which influence the level of profits and the allocation becomes even more important in a program to shift agricultural production to a higher trend line as opposed to the previous pace of gradually moving up the lower trend.

On the other hand, the limitations of economic policy must be realized. Prices provide an environment by which existing resources are allocated and new resources created. Technological change can be induced or discouraged by the economic environment. However, aggressive policies in the other policy areas - inputs, distribution, and research and technology - assume increasing importance. Economic policy is a necessary, but not a sufficient condition for agricultural growth.

Economic policy is entering a new and uncharted phase. The cost of making a mistake is now greater than previously, since the potential for lost growth is greater. "No decision" may have even greater adverse consequences. In sum, the return to investment in better information regarding instrument/target relationship must be very high and a systematic research program to improve existing knowledge is imperative.

VIII. RESEARCH AND TECHNOLOGY
(also education and extension)

The development by Indian institutions of a continuing stream of new technology adaptable to Indian conditions will be the key element in establishing a sustainable high growth rate of cereal production as well as yield increases in the non-cereal agricultural products over the next fifteen years.

A. Research

A useful lesson can be learned from past Indian agricultural development experience. Previous policies had been based on the premises that the research base for sustained agricultural improvement was adequate and that the solution was to identify and harness the innovations possible with existing technology which, while not individually so remunerative, in combination might increase production by 25 to 50 per cent.

The basic problem with this approach was that 25-50 per cent increase was the maximum return expectable if the cultivator did everything. If he did only a few of the "improved practices," he could expect perhaps a 10-15 per cent production increase. These marginal returns were not sufficient to cover the extra effort involved or to offset the risks which might result from poor weather or falling prices.

The HYV promised net returns of 50-100 per cent, which constituted a quantum jump in technology. Where the HYV were adoptable, this led to an upward shift in the production function. The increased income was more than sufficient to offset the possible risks associated with adopting the new technology.1/

1. Background

The New Technology is the result of programs which in part were carried out abroad and in part carried in India.

1/ This may be a small overstatement. We must be reminded that the New Technology has not been met with unmixed success everywhere (Hopper and Freeman, 1969; Cummings and Ray, 1969b). Secondly, the new technology was first introduced in high potential areas and accompanied by programs to make necessary inputs available and during a period of inflated output prices. Therefore, there are a combination of causal factors which should not be under-rated.

The major breakthroughs in wheat and rice can be traced to research programs abroad. In 1946 Dr. D.C. Salmon brought to the U.S. a collection of Japanese wheats, one of which, the Norine wheat variety, had genes which confer a dwarf and non-lodging plant habit (USAID, 1969b; IARI, 1968; Ganderson, 1969). This discovery opened the door to the reconstruction of the morphology of the wheat plant. A plant type was evolved which

..... had shorter, stiffer straw and consequently did not lodge at high levels of fertilizer,

..... had a big head,

..... had maximum tillering,

..... gave higher yields at all comparable fertility levels,

..... was adapted to a broad geographic area because of non-sensitivity to day length, but which

..... required careful attention to agronomic techniques such as depth of sowing, frequency and timing of irrigation, and pest and disease control.

Research work was carried on in Washington State in the U.S. where the Gaines variety was developed in 1961 and in Mexico, where the Lerma Rojo and Sonara varieties were developed simultaneously in the Rockefeller Foundation program.

Similarly, the development of two HYV of rice were evolved in the Far East (Hopper and Freeman, 1969; USAID, 1969c; Freeman, 1967). Taichung Native-1 was the first outstanding dwarf and photo-insensitive rice developed from indica varieties. This work was carried on in Taiwan. The series of IRRI varieties were developed from a collection of dwarf materials at the International Rice Research Institute in the Philippines.

Indian wheat research, which produced a series of improved varieties over the years, dates back to establishment of the Pusa Institute in Bihar about the turn of the century. Although activity in rice research also dates back to the turn of the century, the real beginning of progress dates to the establishment of the Central Rice Research Institute in Cuttack in 1946. ADT-27, the primary variety of paddy used in Madras state, resulted foom this program.

However, the significant progress in the Indian agricultural research programs can be dated beginning with the formal establishment of the all-India coordinated cereal improvement schemes beginning with maize in 1957

and the reorganization of the ICAR to provide more effective central financing and coordination of research in 1966. As a result of these programs, 10 hybrids and 6 composite varieties of maize, 4 hybrids of bajra, 2 hybrids and 1 open pollinated variety of jowar, 6 major varieties of wheat, and five major varieties of rice (plus ADT-27) have been released. At present, there are ICAR coordinated research projects in 21 areas of the crop sciences, 9 areas of soil sciences, soil fertility, soil and water management, agronomy, and agricultural engineering and 23 areas in animal sciences.

In summary, the initial thrust of the New Technology was based largely on germplasm developed abroad. However, India is closely associated with the international scientific community and has a long-standing and improving research facility of her own. With the exception of TN-1 and IR-8 varieties of rice, the major HYV presently grown in India have either been developed in India or adapted from the original material to better match Indian conditions.

2. Research Funding

In determining a policy for research and investment in agriculture, we must look at two aspects:

..... the level of expenditures

..... allocation of expenditures within the total.

a. Aggregate Investment

By almost any criterion agricultural research has not had a priority position among public finances in the past.

Total yearly expenditures by the Central Government on ICAR, IARI and CRRI, and central commodity committee schemes averaged about Rs.5 crores annually during the early 1960's.2/ The expenditure amounts to less than 0.1 per cent of the income from agriculture. Furthermore, food and agricultural research accounted for only 13.5 per cent of expenditures of the Central Government on scientific research according

---

2/ From this point on, this section borrows heavily from Herdt (1968).

to the controlling ministries in 1964-65.3/

If one needs further supporting evidence, Table 21 shows the relatively low priority placed on agricultural research in India as compared to other developing and developed economies.

To my knowledge, no comprehensive study of returns to agricultural research has been carried out for India.4/ The Indian programs in maize, jowar, and bajra would provide excellent conditions in which to carry out such studies. Very rough calculations by Cummings and Ray suggest that the research and technology embodied in the HYV programs (including the higher NPK consumption) has contributed approximately 3.6 and 6.5 million tons additional foodgrain production during the first two post-drought years of the program, 1967-68 and 1968-69 respectively (Cummings and Ray, 1969a; Cummings and Ray, 1969b). This would suggest a return of many hundred per cent to the small level of expenditures.5/

In summary, the aggregate amount of money allocated to Indian agricultural research appears to be low relative to the returns from past activities as well as the future job that must be done. This should be a major priority research area for the future.6/

3/ "...compare the paltry Rs.25 crores originally set apart in the Fourth Plan for the Indian Council of Agricultural Research, with the lavish Rs.50 crores earmarked for the Department of Atomic Energy, or for that matter the generous sum of Rs.24 crores allotted to the Ministry of Education for anthropological, botanical and allied activities of the department of science, which is, of course, quite in addition to the Rs.46 crores provided for the programmes of the CSIR."(Thaper, 1968).

4/ The classic study of the rate of return to research was carried on hybrid maize development in the U.S. by Zvi Griliches (1958b) "After totalling the aggregate returns from use of hybrid corn and the aggregate costs, including those of research failures in this area, he calculated a return of 700 per cent per year as of 1955. Since Griliches' figure includes the cost of a substantial amount of basic research on the hybridization process itself, it is likely that the rate of return to research designed to adapt hybrid maize to the conditions of other areas and countries would provide even higher returns" (Mellor, 1966).

5/ It should be noted however, that these initial contributions were the result of research primarily carried out abroad - which were quickly adopted by Indian research programs.

6/ A part of this research activity might dwell on the absorptive capacity and shape of the function governing future returns. Certainly one of the primary reasons for the low levels of past research funding was the limited number - compared to requirements - of trained scientists and laboratory facilities. Some organizational problems still remain. However, the expansion of physical facilities and trained manpower available for agricultural research, most particularly in the form of the new agricultural universities, has increased several times since the early 1960's.

Table 21

Government Agricultural Research Budgets
and Agricultural Research Workers

Country	Year	Cost per Farmer	Cost per Person in Population	Research Budgets ($1000 US)	Research Workers per 100,000 people Active in Agriculture
Thailand	1960	$ 0.05	$ 0.02	564	4.7
Taiwan	1960	0.49	0.07	735	7.9
Philippines	1960	0.27	0.05	1545	1.6
Mexico	1962	0.35	0.06	2100	3.8
India	1960	0.05	0.02	6843	1.2
Japan	1960	0.69	0.13	12558	60
United States	1961	45.90	1.35	250000	

Sources: Mehren, 1967; Hendrix, et. al., 1966.

b. Allocation of Research Expenditures Among Crops

Table 22 lists the allocation of selected research expenditures among different agricultural crops for the average of 1962-63 to 1964-65 compared to various criteria which might be relevant.7/

Several trends are readily suggested for the period of the first three Five Year Plans:

1. The foodgrains have received less than a proportionate share of research expenditures by all criteria;

2. The one foodgrain which has appeared to have a relatively strongly financed research program, maize, also has resulted in several hybrid varieties developed in India which have had a considerable impact in maize growing areas;

3. Pulses had almost minimal research support.

c. Conclusions from Review of Past Research Funding

The two conclusions which appear to be suggested from this casual review are that:

1. The total amount of agricultural research funding appears to be conservative.

2. It is not at all clear what is the rational procedure for allocating the aggregate among the component parts.

3. Implications for Future Research Investments

The HYV themselves appear to have provided the stimulus to improve the level and allocation of research funding. Under the all-India Coordinated Research Projects in the Fourth Five Year Plan Draft the foodgrains receive an annual average outlay of Rs.11,200,000 which is almost equal to the combined total for commercial and horticultural crops. Among the individual crops, the relative level of research funding for pulses, in particular, appears to have been raised. An additional Rs.18,800,000 is allocated annually for research on soils, agronomy, engineering, agricultural meteorology, and agricultural science technology. In all, the outlay for agricultural education, research institutes, and research schemes - for agriculture, animal sciences, and research statistics averages Rs.170,000,000 annually for the Fourth

---

7/ This table was compiled by Herdt (1968). His paper discusses, in more detail, the sources of data and the relevance of each of these criteria.

Table 22

Selected Research Expenditures Compared to Various Criteria[1]

(Total Yearly Expenditure based on Average of Selected Years 1962/63 to 1964/65)

Category	Research Expenditures(Rs.)	Percentage of the Total			
		Agrl. Research Exp.	Value of Agrl. output[2]	Agricultural Exports[3]	Agricultural Imports[3]
Rice	1,429,890	5.25	35.3		
Wheat & Barley	1,355,385	4.79	10.5		
Millets	1,240,246	4.55	10.4		
Maize	1,878,244	6.89	2.1		
Pulses	26,602	0.10	8.6		
TOTAL FOOD GRAINS	5,930,367	21.77	66.9		62.7
Sugarcane	1,510,564	5.54	8.7	3.8	
Potato	956,000	3.51	1.0		
Oilseeds	3,150,110	11.56	9.9	8.1	1.3
Cotton	2,521,448	9.25	2.8	15.9	17.1
Jute, Mesta	3,030,000	11.12	1.7	33.1[5]	1.5
Tobacco	2,157,305	7.92	1.9	4.0	
Rubber	224,124	0.82			3.3
Coffee	2,263,666	8.31	3.6	2.0	
Tea	621,995	2.28		24.1	
Miscellaneous Crops[4]	4,876,944	17.90	15.1	9.0	9.4
TOTAL NON-FOOD GRAINS	21,312,239	78.23	33.1	100.0	32.6
GRAND TOTAL	27,242,606	100.00	100.00	100.0	100.0

1/ This table excludes Animal Husbandry Research and discipline identified research.

2/ India, 1966c.

3/ India, 1965d.

4/ Includes: Fruits and Vegetables, Coconut, Spices, Nuts, Pastures, Legumes, Fodders, Arecanut, Lac, Floriculture

5/ Jute yarns and manufactures and coir yarns and manufacturers.

Five Year Plan period. This funding appears to be a more pragmatic level and allocation than during previous periods. However, it still is well below the needs of the economy. It is anticipated that the level of funding will be increased as the financial resource position of the economy eases and the quantity and quality of skilled scientists and research facilities increases so that the larger funding can be absorbed effectively.8/

We do wish to address ourselves first to a question which is receiving increasing attention after the recent 1968-69, which largely due to poor rainfall, was below expected production estimates (Cummings and Ray, 1969b). This problem involves the persistent pressures to devote more research attention to dry-land agriculture.

As of today, there is no "new technology" applicable to dry areas which even remotely promises the quantum jump in yields that have been associated with the HYV on irrigated lands. The hybrids of bajra and jowar are generally found to be superior to local varieties under moisture stress conditions during 1968-69. This tolerance has the advantage of reducing the risk from unfavorable rainfall in sowing these hybrids.9/ However, the real differences in yield would appear when rainfall was adequate and fertilizers are added under these unirrigated conditions. The risk of growing HYV of maize, rice and wheat on barani lands, especially when one considers the generally higher input costs, can be more significant.10/ There do not appear to be any startling new barani varieties of pulses or oilseeds, the other major crops generally grown under rainfed conditions.

Furthermore, the scope for dramatic new increases in yield potential for varieties bred specifically for barani conditions - at least in the short-run - while considered essential, is not encouraging.11/ The

---

8/ The paper by Russell and Brinegar (1969) provides more detailed recommendations for research strategy.

9/ On the other hand, other problems, such as the susceptability of jowar to shootfly, must be overcome before there will be wide acceptance of HYV jowar and bajra even in the barani areas. In fact, water availability is necessary in order to get the hybrid jowar quickly past the shoot stage so that it is no longer attractive to shootfly. The other alternative is earlier sowing in order to avoid periods of insect concentration.

10/ Even in these crops, certain varieties such as Kalyan Sona and Chooti Lerma wheats and possibly TN (1) (Swaminathan, 1968) and IR-8 (Parthasarathy, 1969) appear to yield reasonably well in barani areas. The HYV are of more vigorous genetic stock and, with fertilization, aggressively extend their root system so as to make more efficient use of available sub-surface water.

11/ In this regard, the excellent article by Asana (1966) is recommended. See also the papers presented at the Symposium on Planning for Drought Areas (NIS, 1969). The ideal wheat variety for maximum yields under dry conditions would be a low tillering plant with five to seven horizontal leaves, a deep root system, and a very large seed head. However, while this plant structure would maximize yields under very dry conditions, it would inhibit the plant from taking advantage of the better-than-average rainfall years. It is debatable whether average yields over time would be improved by this plant structure except in consistently dry areas. In these consistently dry areas, another crop such as bajra, minor millets, or pulses might be economically preferable.

previous work on hybrid bajra (H.B.1) and jowar (C.S.H.1) and some possibility of developing shorter duration pulses are the most obvious results to date.12/

This is not to argue that genetic breakthrough will not occur if sufficient attention is directed toward any problem. Because of the large acreage sown under rainfed conditions, the large number of people involved, and the threat of further widening of income differences, between irrigated and non-irrigated areas if no solution is found, the problem must be researched. However, the basic fact remains that plant growth requires water, at key timings, for maximum production.13/ As long as researchers stick to a single crop, the genetic opportunities are limited. A more promising path for research might be to focus on crop and varietal selection for specific moisture conditions and use this information as a basis to identify suitable cropping systems for specified areas.14/

A second point which should be noted in the future research planning for agriculture is the quality of the diet. Nutrition can be upgraded in any number of ways including increasing availability of "protective foods," (i.e., pulses, fruits, vegetables, meats), upgrading the quality of foods which presently constitute a significant portion of diet (i.e., higher lysene wheat or maize), or artificial fortification of existing foods (i.e., supplementing atta or fortifying salt with iron). All of these routes should be considered - and the plant breeders in India have not as yet been paying sufficient attention to this problem.

A third point is that research, perhaps more than any other investment area with the possible exception of infrastructure, is a public investment activity which has far-reaching spread effects on future private investments. The very dramatic impact of the HYV should not be forgotten in this most significant respect.

In conclusion, now is the time to increase the pressure of research investment to strive for higher yields, better quality diet, seeds adaptable to new areas, and to stay ahead of rapidly adapting diseases and pests. If any one variable can be cited as crucial to future achievement of a sustained higher level of agricultural growth and development, research would have to be the prime candidate.

12/ The short 90-day duration of hybrid bajra which enables it to make maximum use of available moisture during limited periods when it is available, is one of the major reasons for its popularity.

13/ The timing as well as overall quantity of water is critical if one stays with a selected species. For example, one irrigation at the crown root stage in dwarf wheat can add up to an additional tonne per hectare to yields of dwarf wheats (Hopper, 1968). Other key periods are when the plant is flowering and when the "milk stage" in heading is in process.

14/ For example, if rice prices drop we might expect rice to be concentrated more on irrigated lands while marginal producers shift to other crops such as minor millets to get higher incomes and buy rice on the open market. Furthermore, we might expect more pulses and cane to be grown on irrigated land which traditionally has been sown to wheat in north.

B. Agricultural Education[15/]

Certainly the promise for the future in agricultural education lies with the new agricultural universities. The first was opened in 1961, nine are presently functioning, and a tenth university (Assam) is being organized.

Agricultural universities represent an attempt to introduce the land-grant philosophy into Indian education providing linkage between teaching, research and extension with appropriate influence on public policy. By recruiting many of their students from farm communities the universities hope to be able to build a continuing relationship with farmers. Their program is new but already solid achievements are being made. Some 7300 graduates came out of agricultural and veterinary colleges in 1967-68. Of these almost two-thirds are taking jobs in agricultural universities, in agricultural research stations, with government agricultural offices or with the extension service. By the end of the Fourth Plan (1974) nearly 25,000 students will graduate annually representing a growing infusion of human capital to the sector.

The agricultural universities participate in the all-India crop development projects and in addition undertake research of their own directed toward more specific local problems. Both Punjab Agricultural University and U.P. Agricultural University have become very active research centers. Both of these institutions have strong plant breeding programs and have released new wheat, millet, and maize varieties. The Jawaharlal Nehru Agricultural University (Jabalpur), for example has done important work into multiple cropping of paddy.

Perhaps, the greatest problem still facing the agricultural universities is the method by which to work out a direct relationship with the extension service. Most of the universities have started extension education programs with some degree of coverage in certain blocks and districts of their states but only Punjab Agricultural University and Uttar Pradesh Agricultural University, to a somewhat lesser extent, have gone much beyond this first stage. Such a relationship must be fostered so that a continuing two-way flow of information can operate between farmer, research and extension. The U.S. Land Grant Colleges were built on a very successful integration of teaching, research, and extension in an environment in which the limits of the classroom were the borders

---

15/ The most comprehensive treatment of the Indian agricultural universities is by Naik (1968).

Previous Page Blank

of the state (and today, the borders extend to the nation and the world).16/

Yet, as one considers the future investment program for agricultural education, one is struck by the seeming contradiction between two observations:

- the number of agricultural graduates, trained in a manner so they can make a practical application of their trade, as compared to the total population of the country or to that of the agricultural sector in more developed countries, is very low;

- yet on the other hand, the return on investment in man versus investment in machines in India also appears to be low. 17/

16/ One way to state this problem in terms of division of responsibilities might be as follows:

1) Universities:
   a) are responsible for extension education
   b) provide subject matter specialists at the district level

2) State departments of agriculture furnish:
   a) village level workers and block development officers;
   b) extension structure even up to the district level.

3) The problem is how to create 1) and then get 1) and 2) to interact: The Field Operations Unit sponsored by USAID is one attempt.

17/ Harberger (1965):
- estimated rate of marginal productivity of capital in Indian industry, 1955-59 (in percentages) - assuming that 20 percent of wage bill represents the excess of actual wages over alternative marginal productivity of labor - to be
  17.2 to 26.1 percent or
  13.0 to 19.3 percent if uncorrected for market imperfections.

- estimated rates of return to investment in education in India to be:

1) graduate-post graduate compared with primary	14.1 to 15.0 percent
2) secondary compared with primary	10.0 to 11.9 percent
3) graduate-postgraduate compared with secondary	16.3 to 16.9 percent

- these estimates, of course, depend very heavily on the assumptions which were used.

In essence, the observations might suggest a general reappraisal of educational priorities in terms the role of education in economic development with particular attention to general goal of training an educated citizenry but also to the more specific goal of manpower planning to train graduates for priority needs of the developing society. It would seem - on the basis of casual observation - that agricultural education would rate high on both counts. 18/

C. Extension

The following provocative generalization are offered:

- extension played only a limited role in India's agricultural development through the first three Five Year Plans - the changes in technology were gradual enough so that they did not excite the cultivator to make radical changes, the extension staff was of generally low quality.

- extension has played a limited role in introducing the new technology, particularly in the wheat areas. By and large the quantum jumps in technology have been so obvious that cultivators immitating other cultivators (the early adopters) has been a sufficient mechanism to adopt and extend the technology.

- however, extension must play a key role in the future if the growth and equity targets of agricultural development are to be achieved. The problems will be getting harder. The early successes in wheat were relatively easy. The new technology must now be extended more aggressively to paddy, where the water management problems are more demanding, to the hybrids, to the dry lands, to the smaller cultivators, and even to wheat where future disease or pest problems may appear. The new technology is more complex than were traditional methods; maximum yields require precise operations which are learnable through effective extension.

18/ For a series of studies addressing different aspects of this policy problem see: Grilliches, 1958; Heady, 1961; Schultz, 1963; Becker, 1962; Becker, 1964; Grilliches, 1964; Harbison and Myers, 1965; and Anderson and Bowman, 1965.

The Intensive Agricultural Districts Program (IADP) was set up in 1960, assisted by the Ford Foundation, to induce cultivators to adopt a package of improved agricultural practices in order to bring about a significant increase in yields per acre. The package of improved agricultural practices really became effective with the introduction of the fertilizer responsive varieties of the five major foodgrains. There has now been a sufficient history of experience so that lessons can be learned from this program. 19/ The agricultural universities also introduce a new resource on which to build. 20/

One of the difficulties facing the extension programs in the past and just as important for the future is the very thin information base, particularly at the cultivator level, on which to develop an extension program. The basic question of why a cultivator adopts this process rather than that one is still largely a mystery. Economics provides a starting point. The cultivator will adopt clearly profitable innovations. However, there is obviously more than this - and these questions must be answered soon in order to avoid serious future problems. 21/

19/ For different interpretations of the effectiveness of and lessons learned from IADP see Brown, 1967; Desai, 1969; and India, 1969. Modernizing Indian Agriculture, Report of the Intensive Agricultural District Program (1960-68), Volume I, Expert Committee on Assessment and Evaluation, Ministry of Food, Agriculture, Community Development, and Cooperation (Department of Agriculture), 1969.

20/ The very success of the agricultural universities is causing many cultivators to by-pass the extension agents to come directly to the university for latest information.

21/ For efforts in these directions see Fliegel, Roy, Sen, and Kivlin, 1968; Shetty, 1969; Indian Institute of Management (Ahmedabad), 1968; and UPAU, 1969a.

IX. SOCIALLY ORIENTED PROGRAMS[1/]

The New Strategy appears to be a sound basis around which to build future agricultural development programs. The cultivators with unirrigated land and the small holders are already enjoying directly some of the benefits of the new technology. Furthermore, a demonstrated method of raising the standard of living of some of the lower income groups is through the "trickle-down" effects of faster economic growth.

However, to the extent that these general, production-oriented programs do not extend income gains to all regions and economic groups, then explicitly socially-oriented programs should be developed. The social aspect of these programs should be openly acknowledged and political and social costs and benefits should be weighed explicitly along with the economic analysis.

This policy area, perhaps even more than the others, must receive increasingly imaginative conceptual and empirical research in the near future.

A. Dry Lands

The short-run outlook for a "new technology" especially suited for dry lands was discussed in the previous section on research and technology; prospects for a dramatic genetic breakthrough comparable to that for irrigated lands are not promising.

More effective land preparation with an emphasis on soil moisture conservation is one possibility for improving production on rainfed lands. The traditional methods of ploughing have been at shallow depths leaving a hard pan of earth, which inhibits both water and root penetration, at six to twelve inches depth (Swaminathan, 1969). Effective land preparation would involve deep ploughing in order to break this hard sub-surface and allow root and water penetration. However, such soil preparation generally would require a large investment in mechanization. For example , the black cotton soils in south central India which cover almost 10 million

---

1/ This term was suggested by Erlenkotter and Lubell(1969) to apply to programs whose objective is not necessarily to give the greatest return in terms of national output over a given period. In their language "....programs which have other primary goals, such as increasing employment opportunities and real consumption of the backward groups in the country. This....approach raises a different issue, namely the cost of a socially oriented set of programs in terms of growth foregone because resources are consciously being used less efficiently than they would be in an economically oriented program.. Opting for a socially oriented program may, however, be rationalized on economic grounds as insurance against social unrest which by itself could prevent future economic growth".

acres are most productive in the kharif period when the soil is wet and heavy. These soils cannot be worked when they are dry because of the heavy, adhesive characteristics. Fertilizer could also be more effectively placed close to the root system by drills but this again would require tractors. The capital costs of these programs should be weighed against alternative uses in any planning process.

Perhaps the simplest method would be to increase the use of fertilizer even on the rainfed lands. For example, one might recommend 40 lbs. of nitrogen plus some P_2O_5 for rainfed lands in which there is initial ground moisture. Some rains will give profitable fertilizer response. Good rains, as occurred during rabi 1967-68, can give results comparable to irrigated conditions especially if extra nitrogenous fertilizer is added after it is obvious that moisture is sufficient. Even if no rains follow, the fertilizer will not be a complete waste since some, particularly phosphorous, will carryover for the next year.

Each of these programs previously mentioned - plant breeding, land preparation, or more fertilizer - would have some pay-off. A series of other marginal programs can be tried under specific conditions (NIS, 1969).

However, the most obvious high-payoff policy would be to aggressively extend irrigation. This could be done either through further developing groundwater potential or by increasing surface water storage through various methods of "water harvesting" during wet periods[2/]. The presently unutilized potential for future irrigation development is shown in Appendix J. This would be a "fresh approach" only in the sense that one is using a new slogan to do more of what was previously done. Some areas would still be outside the possibility of high crop growth potential. The other approaches - some with admittedly low economic payoffs - might be applied to these areas. Conservation management with the objective of effectively using very dry lands for grazing should be carefully considered (Jodha, 1969). Even small increases in yields or output of animal products, when applicable to 80 per cent of total area, aggregate to large potential total production increases. However, again it should be emphasized that sights for success cannot be realistically set very high, especially when one examines the individual farm level.

2/ While most attention has been focused on dry areas, the very wet areas also pose production problems which should not be overlooked in any balanced analysis. Here again crop and varietal selection by ability to stand excess water plus experimentation to change sowing dates so that plants need not be in the fields during flood potential periods might be added to flood control and drainage programs in any policy package.

In the last resort, the dry lands problem will have to be attacked by means of a systems approach making full use of all resources. These are areas where agriculture, most probably, will not be the leading growth point. Other activities, such as mining or tourism integrated into a comprehensive strategy, which might even include out migration, should be considered in coordination with the agricultural development.

B. Small Farmers

The limited evidence regarding the extent to which small cultivators were participating in the New Strategy was reviewed in sections II and III.

In summary, there do not appear to be an insurmountable scale problems in the new technology that bias it against small farmers if they have the resources to take advantage of the new production potential[3/]. However, the small farmer does face problems in gaining access to these resources from his own profits under traditional techology. Cooperative credit, which might provide a route, has generally been made more easily available to larger holders partly because the small farmers do not qualify by bankable standards, partly because of the "closed-shop" operation of many cooperatives[4/]. Another alternative, custom-servicing of mechanization and rental of excess water has not as yet been extensively developed over India.

Therefore, the solution to the small fermer, at least the potentially economically viable smaller farmer, is not to develop a different technology, but to give him the resource base to be able to participate fully in the available technology in the New Strategy.

The Small Farmer Development Agency which has been recommended by the All-India Rural Credit Review Committee and included in the Fourth Plan is a start in this direction. It will have the major objective of assisting high potential small farmers pass from the stage of subsistence agriculture to that of commercial farming. The major role of the Agency is to ensure that the small farmers receive the services and supplies required by them. Anticipated activities include:[5/]

3/ In this regard the paper by S.S. Bains (ISAE, 1968), discussing scope for substantial improvements in total production within relatively small holdings is also of special interest.

4/ For example the Rural Credit Survey Report found that in 58 out of 75 districts, more than 60 percent of the total dues were owed to the group of farmers classified as "large cultivators".(INDIA, 1957)

5/ This list is only suggestive since the Report of the All-India Rural Credit Review Committee has not yet been released and the details of the scheme have not yet been finalized.

1. Provide grants to credit institutions which will underwrite "higher risk" loans and will lead to hiring of special staff to supervise credit in order to promote the increased flow of credit to small farmers,

2. Provide equipment to sink private tubewells, organize cooperative utilization of public tubewells and otherwise make irrigation more generally available to small farmers,

3. Ensure that small farmers obtain improved seed, fertilizer, and other inputs in the required quantities and at the right time from the local sales depots of cooperatives, Government or private retailers,

4. Provide custom servicing of mechanization such as spraying of insecticides, tractors, and land levelers.6/

5. Provide farm management advisory services, and

6. Encourage supplemental activities such as dairying and poultry.

During the Fourth Plan, pilot projects in 30 districts are proposed to be established. The scope of activity and method of operation in each location will be determined both by needs and services already provided. The Agency will endeavor to see that provision of the various services and supplies, is, as far as possible, ensured through existing institutions and authorities. It is only where this is not possible that the Agency will undertake such activities itself. At a minimum, it will provide a voice for the small fermer. At the maximum, it may assist many small farmers to make the transition from subsistence agriculture.

C. Tenants and Rentiers7/

One of the earliest and strongest objectives of independent India was agrarian reform. Many creditable programs have been implemented. The

---

6/ Programs of cooperative water distribution and custom servicing of mechanization would enable small-holders to enjoy the benefits of these capital inputs which are necessary in order to stay competitive without being over extended in debt and hence vulnerable to rapid changes in technology, cropping patterns, and prices.

7/ This section has benefitted substantially from several articles and unpublished papers by Wolf Ladejinsky (1964, 1965, 1969). Other pertinent studies and articles include R. Krishna, 1959, 1961, and 1962; P. Raup, 1963 and 1967; Desai and Mehta, 1962; Dandekar, 1968; and Shiva Maggi, 1968. The recently completed but yet unpublished study evaluating land reforms in the Western region of India by Dantwala, Shah, et al (1969) is perhaps the most comprehensive and current of the available studies.

zamindari system, which affected some 20 million cultivators and at one time affected 40 per cent of cultivated land, was abolished. Reforms in the "ryotwari" areas have benefitted another 3 million tenants and share-croppers. Land consolidation has made steady progress. More recently, ceilings have been placed on the size of land holdings in all states and rent ceilings have also been established in all states.

Under the Indian Constitution land reform is a state problem. Outside of broad general principles of legislation directly bearing on distribution of land resources and of land, tenancy relations are under control of the several states. Consequently, while the main features of the reform legislation in different states is practically identical, there is a wide difference in the scope of the work actually undertaken.

As a result of a series of investigations and personal observations, it is generally conceded that the reforms are not completed. For example, while rents may be limited by law to one-third of the crop in a given state, personal observation uncovers many cases where this law is overlooked. Furthermore, land ownership can be divided among members of a joint family so that each of several members can own up to the legal size holding with the result that the total family holding is several times above the legal limit8/. Furthermore, the large number of evictions - many justified on the grounds of a "reform" provision which encouraged the right of land resumption for self-cultivation - and the so-called "voluntary surrenders" of land which were especially prevalent during the 1950's give visible evidence that security of tenure is not an accepted fact of life in India.

Under the conditions prevailing before the introduction of the new technology, some observers have argued that the weaknesses in tenancy, rent control, etc. have not had major economic significance.

However, the problems of land tenancy and ownership have acquired special significance with the recent technological advances in agriculture. Land cultivated on tenancy or rent arrangements can enable the cultivator

---

8/ Perhaps the most attractive policy to discourage larger holdings in the future - while at the same time, encouraging greater efficiency by cultivators who insist on retaining their large holdings - would be the progressive land tax. Thus far, this policy has received little support from the states.

to enlarge the scale of his operations to economically justify mechanization and his own water supply. However, the increased productivity of the HYV has also led to a trend of rising rents, or in the absence of income from this source, the reclaiming of land for owner cultivation. As a result, both the returns from and security of rented and leased lands apparently are decreasing.

A cultivator who does not have security of tenure or must pay a high proportion of output in rents is less likely to:

.....invest in land improvements,

.....adopt high yielding varieties, or

.....use inputs up to optimal economic amounts (Minhas and Srinivasan, 1966)

In order to safeguard the interests of the tenants, the Chief Ministers Conference in July 1967 recommended the following:

1. Tenants in cultivating possession of land should not be disturbed and should be given complete security of tenancy by:

   a. staying all evictions,

   b. suspending right of resumption where such right has been given to land owners, and

   c. regulating voluntary surrenders in such a way that land owners do not get an advantage by persuading tenants to surrender their tenancy;

2. The rate of rent should be reduced to the level of 1/4th or 1/5th of gross produce so that the tenant is in a position to make improvements on his lands;

3. Record of tenancy should be prepared as a special operation and maintained up-to-date;

4. Special attention should be given for ensuring credit and other facilities to tenants and small holders for increasing agricultural production.

Since then all states and especially those non-Congress government are presumbaly giving closer attention on the tenurial problems. In 1967 about 2 million tenants and share-croppers have acquired ownership of more than 7 million acres.

D. Non-viable Small Farmers and Landless Laborers

Basically the non-viable small farmers fall into the same category - for the purposes of policy analysis - with the landless laborers. Unless he is forced to sell output in order to pay debts, production is primarily for consumption. Generally, the small, sub-marginally productive holdings do not fully employ the full family labor available, therefore extra income is gained by hiring out as labor for larger farms. Therefore, if the prospect for increasing yields on these farms is limited (which it is by definition), the potential solution to their problem must be on the labor front.

Furthermore, while this conclusion is still open to careful analysis, it is doubtful that the agricultural sector will create sufficient new employment to fully employ the expanding rural labor force within the agricultural sector[9/]. To quote Ladejinsky:

> "It (the demographic picture) casts a dark shadow on the future of the great mass of cultivators and on India as a whole....."
>
> "In 1961 the agricultural labor force was estimated at 132 million, or 70 per cent of the total. Based on the current projections of population growth, the figure will increase to 192 million in 1976 and 219 million in 1981. This in turn is based on the assumption, supported by the experience of 1951-61, that despite the country's economic development, the ratio of the agricultural labor force to the total will remain unchanged. All this means is that in order to maintain the ratio of farm labor-force at the 1961 level'the non-agricultural sector will have to absorb an additional 26 million persons between 1961-1976 and 38 million between 1961-1985'. Judging by the growth of employment from 1951 to date this absorption is not likely. In fact, the prospect is only one of maintaining the ratio of farm labor-force to the total at the level of 1951-61. If so, rural India is being faced with the problem of additional 60 to 80 million people within a short period of 15-20 years".

9/ We do intend to explore this assertion more carefully.

Additions to land through new acreage brought into cultivation and through multiple cropping are estimated to add only 0.8 per cent annually to gross area sown (Appendix K). Therefore, the land-man ratio will inevitably decline.

> "Unless, therefore, a fresh combination of science and technology of an extra-ordinary fruitful nature takes place, the consequences of existing demographic conditions can have very serious effects on farm incomes, general welfare of the farm population, and relationships within the agrarian structure. It follows that anything India can do to lessen the adverse impact of many people on little land is a step that must be undertaken".

The traditional solution to this problem has been to attempt to accelerate the rate of growth of the non-agricultural employment, particularly modern industry, in order to provide a productive outlet for rural migration. However, a non-agricultural sector with the labor/capital ratios which are characteristic of modern industry even growing at six to eight per cent annually creates surprisingly few new jobs.10/ (Mahalanobis, 1955)

A second potential solution is to encourage intermediate-level, labor-intensive technology probably combined with a rural centering focus of rural development (J.P.Lewis, 1963). Ludhiana is one example where small scale industry has even led to agricultural labor shortages in the surrounding rural countryside. Quite obviously, the strengths and weaknesses of this scheme require careful, detailed study.

A third possibility is for an aggressive expansion of rural works. The scope for this policy must be examined on two sides, (1) the supply of labor, and (2) the demand for rural works.

10/ If maximum advantage is to be made in increasing employment, particularly from the viewpoint of the lower income groups, a strengthened program of primary education must also be carried out in order to increase the skills and mobility of the low-end poverty groups, those who more than proportionately do not ordinarily receive much education, so that they are better able to participate and climb the occupational ladder

The analysis of the supply of labor has revolved around the controversy regarding whether agricultural labor in India has a zero or very low marginal productivity in present occupations, i.e., whether there is "surplus" labor which could be removed from agriculture without decreasing agricultural production. The arguments have covered definitions as well as empirical evidence but the general conclusion appears to be that although the marginal productivity of agricultural labor in India is positive, there are, at the minimum seasonal periods when there is sufficient labor available to mount large rural works programs[11/]. This conclusion is supported by such other evidence as personal observations and analysis of changes in off-season wage rates.

With regard to the demand for rural works, there would appear to be numerous possibilities for the development of an expanded rural and national road system, surface-water storage, rural and urban drinking water, godowns and warehouses, education and health[12/].

Basically an aggressive attack on a rural works program has been withheld for two reasons in the past:

> .....the potentially inflationary impact of generating immediate demand while the resulting supply would come only after a substantial gestation (V.K.R.V. Rao, 1952).
>
> .....the high cost of the program.
>
> .....corruption.

The promising agricultural potential resulting from the New Strategy can be used to advantage to overcome the first problem. If this is not feasible, it may be possible to obtain concessional food imports.

11/ There is an extensive literature on the marginal productivity of labor which can be divided into conceptual and theoretical discussions of the concept (W.A. Lewis, 1954; Nurkse, 1953; Eckaus; 1955; Nakajima, 1965; Raj, 1959; A.K. Sen, 1966; and Mellor, 1963), empirical studies (Hopper, 1965a; Mellor and Stevens, 1956; Mazumdar, 1959; Majumder, 1960; Mellor and Moorti, 1961; Schutlz, 1964; and Paglin, 1965) and descriptions of seasonal demands (Billings and Singh, 1969; Hopper, 1955).

12/ One list is developed by Erlenkotter and Lubell (1969).

The second "bottleneck" is somewhat puzzling. On first impression one might think that rural works projects could be very labor-intensive. However, Indian construction programs do not appear to follow these factor proportions.13/ The reasons for the relatively low labor content in Indian rural works programs should be investigated more carefully. Our feeling is that the "labor intensity" could be increased substantially, without necessarily sacrificing quality, if different techniques (which might not be justified if the labor were costed at the going wage rate than at zero cost to society) were used.

The problem of corruption is more difficult to attack. Effective supervisory personnel are scarce. While the possibilities for corruption are abundant in such dispersed types of programs, the cost of these malpractices may be more than offset by the benefits derived from a more aggressive program 14/. A final possible policy to raise rural labor income would be to encourage growth of labor-intensive agricultural activities as dairying and vegetable growing. Dairying is an especially attractive possibility because there is a high income elasticity of demand for milk, the buffaloes and cattle can be grazed partly on available pastures (which do not necessarily have to be owned by the dairy producers), and Harijans and other under-privileged classes can participate as a means to supplement labor income. Such a program would most probably have to be organized on a cooperative basis in order to arrange low-cost fodder for supplementary feed, and to effectively organize milk pickup points15/. Poultry raising for either meat or eggs, again which requires minimal land ownership, also falls within this category. These operations are not meant to compete directly with commercial enterprices; the economics are based on assumptions of low-opportunity costs for labor and no rent for land (i.e., these are basically scavenger activities).

13/ ".... in practice there are serious limitations on the extent to which non-labor expenditures can be avoided if significant physical results are to be obtained. The wage and salary component of our suggested programs would be in the neighborhood of 40% of total expenditure. This is a weighted average for the different parts of our programs and happens to be close to the labor share of aggregate construction costs for the economy as a whole, since the latter has a large component of industrial plant and housing which use a relatively low labor input and high material inputs". (Erlenkotter and Lubell, 1969).

14/ In other words, the net costs of the corruption may be very small, there may be even net benefits.

15/ If this policy was followed, several interesting problems in milk distribution must be researched (Nightingale, 1969; UPAU, 1969d.)

E. Public Foodgrain Distribution

One objective of any agricultural development program is to prevent starvation and malnutrition. A Public foodgrain distribution system. Perhaps even run at a subsidy, is a necessary complement to the private market in order to ensure minimum food availability to the very low income groups. It is also a necessary component of the total buffer stock program in order to turn over stocks to avoid wastage and enable price support operations to be carried out from one year to the next (Cummings, 1968b).

Krishna (1967b) suggested that every citizen be covered except income-tax paying families, who could afford to pay open market prices, and cultivator families, who would have prior access to the foodgrains.[16/] On the basis of these criteria, he estimates that total distributions for both stability and welfare distribution would have averaged about 16 million tonnes of foodgrains, varying between 3.64 to 19.96 million tonnes or from 5.0 to 26.9 per cent of production between 1951 and 1966.

S.S. Madalgi (1967) challenged the basis of Krishna's calculations. Using different definitions of cultivators and a different multiplier for average family size[17/], he calculated "low-income" populations of roughly half of the population.

These exercises point out the problems with a rigid public foodgrain distribution system based on a low-income criterion:

1. Identification of eligible people;

2. Restriction of distribution only to eligible people without running the enforcement costs up to exorbitant levels;

3. Relationship of the public distribution system with the private market in order that the required volume can be estimated and provided.

16/ The "low income" population in 1961 is defined as total population (439.2 mil.) minus income-tax payers and their families (5.7 mil.) and cultivators and their families (5 times 66.4 mil. or 332 mil.) giving 101.5 million persons or 23.25 per cent of the population.

17/ If the "family size multiplier" for cultivators families is changed from 5 to 3.4, the "low income population" increases to 207.6 million. If the "low-income population" is defined as total rural population minus cultivators and families of wholly or mainly owned land plus total urban population net of 5.7 million income-tax payers and families, the result is 234.6 million people.

We can begin by accepting the present method of public distribution through Fair Price Shops - private traders who sell government stock at fixed prices on commission - as the continuing basis. These shops cover all of India but have tended to be concentrated in cities and larger town and villages.

With regard to volume, the facts of the case are first that the government cannot physically run Fair Price Shop distribution of 1/4 to 1/2 total foodgrain requirements[18], and secondly, the only times that anything approaching this scale of public distribution is needed is when foodgrains are short and prices very high, which really gets to the second part of the public distribution program - the buffer stock component to dampen prices[19].

18/ Marketed surplus amounts to only 30 to 40 per cent of production. To even consider feeding this large a portion of the population would imply government monopoly in distribution. Although the Ashok Mehta Committee in 1954 recommended "socialization" of wholesale foodgrain trade, no effective moves have actually been made to implement such a policy. The marketing cooperatives which were once envisioned to be the instruments of socialization have not proved to be competitive with private trade.

Furthermore, either the costs of such a program - the difference between purchase and subsidized sale price - would be huge or compulsory procurement would have to be enforced at large scale at less than incentive level prices. For example, the subsidy of the public foodgrain distribution program in 1967, which consisted primarily of PL-480 foodgrains was Rs.1,300 millions. This program provided approximately 15 per cent of total foodgrains consumption. Mexican wheat from the 1967-68 crop purchased at Rs.76/quintal was sold at Rs.70/quintal which means a subsidy of Rs.30/quintal (assuming approximately Rs.24/quintal for commissions, transport, taxes etc.) or approximately Rs.750 million for the two and one-half million tonnes procured (India,1967d; India,1968h; India,1966b).

19/ Past experience gives only partial guidance to deriving required volumes for normal public distribution to low income groups.

.....the public distribution programs have heretofore not been restricted to low-income groups;

.....the volumes distributed have been limited by the volumes available which in turn have depended on the amounts on hand in addition to amounts obtainable for soft currency or from domestic production at short notice.

What these past data do show is that net annual volumes of publicly distributed foodgrains have ranged between 1.6 and 14.1 million tonnes during the 1951-1967 period(India,1968i). In only three of the 17 years has the volume fallen below three million tonnes; these were the years 1954-1956, when the index numbers of wholesale prices of foodgrains ranged from 80.8 down to 69.7 then back up to 89.8(India,1968i). In six of the 17 years, the volume distributed was six million tonnes and over; these were the first two years of the First Plan and 1964-1967. During 1953 through 1963, public distribution amounts ranged from 1.6 to 5.2 million tonnes annually.

A basic poverty group - presumably focused on urban areas and rural areas with frequent and wide production variability - should be identified for subsidized foodgrain distribution. A weekly ration based on family size would be determined and the foodgrain price to eligible people would be set sufficiently below market prices so that there would be little question of these people entering and leaving the private market. Presumably they would have very limited incomes and the support price activities would price them out of the market. I would suggest that the volume needed to supply this group is approximately three to five million tonnes of foodgrains.

The public volumes calculated on this basis most probably should increase as population rises (adjusted for urban migrations) i.e., in the order of three per cent a year. Any trend is obscured by the fluctuating production outcome and the institutional measures adopted to meet the changing availability. This projection, of course, depends on the trends in agricultural production and in income distribution.

F. Concluding Comments

At the end of this review, we must ask ourselves what we can really expect to accomplish from these many and assorted programs. At the minimum, there may be some improvement in income distribution. Also India can "buy time" until the pace of overall economic development becomes sufficient to provide adequate employment as part of its own growth momentum. However, the most optimistic acheivement could be more infrastructure building, additional resources generated and possibly some significant impact on the interpersonal and inter-regional distribution problems.

X. LONG RANGE AGRICULTURAL ADJUSTMENT ANALYSIS -CONCLUDING COMMENTS

This whole exercise leaves one with an empty feeling. There is so much to know and so few resources presently devoted to improving this situation.

First of all, we might review some of the topics which we have not treated:

- livestock
- forestry
- industries which depend upon agricultural products for raw materials such as food processing
- programs to create new demands
- the influences of either general economic policies or policies directed toward the non-agricultural sector on agricultural development.

Basically, what we have suggested here is an agenda for research - research which is coordinated to focus on the future. Indian agricultural development is now a new ball game. New problems must be anticipated and new rules developed to play the game. Hopefully, this exercise at least asks the relevant questions in such a way that the answers can be attacked more systematically.

The task remaining is to cost out all policies, individually and in combination, and then to compare these programs with the benefits derived from attaining different levels of targets. The policy question of whether all things in the "package" are necessary in combination, or if not, what sequencing can be followed must be explored. The analysis must then be adjusted to take account of resource, political, and administrative restrictions. In summary, we must sequentially evaluate first-best, then second-best and lower orders of policies before arriving at the ultimate policy choices - which are made politically in the final resort.

The final - and major - omission of this exercise is to specify the implications for future Mission programs in Indian agricultural development.

In concluding, a word of caution is in order. It is frequently argued that planning on the basis of some facts is preferable to planning on the basis of none. However, there is a serious philosophical as well as practical problem in defining what is fact and what is artificially manufactured or improperly substantiated. There is only a limited history of research in the economics of Indian agricultural development. There appears to be a substantial variability in the data available for analysis. Sophisticated techniques applied to unsophisticated data sometimes can be misleading by suggesting a degree of precision which is not justified. These qualifications should be considered in all places when in evaluating the information cited in this study.

Que sera, sera!

Appendices

A. Rainfall Index

B. Selected High, Medium, and Low Income Elasticity of Demand Coefficients.

C. Estimated Number and Cumulative Percentage of Households and Area Owned by Size Limits of Household Ownership Holdings (1953-54 Crop Season).

D. Percentage Distribution of All Cultivating Households and Cultivated Area Under Small Sized (upto 5 Acres), Medium Sized (5-15 Acres) and Large Sized (Over 15 Acres) Holdings in Rural Areas.

E. Percentage Contribution to Crop Output Growth by Specified Kinds of Inputs by States, 1952-53 to 1964-65.

F. Area Irrigated by Sources, 1964-65.

G. Sown Acreage Falling Under Different Rainfall Availabilities, 1964-65.

H. Normal Rainfall for Four Primary Rainfall Reporting Periods for Major Indian Rainfall Divisions.

I. Present Status and Outlook for Increased Crop Production.

J. Present Utilization and Future Potential for Irrigation Development in India.

K. Land Use Projections

L. Growth of Minor Irrigation Since Independence

M. Demand and Yield Assumptions on which to Calculate Cropping Pattern Adjustments.

N. Estimated Price Elasticities of Acreage of Specified Crops, Pre- and Post Partition India.

O. Statewise Consumption of Fertilizer per Unit Cropped Area, 1967-68.

P. Review of Fertilizer Demand Projections

Q. Schedule of Completed and Projected Fertilizer Production by Plant, 1966/67 to 1973/74.

R. Status of Major Irrigation Projects in India.

S. Input Prices.

T. Costs of Production.

U. Incentive Prices Calculated by Modified Production Function Method.

Appendix A

Rainfall Index[1/]

In order to be able to compare the amounts of rainfall on an all-India basis from one year to another and to be able to relate the quantities of rainfall to foodgrain production, we have constructed rainfall indices as follows:

1. Rainfall data are reported in four periods:

   a. Southwest monsoon : June 1 - September 30

   b. Post monsoon: October 1 - December 31

   c. Winter: January 1 - February 28

   d. Pre-monsoon : March 1 - May 31

2. The rainfall data are reported for 31 major divisions in India which have significant agricultural production. Some areas correspond to single states (i.e., Kerala) while other states have as many as four rainfall reporting areas. In these multi-division states, a state-wise average rainfall figure for each reporting period was obtained by weighting individual zones within the state by the percentage acreage in that zone.[2/]

3. In order to weight the rainfall in different years by a common base, the average cereal production for 1959-61 was calculated for each state and an aggregate was summed for each of the groups described below based on their respective normal rainfall and assumed equal to 100. [3/]

4. The Indian states were divided into categories depending upon cropping characteristics and indices for cereals production were calculated on the basis of the following groupings:

1/ The inspiration for this index came from some work carried out by Bob Picciotto. Louis Bean also provided stimulation as our work progressed.

2/ This procedure makes an implicit assumption that aggregate cereal production in each rainfall division is proportional to acreage sown.

3/ Implicit in this choice of base years is the assumption that the distribution of rainfall among states in 1959-61 was consistent with the historical average distribution among states. This base period is the same that we used in the estimation of "normal weather" production in the first section.

a. Group I: (Cereals production concentrated in overlapping season continuing from September through January and is influenced by the rainfall from June to December) - Assam, West Bengal, Bihar, Orissa, Andhra Pradesh, Tamil Nadu, Kerala, and Mysore. Index for total cereals was calculated on basis of southwest and post-monsoons period, June 1 - December 31.

b. Group II: (Cereals production falls within distinct summer and winter seasons and is influenced by the amount of rainfall during the corresponding distinct crop seasons) - Jammu and Kashmir, Punjab-Haryana, Himachal Pradesh, Uttar Pradesh, Rajasthan, Madhya Pradesh, Gujarat, and Maharashtra.

1. Southwest monsoon (kharif cereals excluding rabi jowar, winter rice, summer rice), June 1 - September 30. Group II rainfall indices for cereals falling within this season are obtained from a weighted sum of the corresponding state indices.

2. Post and winter monsoons (rabi cereals including rabi jowar, winter rice, and summer rice), October 1 - February 28. Group II rainfall indices for this period are obtained similarly as above.

3. Group II rainfall indices for total cereals production are obtained from the weighted sums of the state indices falling within this Group. For each state, rainfall indices for total cereals production are obtained by weighting the two distinct rainfall indices by the corresponding production in the base year.

c. All-India Index: A weighted summation of Group I and Group II indices.

The summary calculations for the production years 1951-52 through 1968-69 are given in Table A.

Appendix A (continued)

Table A

Rainfall Index for Cereals Production - 1951-52 through 1968-69

Category	Period	Production of cereals during the period (Av. of 59-60 to 61-62 (000 tons)	RAINFALL INDEX								
			Normal	1951-52	1952-53	1953-54	1954-55	1955-56	1956-57	1957-58	1958-59	1959-60
Group I	South-West & Post Monsoons	33,823	100	91.24	96.72	103.67	88.62	104.27	115.89	86.40	94.56	103.43
Group II	South-West Monsoon	19,309	100	76.07	98.18	103.94	106.84	109.53	113.77	84.50	104.86	109.06
Group II	Post & Winter Monsoons	15,143	100	63.62	58.21	99.97	90.23	190.54	234.85	67.86	123.96	105.61
Group II	South-West, Post & Winter Monsoons	34,452	100	73.62	92.88	101.69	103.48	114.11	121.96	83.11	106.56	108.86
All-India	Agricultural Year (weighted Average of Row 1 and Row 4)	68,275	100	82.35	94.78	102.67	96.12	109.24	118.95	84.74	100.62	106.17
All-India	Agricultural Year	Cereal Yield (lbs/Acre)	-	497	542	605	592	570	592	562	631	636

Table A (contd.)

Appendix A (continued)

Category	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69
Group I	102.62	101.96	96.66	98.30	104.40	84.61	87.62	96.23	96.24
Group II	94.14	98.84	93.25	97.41	109.61	65.58	82.83	106.50	84.50
Group II	170.47	87.03	59.60	52.96	57.49	44.53	40.07	123.46	56.14
Group II	100.69	97.83	90.39	93.70	105.20	63.78	79.22	109.65	82.17
All-India	101.65	99.88	93.50	95.98	104.80	74.10	83.38	103.00	89.14
All-India	672	681	654	675	729	609	631	752	

Appendix B

Selected High, Medium and Low Elasticity Coefficients

	Rural			Urban			All-India		
	High	Medium	Low	High	Medium	Low	High	Medium	Low
1. Rice	0.40	0.31	0.22	0.18	0.15	0.12	0.36	0.28	0.20
2. Wheat	1.10	0.90	0.70	0.48	0.30	0.12	0.99	0.79	0.60
3. Other Cereals	0.28	0.26	0.24	0.10	0.09	0.08	0.25	0.23	0.21
4. Total Cereals	0.46	0.38	0.29	0.22	0.16	0.11	0.42	0.34	0.26
5. Pulses	0.59	0.55	0.52	0.43	0.32	0.21	0.56	0.51	0.46
6. Foodgrains	0.48	0.40	0.32	0.25	0.19	0.13	0.45	0.36	0.29
7. Starchy Roots	0.19	0.17	0.15	0.19	0.17	0.15	0.19	0.17	0.15
8. Fruits & Vegetables	1.07	0.95	0.84	1.07	0.95	0.84	1.07	0.95	0.84
9. Edible Oil	0.86	0.70	0.53	0.80	0.58	0.36	0.85	0.68	0.50
10. Sugar and Gur	1.04	0.98	0.92	1.50	1.44	1.38	1.23	1.06	1.00
11. Milk	1.51	1.44	1.36	1.78	1.65	1.52	1.56	1.48	1.39
12. Meat, Fish & Egg	1.02	0.93	0.83	1.02	0.93	0.83	1.02	0.93	0.83
13. Cotton Clothing	1.55	1.25	0.94	1.55	1.25	0.94	1.55	1.25	0.94

Source: S.K. Ray, 1968.

Appendix C

Estimated Number and Cumulative Percentage of Households and Area Owned by Size Limits of Household Ownership Holdings (1953-54 Crop Season)

Holding Size (acres)	No. of Households ('000)	Area Owned ('000 Acres)	Cumulative Percentage	
			Households	Area
1. 0.00*	14,669	-	23.09	-
2. 0.01-0.99	15,360	4,166	47.26	1.37
3. 1.00-2.49	8,879	14,839	61.24	6.23
4. 2.50-4.99	8,569	30,821	74.73	16.32
5. 5.00-7.49	4,966	30,411	82.55	26.28
6. 7.50-9.99	2,972	25,766	87.23	34.72
7. 10.00-14.99	3,207	39,053	92.28	47.50
8. 15.00-19.99	1,690	29,253	94.94	57.08
9. 20.00-24.99	929	20,623	96.40	63.83
10. 25.00-29.99	636	17,480	97.40	69.55
11. 30.00-49.99	1,051	39,439	99.06	82.46
12. 50.00-and over	604	53,580	100.00	100.00
Total	63,532	305,431	-	-

Source: The National Sample Survey: Eighth Round: July 1954 - April 1955, Number 36 - Report on Land Holdings (3) (Some Aspects of Ownership Holdings), Cabinet Secretariat, Government of India, 1961, pp. 18-19.

* Includes landless households

from M.L.Dantwala, "Problem of Subsistence Farm Economy: The Indian Case", in Indian Society of Agricultural Economics Seminar Series - VII, Seminar on Problems of Small Farmers, Bombay: ISAE, 1968, pp 1-8.

Appendix D

Percentage Distribution of All Cultivating Households and Cultivated Area Under Small Sized (up to 5 acres), Medium sized (5-15 acres) and Large Sized (over 15 acres) Holdings in Rural Areas

	Small Sized				Medium sized		Large Sized				Average size of holding (acres)
	Cultivating less than 1 acre		Upto 5 acres		5-15 acres		15-50 acres		over 50 acres		
	H	A	H	A	H	A	H	A	H	A	
Andhra Pradesh	11.61	0.72	57.87	14.72	28.61	30.29	11.86	37.52	1.62	17.44	8.04
Assam	9.69	1.02	67.86	35.53	28.28	46.72	3.10	15.28	0.11	1.59	4.75
Bihar	21.49	2.24	71.46	28.19	22.83	38.59	5.22	26.81	0.42	6.33	4.80
Gujarat	3.24	0.13	35.18	6.93	38.39	26.11	24.75	52.08	2.29	14.68	12.53
Jammu & Kashmir	12.07	1.58	75.26	43.93	23.03	45.79	1.66	9.73	0.03	0.45	3.84
Kerala	48.32	8.46	92.68	59.92	6.37	26.44	0.79	10.32	0.05	2.93	1.83
Madras	14.61	1.59	73.23	23.90	21.94	37.93	4.30	22.89	0.32	4.99	4.58
Madhya Pradesh	3.90	0.18	37.40	8.75	42.35	35.17	18.46	43.29	1.74	12.76	10.60
Maharashtra	4.89	0.19	37.36	6.70	34.56	23.86	24.26	49.20	3.27	19.97	12.87
Mysore	3.23	0.16	43.35	10.71	36.86	30.08	17.54	43.11	2.24	16.10	10.48
Orissa	8.20	0.79	66.33	28.75	27.78	42.46	5.11	23.81	0.35	4.46	5.19
Punjab	2.32	0.09	24.39	4.60	44.65	29.81	28.16	51.50	2.29	13.86	13.78
Rajasthan	1.70	0.05	31.27	5.00	36.57	20.23	24.73	41.44	6.28	32.87	16.01
Uttar Pradesh	13.30	1.26	65.42	26.40	28.18	43.57	5.48	25.02	0.31	4.29	5.27
West Bengal	15.93	1.94	72.73	36.50	23.87	45.41	2.86	15.70	0.08	1.68	4.10
All India	11.34	0.71	57.03	15.85	29.95	32.71	11.33	37.31	1.33	13.83	7.39

N.B: The sum total of percentages under broad size-classes may not add up to 100 because the percentages for unspecified households have not been given.

Source: P.S. Sharma, 1965
H=Cultivating households. A=Cultivated area.

/in/ Sundaram, 1968.

Appendix E

India: Percentage Contribution to Crop Output Growth by Specified Kinds of Inputs by States 1952-53 to 1964-65

State	Crop Output Growth Rate	Percentage of Crop Output Growth Contributed by Increases in Specified Inputs				
		Land Inputs 1/	Fertilizers 2/	Irrigation 3/	Other Inputs 4/	Total
Punjab	4.56	37.30	15.81	12.76	34.13	100.00
Gujarat	4.55	8.98	37.08	20.01	33.03	100.00
Madras	4.17	23.01	30.14	10.22	36.63	100.00
Mysore	3.54	20.44	19.56	7.82	52.18	100.00
Bihar	2.97	22.11	9.50	12.88	55.51	100.00
Maharashtra	2.93	13.79	26.10	12.36	47.75	100.00
Rajasthan	2.74	104.87	6.09	13.55	*	100.00
Andhra Pradesh	2.71	8.82	33.06	20.45	37.67	100.00
Madhya Pradesh	2.49	48.38	11.29	4.92	35.41	100.00
Orissa	2.48	30.88	7.54	12.71	48.87	100.00
Kerala	2.27	54.76	31.72	5.59	7.93	100.00
West Bengal	1.94	28.99	22.50	10.75	37.76	100.00
Uttar Pradesh	1.66	40.66	13.55	7.46	38.33	100.00
Assam	1.17	105.61	7.33	1.27	*	100.00
All-India	3.01	37.43	18.32	9.14	35.11	100.00

* New land brought into cultivation appears to have been less productive than land already in use in 1952-53.

1/ This includes contribution of increases in land inputs and of proportionate increases in fertilizers, irrigation and other inputs.

2/ This includes contribution of increases in fertilizers per unit of gross sown area under the assumption of zero fertilizer application in 1952-53. This assumption approximates the 1952-53 level of fertilizer application in most states of India, Kerala being an exception.

3/ This includes contribution of increases in irrigated per 100 hectares of grossssown area.

4/ Residual.

Source: Hendrix, 1969.

Appendix F

Area Irrigated by Sources 1964/65

(thousand acres, net)

State	Canals			Other			
	Government	Private	Total	Tanks	Wells	Sources	Total
North							
Jammu & Kashmir	160	500	660	-	2.5	17.5	680
Punjab	5567.5	122.5	5690	15	2642	115	8462
Rajasthan	1535	-	1535	739	2817	110	5200
U.P.	5418	22	5440	1102	6210	692	13445
East							
Assam	180	730	910	-	-	640	1530
Bihar	1457	43	1490	500	780	2180	4950
Orissa (55-56)	492	70	562	1237	95	547	2442
West Bengal (62-63)	1285	967	2252	822	40	460	3575
West							
Gujarat	242.5	2.5	245	45	1412	73	1775
M.P.	1318	42	1360	317	910	105	2692
Maharashtra	547.5	77.5	625	517	1628	105	2875
Mysore	692.5	15	707.5	942.5	440	320	2400
South							
Andhra	3122	65	3187	3352	1010	345	7895
Kerala (62-63)	405	20	425	140	10	305	880
Tamil Nadu	2183	2	2185	2287	1510	102	6085
Others	57.5	170	227.5	19.5	52.5	182.5	482
Total	24652	2840	27492	12037	19560	6280	65390

Source: India, 1967 .

Appendix G

Sown Acreage Falling Under Different Rainfall Availabilities 1964-65

('000 acres)

	≥ 46 in. (1150 mm)			30-46 in. (750-1150 mm)			< 30 in. (750 mm)			Total			
	Net Area Sown	Net Irri-gated	Double Cropp-ing	Net Area Sown	Net Irri-gated	Double Cropp-ing	Net Area Sown	Net Irri-gated	Double Cropp-ing	Net Area Sown	Net Irri-gated	% Irri-gated	% Double Cropping
North													
Jammu & Kashmir	536	84	262	887	464	193	235	163	5	1657	711	42.9	28.4
Punjab	22	10	17	2626	613	1079	16243	7739	5012	18891	8361	44.3	32.3
Rajasthan	-	-	-	4061	729	529	31636	4409	2062	35696	5138	14.4	7.3
U.P.	4631	1405	1497	32056	8843	8551	6128	3312	2023	42815	13560	31.7	28.2
East													
Assam	5772	1512	1092	-	-	-	-	-	-	5772	1512	26.2	18.9
Bihar	16942	2826	3665	4164	2065	1981	-	-	-	21106	4890	23.2	26.8
Orissa	14793	1902	3599	-	-	-	-	-	-	14793	1902	12.9	24.3
West Bengal	13444	3532	2342	-	-	-	-	-	-	13444	3532	26.3	17.4
West													
Gujarat	1941	109	138	6074	371	531	15235	1275	501	23250	1754	7.5	5.0
M.P.	23505	1509	4206	15820	936	1158	2011	215	138	41335	2660	6.4	13.3
Maharashtra	9700	1307	726	18886	585	682	16314	1218	1052	44900	2841	6.3	5.5
Mysore	2292	694	259	5960	620	351	17443	1233	353	25695	2547	9.9.	3.7
South													
Andhra	-	-	-	18051	6439	2564	10315	1361	578	28365	7800	27.5	11.1
Kerala	5031	869	1116	-	-	-	-	-	-	5031	869	17.3	22.2
Tamil Nadu	2487	1200	692	12407	4789	2139	-	-	-	14894	5990	40.0	19.0
Others	1531	316	309	687	96	410	180	62	72	2398	474	-	-
Total	102629	17006	19920	121677	26550	20168	115739	20985	11796	340045	64541	19.0	15.3
Percentage		16.6	19.4		21.8	16.6		18.1	10.2				

Source: India, 1968a and India, 1968b.

Appendix H

Normal Rainfall for Four Primary Rainfall Reporting Periods for Major Rainfall Divisions

		Total Rainfall (in.)	Percentage Distribution (%)				Probability of drought during southwest monsoon (-20% normal)	Coefficient of variation of Monsoon Rainfall - per cent
			Monsoon	Post-Monsoon	Winter	Pre-Monsoon		
1	2	3	4	5	6	7	8	9
							1 in x years	
North								
Punjab	-	27.8	78.2	6.9	8.4	6.5	-	32
Rajasthan	west	12.2	84.8	4.2	3.9	7.1	2.5	49
	east	33.6	91.0	4.8	1.6	2.6	3	28
U.P.	west	44.1	86.6	6.4	3.6	3.4	3	24
	east	47.8	84.7	6.1	2.9	6.3	4	22
East								
Assam	north	93.7	64.7	7.3	2.5	25.5	15	9
	south	101.1	63.0	9.8	2.0	25.2	-	-
Bihar	plains	47.8	84.7	6.1	2.9	6.3	5	12
Orissa		60.3	77.7	12.3	2.5	7.5	5	13
West Bengal	Gangetic	59.3	74.8	10.9	2.4	11.9	5	11
West								
Gujarat		34.5	93.7	4.2	0.5	1.6	3	30
Saurashtra & Kutch		23.3	92.9	6.6	0.5	NA	-	-
M.P.	west	42.2	90.1	5.6	2.0	2.3	5	17
	east	55.7	87.1	5.8	3.1	4.0	-	13
Maharashtra -								
Konken & Goa		93.6	92.0	5.7	0.2	2.1	5	27
Madhya Maharashtra		27.0	74.6	16.5	0.9	8.0	5	18
Marathwada		31.2	82.6	11.4	1.7	4.3	-	-
Vidarbha		44.2	87.3	7.0	2.0	3.7	4	24

continued on next page

Appendix H (continued)

1	2	3	4	5	6	7	8	9
Mysore - Coastal		131.3	88.4	7.0	0.1	4.5	-	27
Interior - North		31.1	73.5	15.6	1.2	9.5	-	20
Interior - South		31.3	52.1	27.3	1.3	19.3	4	20
South								
Andhra - Central		38.7	56.4	34.8	1.7	7.1	5	18
	Telengana	37.9	80.8	11.3	1.3	6.6	3	21-24
	Rayalseema	26.0	58.9	28.9	1.9	10.3	3	30
Kerala		107.2	61.0	19.8	1.4	17.8	5	19
Tamil Nadu		38.0	27.3	54.8	5.7	12.2	3	23

Source: Columns 3-7: Meteorological Department, GOI.
Column 8 : S.R. Sen, 1967.
Column 9 : Coefficient of variation = 100 x standard deviation ÷ mean; expressed as a percentage; Das, 1968.

Appendix I

Present Status and Outlook for Increased Crop Production 1/

The availability and rate of adoption of yield-increasing technology does not occur uniformily for all crops or in all areas of production. The present status and outlook for each of the major food grains is briefly reviewed.

Rice is the major food grain of India. It currently represents about 40 percent of the nation's total food production and occupies 30 percent of the gross acres sown to food crops. The current situation and future outlook for improved high-yielding varieties is good. Lack of proven technology for positive on-the-farm control of water is probably the most important single deterrent to the more rapid adoption of high-yielding fertilizer-responsive varieties. To realise more fully the potential of such varieties and other yield increasing production technology, greater effort is required in land leveling and on-the-farm distribution systems that will bring water under more positive control by the individual cultivator. Encouraging developments in disease and insect resistance and control and in the breeding of photo-insensitive varieties of improved quality suggest that the flow of new varieties and plant protection technology will keep pace with the needs to increase rice production.

As multiple-cropping expands, varieties and production practices designed for particular parts of the 12-month growing season will be needed. In some areas multiple-cropping may be with a mono-culture of rice, probably three crops per year. This may develop as a system in which rice is being planted and harvested during every week of the year. Such a system would level out the seasonal peaks in labor and on the supply and marketing agencies serving the area. It would however make more difficult such problems as water management and the control of insects, diseases and pests by making group action on these problems more complicated.

Although paddy mono-culture may develop in some of the multiple cropping areas, the high water demand of paddy will favor its use as a kharif crop in a mixed multiple cropping system. The major technical problem to be solved in such a system is that of quickly converting a paddy field into an adequately drained seedbed for other crops. The bedding technique developed in Taiwan and extended by Bradfield at IRRI is an approach to this problem that shows considerable promise.

Wheat is second only to rice as a food grain in India. It is grown on about 15 million hectares and represents about 18 - 20 percent of the nation's annual food grain supply. Production has shown a sharp response to the introduction of the fertilizer-responsive varieties and the associated set of improved practices. This breakthrough has

---

1/ Source: Russell and Brinegar, 1969.

been most dramatic in the irrigated wheat producing areas of Punjab, Western Uttar Pradesh and Haryana. For these areas the flow of improved varieties, more efficient methods of using fertilizer, water and plant protection materials appear sufficient to keep the wheat revolution moving. More attention must be given to problems of harvesting, marketing and storage as the size of the wheat crop in this important production area continues to grow rapidly.

The impact of the improved practices on wheat production in the extensive rain-fed areas has been much less dramatic. For these areas, which constitute the major part of India's wheat growing region, further improvement in production technology are needed. Wheat grown in the rain-fed or "baroni" areas is dependent largely on water stored in the soil profile. Therefore increased attention should be given to (1) increasing the intake and retention of water in the rooting zone, (2) increasing the vigor and depth of penetration of wheat roots, (3) improving the physiologic efficiency of the wheat plant under conditions of water stress, (4) development of varieties having shorter growing seasons and (5) improvement of seedbed preparation and planting methods that will permit more timely sowing to maximize favorable early season growing conditions. Because it is unlikely that yeilds under baroni conditions can consistently match those obtained under irrigation, the set of production practices developed for the rain-fed areas will necessarily be different from those that have been so successfully adopted in the irrigated areas.

Sorghum and millets are important food grains, particularly in the drier parts of India. In 1967-68 they constituted about 25 percent of the acreage and about 15 percent of India food grain production. Progress to date in variety improvement and innovative change in production practices has not been as great as that in rice and wheat. This is due in part to the lack of comparably large reservoir of production technology in other parts of the world on which an adaptive program for India could be quickly developed. Rapid progress is being made, however, to exploit the world-wide pool of germ plasm and to develop suitable production technology for Indian conditions. Varieties and hybrids with greatly improved yield potential, shorter growing season and improved disease and insect resistance have already been developed and field evaluated. Although the major emphasis with these crops is for improving their productivity under rain-fed conditions, they have considerable potentialities for use in multiple-cropping systems under irrigation. This is particularly true for the sorghums which by rattooning can be harvested two or more times from a single planting.

Because the sorghums and millets rank below both rice and wheat in consumer preference, their long-term importance for direct consumption will decline as the production of rice and wheat more nearly meet India's food grain needs. Although there is a small demand for the sorghums and millets for local consumption and speciality food uses,

the pattern of use for these grains will, we believe, slowly shift to livestock and poultry feed and to industrial utilization.

Pulses are grown on nearly 20 percent of the land used for food grain production and represent about 13 percent of India's food grain supply. Although the pulses are an important part of the diet and constitute the major source of protein in it, this important group of crops has received very little attention by research and agricultural development agencies in India or elsewhere. There is a serious lack of both basic knowledge and empirical data on even such major pulse crops as gram and tur upon which to build a program for improvement of these crops. Preliminary studies indicate that sufficient diversity exists in gram and other pulses to permit selection for length of growing season, yield, and other agronomic characteristics. It is reasonable to expect that highly significant imporvements can be made in variety development. Such efforts to be effective in improvement of pulse production must be accompanied by the discovery and development of a suitable set of production practices that will permit the full expression of the genetic potential of the improved varieties.

Because of the lack of suitable yield-increasing technology, the production of pulses has been slowly declining. This trend probably will continue as the spread of improved technology in other crops proceeds at a faster pace than is likely to occur for the pulses. Although pulse production to meet local consumption may keep pace with that demand, major changes in production technology are needed if the production of these important food crops is to keep pace with the off-farm market demand. A major research and development effort directed at improvement of systems of pulse production is clearly needed and should be given high priority.

Maize represents about 6 percent of India's current food grain production. Except in limited areas, it ranks below rice and wheat in consumer preference. It has been repeatedly demonstrated that hybrid maize is widely adapted throughout India and, when improved production technology is used, is one of the most productive of the cereals on a per acre per month basis. More rapid expansion of this crop in India is also favored because of the existence in the United States of a large reservoir of basic knowledge and practical experience about the crop and systems for its efficient production. Although hybrid maize was introduced and research and development efforts on its production initiated many years before the introduction of the high yielding wheat and rice programs, its spread has been limited. It appears therefore that like the sorghums and millets, this crop will not effectively compete with rice and wheat as a major food grain. Maize does have a great potential as a feed grain and for processing for food and non-food uses. Modification of the crop and systems for its production to meet any foreseeable demand for maize could be made rather quickly because of the existing reservoir of knowledge and technology on this crop.

Soybeans are not now produced in significant quantities in India. Research in progress indicates clearly that they are well adapted for kharif production in central and northern India. Commercial United States varieties have been shown to be agronomically suited for these areas, although the performance under farm conditions have not yet been extensively evaluated. The data at hand suggest that this crop can make a major contribution to India's food needs, not as a pulse for direct local consumption, but as a productive source of industrially processed edible oil and protein. It appears that the soybeans will adapt well to a multiple-cropping system in much of the rain-fed wheat producing areas. The development of suitable day-length insensitive varieties may also make feasible the use of soybeans during the rabi and zaid seasons in situations where it would fill a need in a year around multiple cropping system.

Like hybrid maize, the future of the soybean in India is more dependent on the development of a suitable market demand than on the development of adapted production technology. As a source of edible oil and protein, the soybean has a clear comparative advantage over other alternative pulse and oilseeds being grown in India. It also has the advantage of a large United States reservoir of basic knowledge and practical production and utilization experience on which to draw. Soybeans not only have a great potential as a source of edible oil and protein, but also as raw material for livestock and poultry feeds and for industrial utilization.

Appendix J

Present Utilization and Future Potential for Irrigation Development in India

(Gross Area - Thousand Acres)

	Potential			1968-69	1964-65		% of Potential Utilization		
		Minor		Potential Created	Minor-Utilization			Minor	
	Major[2]	Surface[1]	Ground[1]	Major[3]	Surface[1]	Ground[1]	Major[3]	Surface[1]	Ground[1]
North									
Jammu & Kashmir	241	1000	150	151	554	3	63	55.4	2.0
Punjab	10229	400	6700	5773	163	3603	56	40.7	53.8
Rajasthan	7800	1000	3500	2569	474	2784	33	47.4	79.5
U.P.	18800	2500	16000	7420	1401	6870	39	56.0	42.9
East									
Assam	2400	2500	500	214	1458	-	9	58.3	-
Bihar	10600	4500	4500	4884	2713	861	46	60.3	19.1
Orissa	6000	3000	1000	3068	2221	171	51	74.0	17.1
West Bengal	5700	3000	2000	2729	1850	38	48	61.7	1.9
West									
Gujarat	5300	1200	3000	1309	111	1629	25	9.3	54.3
M.P.	13900	2000	4000	2377	309	917	17	15.4	22.9
Maharashtra	5800	2000	3500	1578	509	1882	27	27.4	53.8
Mysore	4400	2000	2000	1852	890	484	42	44.5	24.2
South									
Andhra	16000	5000	4500	6196	2516	1218	39	50.3	27.1
Kerala	1543	2000	250	890	549	16	58	22.4	6.4
Tamil Nadu	3858	2000	3250	3607	1653	2002	93	82.6	61.6
Others[4]	-	900	150	2266	655	62	-	72.8	47.3
Total	112571	35000	55000	46883	18026	22539	42	51.5	41.0
		90000			40565				

Appendix J (continued)

1/ Source: India, 1968c.

Notes : "Any precise estimate of the long-term potential of development of Minor Irrigation requires systematic basis-wide study which has not yet been carried out by the States. However, certain broad indications are available.

a) : It is roughly estimated that the irrigation potential remaining unrestored due to works still likely to remain derelict at the end of 1968-69 may be of the order of 3 million acres. Apart from restoration of this lost potential, there are yet good possibilities for constructing new storage and diversion projects in the undulating tracts of Maharashtra, Gujarat, Andhra, Madhya Pradesh, Rajasthan, Orissa, Kerala, and parts of Bihar and Assam. There are several tracts in these regions where patches of cultivable land available are small and can be brought under irrigation only through construction of minor surface water projects. Minor diversion channels called "kuhuls" are the only source of irrigation available in the hilly tracts and there are yet good prospects for their future development. Lift irrigation from rivers and streams has also considerable scope for development in several States and is now getting increasingly into vogue through use of floating barges in addition to the conventional types of stationary headworks.

b) : A broad study taking into account the contribution of rainfall to ground-water recharge at varying rates according to differential geological formations, the possible recharge from canals, streams, etc. and the evapo-transpiration and sub-surface run-off losses, places the net annual groundwater recharge in the country at about 215 million acre feet. It may, however, not be possible to tap all this net groundwater recharge available due to various limitations. It is visualized that the total useable groundwater potential may not be more than 75 to 80 per cent of the net groundwater recharge available. Taking useable groundwater potential as about 165 million acre feet, the long-term potential for groundwater development is assessed to be of the order of 55 million acres (gross).

2/ : "The available annual river water resources of the country are about 1,360 million acre feet, of which it is estimated that because of physio-graphical conditions, only about 450 million acre feet can be used for irrigation. Upto 1951, 76 million acre feet that is about 17 per cent of the useable flow had been utilized. By the end of the Third Plan, it is estimated that about 150 million acre feet representing about 33 per cent of the useable flow had been utilized. It is anticipated that in the next three annual plans, the utilization has gone upto 167 million acre feet that is 37 per cent of the useable annual flow. It is proposed to have an additional utilization of about 43 million acre feet during the Fourth Plan, under major, medium and minor schemes, bringing the total utilization to about 210 million acre feet, i.e., 47 per cent of the useable flow." (Source: Report of the Working Group for Formulation of Fourth Five Year Plan Proposals on major and medium irrigation).

3/ : Anticipated potential up to end of 1968-69 from schemes of First Plan and schemes approved during 1966-69 including pre-Plan. (Source: Irrigation Division, Planning Commission).

4/ : These data are balancing items; individual data do not otherwise add up to total.

Appendix K

Land Use Projections

(In Million Acres)

	Source	1952/53	1964/65	1967/68	1968/69	1973/74	1978/79	1983/84	1968/69 to 1983/84 compound rate per year %
1. Net Area Under Cultivation	(1)	305.0	340.7	340.1	340.1	343.1	346.1	349.1	0.2
2. Net Area Irrigation	(4)	52.2	64.6	73.9	75.3	83.0	95.0	107.0	2.4
3. % of Net Irrigated Area	2 ÷ 1	(17.1)	(19.0)	(21.9)	(22.1)	(24.2)	(27.4)	(30.7)	-
4. Multiple Cropping Irrigated	(3)	5.4	12.6	12.6	15.0	30.0	40.0	50.0	8.4
5. % of Net Irrigated Area Multiple Cropped	4 ÷ 2	(10.3)	(19.5)	(17.1)	(20.0)	(36.1)	(42.1)	(46.7)	-
6. Gross Area Irrigated	(2)	57.6	77.2	86.5	90.4	113.0	135.0	157.0	3.7
7. Net Area Unirrigated	1 - 2	252.8	276.1	266.2	264.8	260.1	251.1	242.1	-0.5
8. Multiple Cropping Unirrigated	(5)	29.8	37.3	39.8	39.0	41.5	43.7	46.2	1.1
9. % of Net Unirrigated Area	8 ÷ 7	(11.8)	(13.5)	(15.0)	(14.7)	(16.0)	(17.4)	(19.1)	-
10. Gross Area Unirrigated	7 + 8	282.6	313.4	306.0	303.8	301.6	294.4	288.3	-0.3
11. Total Area Added by Multiple Cropping	4 + 8	35.2	49.9	52.4	54.0	71.5	83.7	96.2	3.9
12. Gross Area Sown	6 + 10	340.2	390.7	392.5	394.2	414.6	429.4	445.3	0.8

Sources: 1950-51 and 1964-65: Various GOI publications.
1967-68 to 1983-84: extrapolations.

Appendix L

Growth of Minor Irrigation Since Independence

(Million Acres)

Period	During Period				Gross Area Irrigated at Close of Period		
	New Irrigation		Depreciation				
	Surface Schemes	Groundwater	Surface	Groundwater	Surface	Groundwater	Total
1950-51					15.64	16.18	31.82
1951-56	1.50	3.50	1.37	0.75	15.77	18.93	34.70
1956-61	2.00	3.00	1.52	1.67	16.25	20.26	36.51
1961-66	3.50	5.00	1.25	1.76	18.50	23.50	42.00
1966-69	2.25	4.45	0.75	0.95	20.00	27.00	47.00
1969-74	4.00	10.00*	1.50	2.50	22.50	34.50	57.00

Source: India, 1968c.

Note: Depreciation (pp.9-10) "Works like tanks gradually lose their irrigation capacity as result of silting. The discharge of tubewells would generally reduce as a result of gradual deterioration of the strainers. Several dug wells also fail after certain number of years. Mechanical appliances like persian wheels and pumpsets have to be replaced after 10 to 20 years. It is very difficult to have any precise assessment of the area lost by depreciation, particularly so because the rate of depreciation varies widely from scheme to scheme and region to region and no reliable data on this aspect has yet been collected by the States."

* Benefits other than new irrigation (stabilization/supplemental, irrigation, drainage, embankment, etc.) estimated to be 7.50 million acres.

Appendix M

Demand and Yield Assumptions on which to Calculate Cropping Pattern Adjustments

(compound annual rate)

	Demand 1/	Yield		Acreage	Production
		Historical 2/	Expected 3/		
Cereals			5.0		
Rice	3.2	1.68	6.0	0.6	6.5
Wheat	4.6	0.97	6.0	1.5	7.5
Other	3.1	-	-	-0.5	-0.5
Pulses	3.9	- 0.62	1.0	0.6	1.5
Milk	6.5	-	-	-	-
Meat, eggs, fish	5.2	-	-	-	-
Edible oils	4.6	0.83	0.83	2.7	3.5
Sugar and gur	5.7	1.82	1.82		
Cotton	5.6	2.08	2.08	2.1	
Starchy roots	3.2	-	-	-	
Fruits & Vegetables	5.2	-	-	-	

1/ Medium Demand Projections. The demands for foodgrains are for human consumption only.

2/ India, 1966a.

3/ Tentative adjustments.

Appendix N

Estimated Price Elasticities of Acreage of Specified Crops, Pre and Post-Partition India

Crop and Country or Region	Period	Elasticity: Short-run	Elasticity: Long-run	Source
Rice				
Punjab (India-Pak)	1914-45	0.31	0.59	Krishna, 1963b
Pakistan	1948-63	0.05*	-	Hussain, 1964
Wheat				
Punjab (India-Pak)	1914-43	0.08	0.14	Krishna, 1963b
Pakistan	1944-59	0.20	-	Falcon, 1964
Maize				
India-Pakistan	1914-43	0.23	0.56	Krishna, 1963b
Barley				
Punjab (India-Pak)	1914-45	0.39**	0.50	Krishna, 1963b
Millets				
India-Pakistan	1914-45	0.09	0.36	Krishna, 1963b
Gram				
Punjab (India-Pak)	1914-45	-0.33**	-	Krishna, 1963b
Sorghum				
Punjab (India-Pak)	1914-43	-0.58	-	Krishna, 1963b
Sugarcane				
Punjab (India-Pak)	1915-43	0.34	0.60	Krishna, 1963b
Cotton				
India-Pakistan	1922-43	0.59	1.08	Krishna, 1963b
India	1948-61	0.64	1.33	Krishna, 1965
Pakistan (8 districts)	1933-58	0.41	-	Falcon, 1964
Pakistan	1935-62	0.50 a/	-	Mohammad, 1963
Jute				
India-Pakistan	1911-38	0.46	0.73	Venkataramanan, 1958
Bengal (India-Pak)	1911-38	0.68	1.03	Stern, 1962
India-Pak (Bengal, Orissa, Bihar)	1893-1938	0.57to 0.65	-	Stern, 1962
Pakistan	1931-53	0.60		Clark, 1957
Pakistan	1948-63	0.40		Hussain, 1964

* For summer and winter crops combined; elasticity for summer crop alone, 0.12.
** Not significant at 10 percent level
a/ Based on simple calculations from yearly variations.

Appendix N (Contd.)

Short-run Elasticities

0-0.1	0.1-0.4	0.4-0.7
Rice	Rice	Cotton
Wheat	Wheat	Jute
Barley	Maize	
Millets	Sugarcane	
Gram		

Source: R.Krishna, 1967c

Appendix O

State-wise Consumption of Fertilizers Per Unit Cropped Area - 1967-68

Zone/State	Distribution kg/hec.			
	N	P_2O_5	K_2O	Total
North	7.49	2.43	1.36	11.28
Jammu & Kashmir	15.04	15.01	11.77	41.82
Punjab	14.00	3.68	1.05	18.73
Rajasthan	1.59	0.49	0.08	2.16
U.P.	8.24	2.65	2.04	12.93
(Delhi)	-	-	-	-
H.P.	10.65	5.29	0.49	16.43
East	4.75	1.43	0.65	6.83
Assam	0.15	0.57	0.26	0.98
Bihar	6.01	2.44	0.28	9.73
Orissa	1.50	0.23	0.29	2.02
West Bengal	5.93	1.52	1.91	9.36
Others (Manipur, Tripura, Nangaland, Andamans)	-	-	-	-
West	3.92	2.00	0.59	6.51
Gujarat	5.97	3.20	0.30	9.47
M.P.	1.32	0.44	0.19	1.95
Maharashtra	5.38	2.90	1.12	9.40
Goa	-	-	-	-
South	13.18	5.30	2.74	21.22
Andhra	12.50	3.97	0.33	16.80
Kerala	10.48	4.72	8.04	23.24
Madras	20.71	9.19	6.24	36.14
Mysore	8.06	4.35	1.98	14.39
Pondichery	-	-	-	-
All-India	7.18	2.77	1.30	11.25

Source: FAI, 1968.

Appendix P

Review of Fertilizer Demand Projections 1/

The calculations in this paper give a minimum fertilizer requirement which is significantly below the official GOI demand targets.

	68/69	69/70	70/71	71/72	72/73	73/74
1. GOI Targets (India, 1968d)	2.80	3.35	4.10	4.80	5.61	6.60
2. Minimum Requirements 2/	1.98	2.29	2.65	3.06	3.54	4.10
3. Adjusted Supply Requirements 2/	2.38	2.75	3.18	3.67	4.25	4.92
Gaps : 1 - 2	0.82	1.06	1.45	1.74	2.07	2.50
1 - 3	0.42	0.60	0.92	1.13	1.36	1.68

It should be reemphasized that our calculations should be interpreted as minimum requirements based on the assumptions in our scheme for projection. Admittedly larger than minimum availabilities are necessary in order to "fill up" the distribution system in order that NPK is in the right place at the right time.

However:

1- If imports are based on GOI targets and our requirements are sound, inventories will build up quickly, and

2- Although fertilizer is a storable commodity and therefore "money in the bank", inventories do freeze this "money" into a specific use when alternative uses, ie., spare parts, may have high foreign exchange priorities; and

3- Because of the tightening of AID appropriations, this trade-off becomes very important. Therefore this note tries to explore the questions:

   a- Are our requirement figures too low?

   b- Are the GOI targets too high?

1/ This appendix borrows heavily from a paper by Martin Billings and S.K. Ray (1968).

2/ Minimum requirements were derived from the supply projections in the main body of the annex. Adjusted Supply Requirements include a 20% addition to minimum requirements in order to account for waste, inventory and lead time on orders in order to have inventory in the place, at the time, and in the quantity needed.

A. The Projections

Table P lists the results of the various projections of fertilizer requirements/demand which have come to our attention. A description of the methods employed in some of these studies is instructive in suggesting reasons for differences - and the probability of each being attained.

1. [1/] USAID (1964) put out two estimates based on alternative assumptions:

a. Foodgrain self-sufficiency by 1970 and a foodgrain consumption availability figure of 87.5 per cent of production.

b. Foodgrain self-sufficiency by 1970 but with on the basis of a higher definition of "self-sufficiency" and a greater deduction for seed, feed, and waste.

3. The official targets through 1970-71 of the GOI were those laid down by the Sivaraman Committee on Fertilizers (India, 1965a). It did not make an independent attempt to derive fertilizer requirements. It derived a compromise figure from considering estimates given by the Working Group for the Fourth Plan (original)(India, 1965b) Roy Donahue (1964) and USAID (1964), after making allowances for the HYV program.

4. The estimates by the Fourth Five Year Plan Working Group on Manures and Fertilizer (India, 1965b) were made in 1965. These estimates were based on cropped and irrigated area with normal fertilizer doses recommended by the State Agricultural Departments. The initial estimates were revised downward (by the order of approximately one-half) in the light of past experience.

5. Donahue's second study(1966) was carried out in early 1966. He built up his estimates on the basis of

a. Crop acreage by districts,

b. the fertilizer recommendations for each crop, and

c. the percentage of the present acreage of each crop expected to be covered in 1970-71 with the current recommended rate of fertilizer.

Donahue assumed that if a farmer 'adopts' fertilizer at all, he will use the entire recommended dose. This probably gives an

---

1/ These numbers correspond to the ordering in Table

upward bias to the estimates. The percentage of coverage by fertilizer is a purely subjective part of the scheme and was based upon district officials' estimates of what they thought could be expected in 1971.

In summary, Donahue's methodology was as follows:

District demand for nutrient per crop = (recommended dosage for the crop on irrigated land)

x (estimated irrigated area on which crop was sown in base year)

+ (recommended dosage for the crop on unirrigated land)

x (estimated unirrigated area on which crop was sown in base year).

An adjustment was made for the additional fertilizer required in 1970/71 for the fertilizer-intensive crops of rice, jowar, hybrid maize, and hybrid bajra (although apparently not for which) in an effort to anticipate the high yielding varieties program. No effort was made to estimate cropping pattern shifts.

6. Willem Holst (1967) in the PSAC Study assumed foodgrain self-sufficiency by 1975/76; NPK application 121 lbs/acre for HYV and 40 lbs/acre for other areas.

7. Indicative World Plan (India, 1968e) assumed full fertilizer coverage for irrigated areas, less than full coverage for unirrigated areas as well as taking into account the HYV.

8. Billings and Ray (1968) worked Donahue estimates in 1968 on the basis of the following assumptions:

a. The GOI targets for HYV in 1971 (which were revised downward slightly from the time of Donahue's study) are met.

b. All cultivators use the full recommended dosage of fertilizer on all acreage under HYV.

c. The recommended dosages of $N/P_2O_5/K_2O$ on HYV of rice, wheat and hybrid maize are 80/60/40 lbs per acre except in Punjab where they are 100/60/40. Hybrid jowar and Bajra use 60/40/30.

d. Donahue's assumptions for remaining area, cropping pattern, dosage, and percentage of adoption were retained.

9. The Perspective Planning Division (India, 1968f) of the Planning Commission based estimates on optimal fertilizer doses from fertilizer trial experiments and on adjusted cropping pattern.

B. Discussion

With the exception of the K_2O estimate for the Fourth Plan Working Group (original) all the reported estimates are well above those calculated by the scheme in this annex. However the tentative nature of the assumptions underlying the requirements calculated must be reemphasized.

It should be kept in mind that these estimates are characterized by either one or two approaches:1/

1- Accomplishment of recommended fertilizer dosages based on technical considerations or

2- Foodgrain self-sufficiency by 1970-71 - the period ending the Fourth Plan (original).

Either one of these approaches would tend to overstate fertilizer requirements particularly in view of better knowledge of NPK/output relationships of the new technology. The HYV use much larger optimal dosages than the local varieties, and the average response would be raised from 9 to 1 to 13.5 to 1 - or in other words, two-thirds of the previously anticipated NPK would be necessary to produce the same amount of foodgrains as previously.

I suggest that the answer to which projections to use lies somewhere in between:

1- The GOI targets are too high

2- My requirements should be considered as minimum requirements and the policy figure be the adjusted supply requirements.

We want more than the minimum in the pipelines for the very simple reason that the distribution system is inefficient, there is waste, and orders must be placed ahead of season in order to have the quantity at the time and place required.

The costs of having too much fertilizer on hand for any growing season are probably much less than the costs of having too little fertilizer. Fertilizer is a storable commodity while restricted agricultural production can be quickly translated into rapidly rising prices. Furthermore, many argue that the most effective way to liberalise and modernise the distribution system is to ensure ample supplies available which would encourage distributors and producers to aggressively sell their product.

1/ FAI (1968b) projections reflect reasonable goals rather than an attempt to project requirements or demand.

The solution to this uncertainty is probably to plan high but allow enough year to year flexibility in import orders - the residual between domestic production and total distribution - to be adjusted on the basis of the quarterly stock position. However, an adequate stock reporting system is an essential prerequisite for such a policy - and one is not in place at present.

Table P

Source			1970-71 N	P_2O_5	K_2O	Total	73-4 NPK	75-6	78-9	80-81
1. USAID	a	(1964)	1.96	0.98	0.49					
	b	(1964)	2.69	1.34	0.67					
2. Donahue, 1964		(1964)				3.4				
3. Sivaraman Committee		(India 1965a)	2.4	1.1	0.7	4.1 2/	(5.8)	7.0		
4. Fourth Plan Group (Original)		(India 1967b)	2.0	1.1	0.35					
5. Donahue, 1966		(1966)	2.67	1.8	0.93	5.6				
6. Holst		(1967)	2.63	1.17	0.58	4.2	(5.7)	6.8	(8.2)	9.2
7. IWP		(India 1968e)	2.4	1.0	0.74	4.1				
8. Billings and Ray		(1968)	2.66	1.875	1.030	5.6	7.1	(8.8)	(11.3)	13.0
9. Planning Commission 1/		(India 1968f)	2.64	1.1	0.58	4.1	6.3	8.3	11.4	
10. FAI 2/		(1968b)				4.0	6.6			
11. GOI Official Targets		(India 1968d)	2.4	1.1	0.7	4.1	6.6			
12. Annex F 3/						3.18	4.92		7.69	11.0

Notes: Figures given in Table are variously stated in these reports as "requirements", "demand", or "consumption", however they all are discussed as being "expected consumption".

1/ Planning Commission report used four methods with range of results as follows:

1970-71	3.8-4.2	(Ave. 4.1)	m. tons
1973-74	5.9-6.7	(Ave. 6.3)	m. tons
1975-76	7.7-9.0	(Ave. 8.3)	m. tons
1978-79	9.7-12.1	(Ave. 11.4)	m. tons

2/ The Fertilizer Association report used four methods with range of results as follows:

1970-71	3.2-4.6	(Ave. 4.0)	m. tons
1973-74	5.4-7.6	(Ave. 6.6)	m. tons

3/ Adjusted Supply figure = Requirements +20%

Appendix Q

SCHEDULE OF COMPLETION AND PROJECTED PRODUCTION BY PLANT
(In Thousands of Metric Tons - Indian Fiscal Years)

Plant	Installed Capacity Nitrogen (N)	Installed Capacity Phosphate (P_2O_5)	Attainable Capacity N	Attainable Capacity P_2O_5	Completion Year IFY	1966-67 N	1966-67 P_2O_5	1967-68 N	1967-68 P_2O_5	1968-69 N	1968-69 P_2O_5
PUBLIC SECTOR											
IN OPERATION:											
Alwaye	90	30	62	30	1946-47	25	12	26	11	35	13
Sindri	117	-	95	-	1950-51	90	-	74	-	76	-
Nangal	80	-	80	-	1960-61	72	-	78	-	77	-
Rourkela	120	-	40	-	1962-63	39	-	39	-	48	-
Trombay	90	45	77	45	1965-66	36	17	44	11	54	21
Neyveli	70	-	70	-	1966-67	28	-	34	-	41	-
Gorakhpur	80	-	80	-	1967-68	-	-	1	-	47	-
Namrup	45	-	45	-	1968-69	-	-	-	-	12	-
	692	75	549	75		290	29	296	22	390	34
UNDER CONSTRUCTION:											
Sindri (Expansion)	20	-	20	-	1969-70	-	-	-	-	-	-
Rourkela (Gassifier)	80	-	80	-	1969-70	-	-	-	-	-	-
Alwaye (Expansion)	30	15	30	15	1969-70	-	-	-	-	-	-
Cochin	160	-	160	-	1971-72	-	-	-	-	-	-
Durgapur	160	-	160	-	1971-72	-	-	-	-	-	-
Barauni	160	-	160	-	1971-72	-	-	-	-	-	-
Namrup (Expansion)	160	-	160	-	1971-72	-	-	-	-	-	-
	770	15	770	15		-	-	-	-	-	-
PLANNED:											
Trombay (Gassifier)	13	-	13	-	1970-71	-	-	-	-	-	-
Sindri (Rationalization)	-	156	-	156	1971-72	-	-	-	-	-	-
Trombay Expansion	256	124	256	124	1972-73	-	-	-	-	-	-
	269	280	269	280		-	-	-	-	-	-
UNDER CONSIDERATION:											
Haldia	160	50	160	50	1973-74	-	-	-	-	-	-
Korba	228	-	228	-	1973-74	-	-	-	-	-	-
Ramagundum	228	-	228	-	1973-74	-	-	-	-	-	-
Nangal (Expansion)	160	-	160	-	1973-74	-	-	-	-	-	-
	776	50	776	50		-	-	-	-	-	-
TOTAL PUBLIC SECTOR			2,364	420		290	29	296	22	390	34

(Contd)

Appendix Q

SCHEDULE OF COMPLETION AND PROJECTED PRODUCTION BY PLANT
(In Thousands of Metric Tons - Indian Fiscal Years)

Plant	1969-70		1970-71		1971-72		1972-73		1973-74	
	N	P_2O_5	N	P_2O_5	N	P_2O_5	N	P_2O_5	N	P_2O_5
PUBLIC SECTOR (Contd)										
IN OPERATION:										
Alwaye	56	27	56	27	56	27	56	27	56	27
Sindri	86	-	86	-	86	-	86	-	86	-
Nangal	72	-	72	-	72	-	72	-	72	-
Rourkela	36	-	36	-	36	-	36	-	36	-
Trombay	69	40	69	40	69	40	69	40	69	40
Nayveli	63	-	63	-	63	-	63	-	63	-
Gorakhpur	72	-	72	-	72	-	72	-	72	-
Namrup	27	-	40	-	40	-	40	-	40	-
	481	67	494	67	494	67	494	67	494	67
UNDER CONSTRUCTION:										
Sindri (Expansion)	10	-	18	-	18	-	18	-	18	-
Rourkela (Gassifier)	16	-	48	-	72	-	72	-	72	-
Alwaye (Expansion)	15	8	27	13	27	13	27	13	27	13
Cochin	-	-	-	-	32	-	96	-	152	-
Durgapur	-	-	-	-	32	-	96	-	152	-
Barauni	-	-	-	-	32	-	96	-	152	-
Namrup (Expansion)	-	-	-	-	32	-	96	-	152	-
	41	8	93	13	245	13	501	13	725	13
PLANNED:										
Trombay (Gassifier)	-	-	7	-	12	-	12	-	12	-
Sindri (Rationalization)	-	-	-	-	-	31	-	94	-	140
Trombay Expansion	-	-	-	-	-	-	51	25	154	74
	-	-	7	-	12	31	63	119	166	214
UNDER CONSIDERATION:										
Haldia	-	-	-	-	-	-	-	-	32	10
Korba	-	-	-	-	-	-	-	-	46	-
Ramagundum	-	-	-	-	-	-	-	-	46	-
Nangal (Expansion)	-	-	-	-	-	-	-	-	32	-
	-	-	-	-	-	-	-	-	156	10
TOTAL PUBLIC SECTOR	522	75	594	80	751	111	1,058	199	1,541	304

(Contd) Appendix 4

Plant	Installed Capacity Nitrogen (N)	Installed Capacity Phosphate (P_2O_5)	Attainable Capacity N	Attainable Capacity P_2O_5	Completion Year IFY	1966-67 N	1966-67 P_2O_5	1967-68 N	1967-68 P_2O_5	1968-69 N	1968-69 P_2O_5
PRIVATE SECTOR											
IN OPERATION:											
Miscellaneous	34	230	34	230	-	20	151	24	144	27	150
Vizag	85	75	85	75	1967-68	-	-	7	2	52	37
Baroda	100	55	100	55	1967-68	-	-	40	13	70	27
Kota	120	-	120	-	1968-69	-	-	-	-	-	-
	339	360	339	360		20	151	71	159	149	214
UNDER CONSTRUCTION:											
Baroda (Expansion)	130	-	130	-	1969-70	-	-	-	-	-	-
Kanpur	200	-	200	-	1970-71	-	-	-	-	-	-
Madras	200	85	200	85	1970-71	-	-	-	-	-	-
	530	85	530	85		-	-	-	-	-	-
PLANNED:											
Goa	160	42	160	42	1972-73	-	-	-	-	-	-
Kandla	260	130	260	130	1972-73	-	-	-	-	-	-
Kota Expansion	8	30	8	30	1972-73	-	-	-	-	-	-
Bombay (Dharmsi)	90	230	90	230	1971-72	-	-	-	-	-	-
Vizag (Occidental) / Vizag (Coromandel)	155	55	155	55	1971-72	-	-	-	-	-	-
Mirzapur	160	-	160	-	1972-73	-	-	-	-	-	-
Okha	130	140	130	140	1972-73	-	-	-	-	-	-
Mangalore	160	-	160	-	1972-73	-	-	-	-	-	-
	1,123	627	1,123	627		-	-	-	-	-	-
UNDER CONSIDERATION:											
Paradeep	94	240	94	240	1973-74	-	-	-	-	-	-
Tuticorn	229	150	229	150	1973-74	-	-	-	-	-	-
	323	390	323	390		-	-	-	-	-	-
TOTAL PRIVATE SECTOR			2,315	1,462		20	151	71	159	149	214
TOTAL BOTH SECTORS			4,679	1,882		310	180	367	181	539	248

(Contd)

Appendix Q

Plant	1969-70 N	1969-70 P_2O_5	1970-71 N	1970-71 P_2O_5	1971-72 N	1971-72 P_2O_5	1972-73 N	1972-73 P_2O_5	1973-74 N	1973-74 P_2O_5
PRIVATE SECTOR (Contd)										
IN OPERATION:										
Miscellaneous	31	150	31	150	31	150	31	150	31	150
Vizag	77	68	77	68	77	68	77	68	77	68
Baroda	90	50	90	50	90	50	90	50	90	50
Kota	72	-	108	-	108	-	108	-	108	-
	270	268	306	268	306	268	306	268	306	268
UNDER CONSTRUCTION:										
Baroda (Expansion)	26	-	78	-	117	-	117	-	117	-
Kanpur	-	-	40	-	120	-	180	-	180	-
Madras	-	-	40	17	120	51	180	77	180	77
	26	-	158	17	357	51	477	77	477	77
PLANNED:										
Goa	-	-	-	-	-	-	32	8	96	25
Kandla	-	-	-	-	-	-	52	26	156	78
Kota Expansion	-	-	-	-	-	-	2	6	7	18
Bombay (Dharmsi)	-	-	-	-	18	46	54	138	81	207
Vizag (Occidental) / Vizag (Coromandel)	-	-	-	-	31	11	93	33	140	50
Mirzapur	-	-	-	-	-	-	32	-	96	-
Okha	-	-	-	-	-	-	26	28	78	84
Mangalore	-	-	-	-	-	-	32	-	96	-
	-	-	-	-	49	57	323	239	750	462
UNDER CONSIDERATION:										
Paradeep	-	-	-	-	-	-	-	-	19	48
Tuticorn	-	-	-	-	-	-	-	-	46	30
	-	-	-	-	-	-	-	-	65	78
TOTAL PRIVATE SECTOR	296	268	464	285	712	376	1,106	584	1,598	885
TOTAL BOTH SECTORS	818	343	1,058	365	1,463	487	2,164	783	3,139	1,189

Appendix Q (continued)

Notes to Projection

1. Installed capacity is the designed daily capacity times 330 days; 35 days have been allowed for maintenance.

2. In four older plants (Sindri, Alwaye, Rourkela and Trombay) the attainable capacity is less than the designed capacity primarily due to raw material problems. In these cases the projections are based on the attainable capacity. In each instance steps are being taken which will bring the plant up to its installed capacity. These actions are carried separately under the headings "under construction" or "planned". For example, Rourkela has a designed capacity of 120,000 MT/Y of N but because of a raw material limitation (coke oven gas) it can only produce 40,000 MT/Y. A gassifier is being added which will use naphtha as a feedstock and supplement the coke oven gas feedstock and will add 80,000 MT/Y of N capacity bringing the unit back to its original installed of 120,000 MT/Y. The gassifier addition is carried separately but is an integral part of the existing unit.

3. New plants and substantial expansions have been phased as follows:

- production of 20 percent of capacity in the Indian Fiscal Year (IFY) in which the plant comes on stream.

- production of 60 percent of capacity in the next IFY, the first full production year.

- production of 90 percent of capacity in the third and succeeding IFY's.

This is a slight change from earlier projections. Previously we had limited production in public sector plants to 85 percent of capacity and in private sector plants to 95 percent of capacity. Our reasons for equalizing the two sectors are: (1) the GOI is making a greater effort to keep the existing plants operating at capacity through a more liberal release of foreign exchange for spare parts, raw materials, etc., staffing changes and utility supplies; and (2) although the private sector plants are operated more efficiently, they are subject to constraints not under their control (power, raw materials) which limit their production.

4. Small expansions (Sindri, Alwaye, Trombay and Kota) have been phased as follows:

- production of 50 percent of expansion capacity in the IFY that the expansion comes on stream.

- production of 90 percent of expansion capacity in the second and succeeding IFY's.

5. An exception to the foregoing principles was made for the DCM plant at Kota. We have projected the plant to operate at 60 percent capacity in its first operating year (1969-70) because (1) the plant start up was March 1, 1969 therefore allowing a full 12 months for production and (2) the plant performed well in the first quarter of this IFY.

6. The plants shown in the "planned" sections include all plants that have at least a letter of intent except for the Kalinga Tube Ltd.'s plant in the Punjab because our information indicates this to be a non-starter.

7. The plants shown in the "under consideration" category include all plants currently being discussed except for the Thapur Group's coal based plant at Nagpur. We, at this time, consider the plant an unlikely prospect.

8. In the category "under consideration" in the public sector section we have listed two coal based plants (Korba and Ramagandum) currently being discussed. While there is some question as to the economic feasibility of these plants, and therefore some questions as to their inclusion, we have not included the three plants (Trombay, Cochin and Madras) which would be based on imported ammonia from Iran. The GOI expects to conclude its negotiations with Iran shortly. We then will have a better idea of the configuration of the public sector plants. In the interim, we believe this approach is conservative.

9. In the private sector "planned plants" section we have included both the Coromandel expansion at Vizag and the Occidental plant at Vizag. Since we believe the decision of one company will pre-empt the decision of the other and that only one plant will eventually be built, we have projected production from only one plant, using the average capacity of the two.

10. We have reduced the nitrogen capacity of the small miscellaneous plants from 60,000 MT/Y to 34,000 MT/Y, the capacity of three of the many plants, because we get accurate monthly figures on the three while none on the many. Also, the estimate of production from the small phosphate plants is a guess, albeit an educated one.

11. We believe the projections to be, on balance, conservative -- with the following caveats:

(a) While we have projected a delay of about two years in the completion of the Durgapur and Cochin plants, we have not postponed the completion of the Baruni and Namrup plants. All four plants are identical. The Baruni and Namrup plants were started about two years after Durgapur and Cochin, and, therefore, presumably should be two years behind in

completion. We do not, however, at this time, have conclusive evidence that Baruni and Namrup will be delayed and theoretically they can still be completed by 1971-72.

(b) Based on our prior experience, it is unlikely that all of the planned plants, will, in fact, materialize.

(c) Projecting production at 90 percent of capacity, at this time in India, may be a little optimistic.

F-260

APPENDIX R

Status of Major Irrigation Projects in India

Name of Project	Date of Commence-ment	Date Completed/Anticipated	Total Est. Cost (m/Rs.)	Approx. Exp. upto 3/67 (m/Rs.)	Percentage of completion	Planned Irrigation potential in acres(net)	Irrigation Utilization Anticipated upto 67-68 in ac. (Net)
1	2	3 4	5	6	7	8	9
ANDHRA PRADESH							
K.C. Canal & Sun Kesula Anicut	1954-55	1962	75.77	75	100	302,000	278,000
Tungabhadra Low Level Canal	1945	1957	128.1	124	100	148,870	156,070
Kadam Project	1949	4th Plan	83.8	79	94	85,000	30,000
Nagarjuna-sagar Project	1956	End of 4th Plan	1645.00	1207	73	2,050,000	330,000
Tungabhadra High Level Canal							
Stage I	1956-57	1967-68	177.8	112	63	119,000	15,000
Stage II	(Preliminary work started)	During 5th Plan	116.50	6	5	137,430	nil
Pochampad Project	1963	During 5th Plan	401.0	62	15	570,000	nil

1.	2.	3.	4.	5.	6.	7.	8.	9.
BIHAR								
Badua Irrigation Project	1958	1965-66		62.8	63	100	105,000	81,000
Sone Barrange Including Sone High Level Canal	Barrage and Remodelling Works 1961	1966-67		163.93	165	100	307,000	380,000
	High-level Canal not yet started			59.1	NA		252,000	nil
Kosi Project (Barrage)	1957	completed		Kosi Project 681.3				
Eastern Canal	1959				370		1,405,000	1,000,000
Rajpur Canal	1961		1969-70	64.8	34	54	397,000	10,000
Western Canal	(not yet started)			196.9	4	2	773,000	nil
Gandak Project	1960	During 5th Plan(72-73)		949.2	281 (for Bihar only)	30	2,845,000 (Bihar only)	-
Chandan Reservoir Project	1961-62	During 4th Plan		95.3	33	34	100,000	9,000

Appendix R (continued)

1.	2.	3.	4.	5.	6.	7.	8.	9.
GUJARAT								
Shetrunji	1955	1965		69.6	68	100	86,000	50,560
Kakrapar	1949		During 4th Plan	185.7	169	91	562,200	134,000
Mahi Right Bank Canal (Mahi Stage I)	1948		End of 4th Plan	245.68	164	67	460,000	76,370
Banas (Dantiwada) Project	1958		During 4th Plan	108.79	118	100	110,000	64,220
Hathmati Res. Project	1959		During 4th Plan	54.46	50	92	92,900	37,990
Kadana Project (Mahi Stage II)	1956 (preliminaries)		End of 5th Plan	162.6	9	6	40,910	-
Narmada(Broach) Irrigation Project	1959		not fixed	414.00	54 (under Revision)	13	997,500	-
Ukai Project	1960		Head Works (End of 4th Plan) Canal during 5th Plan	963.3	175	18	391,550	-

Appendix R (continued)

1.	2.	3.	4.	5.	6.	7.	8.	9.
HARYANA								
Remodelling Western Jamuna Canal	1951-52		During 4th Plan	95.2	35	37	612,690	354,000
Gurgaon Canal Project	1959-60		During 4th Plan	87.90	47	53	251,000	-
KERALA								
Malampuzha Project	1949	1967		58.0	54	93	95,200	95,200
Kuttiyadi Project	1962		During 4th Plan	49.6	9	18	77,000	-
Periyar Valley Project	1956		End of 4th Plan	64.0	45	70	101,300	38,000
Pamba Irrigation Project	1962		During 4th Plan	64.0	17	27	84,000	-
Kallada Project (only preliminaries)	1962		During 5th Plan	132.8	3	3	260,000	-

(Appendix R continued)

1.	2.	3.	4.	5.	6.	7.	8.	9.
MADHYA PRADESH					Total for Stage I			
Gandhi Sagar Dam-Chambal Project	1954	(Dam completed) 1960		(Irrigation) 136.03	M.P. portion 347	100	(Combined for Chambal I & II) 700,000	172,000
Barna Project	1960		End of 4th Plan	700.00	7	1	164,160	-
Tawa Project	1962		During 5th Plan	341.4	47	14	750,000	-
MADRAS								
Lower Bhavani	1949	1956		103.40	103	100	195,000	195,000
Mani Mathar	1950	1958		50.5	51	100	103,000	103,000
Chittar			End of 4th Plan	73.3	30	41	47,000	-
Pattnamkal	1963							
Parambikulam	1958		During 4th Plan	370.0	334	90	240,000	70,000
MAHARASHTRA								
Ghod	1954	1965-66		57.97	49	85	60,800	60,800
Bagh Project	1958		During 4th Plan	58.4	15	26	83,200	-
Vir Project	1957	1965-66		54.1	49	89	66,000	52,840
Girva Project	1958		During 4th Plan	127.5	122	95	141,360	59,160

Appendix R (continued)

1.	2.	3.	4.	5,	6,	7.	8.	9.
MAHARASHTRA (contd.)								
Itiadoh Project (only preliminaries)	1958		End of 4th Plan	73.4	17	23	114,000	-
Khadakwasla Pro. Stage I	1957		End of 4th Plan	160.7	137	85	55,100	162,200
Mula Project	1959		During 4th Plan	161.6	89	85	162,000	-
Purna Project	1957		" "	153.4	156	100	152,000	20,830
Bhimla Project (only preliminaries)	1964		End of 5th Plan	425.8	19	4	468,738	-
Jayakwadi Project Stage I	1964		During 5th Plan	384.6	34	9	350,000	-
Krishna Project (not yet started)					1		262,640	-
Warna Project (only preliminaries)	1964		End of 5th Plan	316.4	5	2	244,770	-
MYSORE								
Chataprabha Stage I	1949	Completed		57.6	57	100	48,000	45,000
Stage II	1956		During 5th Plan	420.0	70	16	250,000	10,400
Tungabhadra Project	1945							
Dam Completed		1956		175.1	NA	100		
Right Bank low level Canal completed		1955		14.5)			92,340	80,000
Left Bank Canal completed		1963		355.2)	320	89	580,000	430,000

Appendix R (continued)

1.	2.	3.	4.	5.	6.	7.	8.	9.
MYSORE (contd.)								
High level Canal (Stage I completed)		1966-67		44.0	28		100,000	30,000
Stage II			During 5th Plan	30.0	-		93,000	-
Bhadra	1947		End of 4th Plan	342.7	272	80	244,660	170,000
Kabini Project	1959		During 5th Plan	170.4	26	15	128,180	-
Malaprabha Proj.	1965		" " "	200.0	28	14	300,000	-
Upper Krishna	1964		" " "	590.0	18	3	600,000	-
Harangi Project (Tentative)	1966		" " "	110.0	0.4	-	75,000	-
Hemavathi Project (Tentative)	1966		" " "	163.0	0.6	-	100,000	-
ORISSA								
Hirakud	1948						627,000	500,000
Dam completed		1957		678.1	655	97		
Irrigation Potential			End of 4th Plan	149.5	NA	-		
Mahanadi Delta Irr. Proj.	1955		During 4th Plan	343.4	236	68	1,608,000	1,021,000
Salandi Project	1961		" " "	130.77	90	68	153,000	30,000

Appendix R (continued)

1.	2.	3.	4.	5.	6.	7.	8.	9.
PUNJAB								
Bhakra-Nangal	1948(Dam & Canal System completed)			1,031.77 (irri.)	801	80% (Pb.) (Haryana) (Rajasthan)	1,364,590 1,671,000 570,000	1,364,590 1,671,000 570,000
Harki Project (Makhu Canal)	1950	1958		91.29	91	100	34,100	34,100
Sirhind Feeder	1953-54	1960		67.00	60	90	No direct benefits	
Beas-I Beas Sutlej Link	1961		During 5th Plan	1105.00	10(Punjab portion)	1	NA	NA
Beas II-Dam at Pong	1961			1300.00	65	5	NA	-
RAJASTHAN								
Kota Barrage Chambal Project Stage I	1953	(barrage com.) 1960	Canal system End of 4th Plan L.B.C R.B.C	48.3 33.9 126.2	170	81	550,000	550,000
Rajasthan Canal Project Stage I Stage II	1958		End of 4th Plan after 5th Plan	801.2 1039.7	475.00	59	1,300,000	165,000

Appendix R (continued)

1.	2.	3.	4.	5.	6.	7.	8.	9.
RAJASTHAN (contd.)								
Rana Pratab Sagar Dam Chambal Project Stage II	1961		During 4th Plan	232.2	55	24	150,000	-
UTTAR PRADESH								
Matatilla Proj.	1952	1966		124.60	123	100	409,580	409,580
Sarda Sagar	1957	1962		73.23	72	100	185,150	185,150
Ramganga	1961		During 5th Plan	680.00	303	44	1,706,100	200,000
Western Gandak Canal Project (Inter-State Proj. with Bihar)	1961		During 5th Plan	467.9	99	21	711,750	-
WEST BENGAL								
Mayarakshi (Massanjore or Canada Dam)	1946	1956		204.6	161	80	610,000	550,000
Kangsabati Reservoir Proj.	1956		During 4th Plan	360.0	171	48	950,000	135,000
DAMODAR VALLEY CORPORATION								
Durgapur Barrage	1952	1955		188.2	48	21	880,000	758,000
			GRAND TOTAL	23,288.68	9,978,00		35,176,660	12,518,000

APPENDIX S

INPUT PRICES

a. Fertilizer

Although the main object of GOI in setting up a Central Fertilizer Pool (see Fertilizer Distribution Policies) was to make fertilizers - imported as well as indigenously produced - available to cultivators at uniform prices throughout the country, the fact is that the Pool made a net profit of nearly Rs.434 million from its inception in 1944-45 to 1963-64. This gave rise to criticism both inside and outside the Parliament. When, however, in June 1966 the rupee was devalued and the cost of fertilizers imports went up, GOI did not raise the prices of Pool fertilizers immediately. The profits made in the past were used to subsidize sales of fertilizers up to March 31, 1967. From April 1, 1967 the Pool prices were raised and the subsidy was partially withdrawn. From April 1968 it was withdrawn in toto. On earlier occasions, in order to stimulate sales of Calcium Ammonium Nitrate and Urea which had failed to become popular with the cultivators, GOI drastically reduced their prices by Rs.32 and Rs.100 per tonne, respectively. Presently the Pool's working is, broadly speaking, on a no profit - no loss basis.

Theoretically, indigenous manufacturers now have full freedom in pricing their products (see Fertilizer Distribution). However, in practice, Government action dominates the pricing structure. Imported fertilizers, which account for well over half of the total, are distributed exclusively through the Pool, with the exception of most of the potash, and the government sets the consumer price at which such fertilizers shall be sold. Thus, the Pool price tends to establish indirectly the maximum price at which indigenously produced fertilizers of the same types are sold.

The Fertilizer Association of India, as an agent for the GOI, establishes the maximum ex-factory price for superphosphate, although distribution margins are established by the manufacturers. In most States, fertilizer mixers are forced to pay the same price for nitrogenous and complex materials as is established for cultivators, so that the nutrient cost of mixtures in these states is necessarily greater than the nutrient cost of the straight materials.

Appendix S (continued)

Most of the potash is distributed through a private organization called the Indian Potash Supply Agency, although procurement is through the State Trading Corporation. Some potash, particularly potassium sulphate, has been procured and distributed by the Pool in recent years, but this has apparently been discontinued. Potash prices are regulated by the GOI through the establishment of distribution margins.

With massive imports and more factories coming into production, the fertilizer supply situation has changed since 1966-67 from one of scarcity accompanied by black marketeering to one of aggregate plenty. Indigenous producers, particularly the superphosphate manufacturers, have been experiencing increasing difficulty in marketing their products. As a result, there are reports from many parts of India of pricing below the established patterns.

The limits within which price reduction can be effected are very narrow, however, because of the high cost of production in India and the relatively small profits margins which are allowed. Nevertheless, in the longer term, it can reasonably be expected that as the newer, larger plants utilizing latest technological developments come on stream, some reduction in fertilizer prices can be expected as a result of both reductions in cost and increased competition.

Prices of certain fertilizers in 1966-67 in selected countries as compared with those in India, on a nutrient basis, as reported by the FAO, are shown in the Table. It will be noted that prices paid by farmers in India are about the highest in the world.

There are good reasons for the high prices of fertilizers in India. Sulphur and phosphate rock are imported, as is much of the crude oil from which naptha is obtained for ammonia production. Machinery and equipment for plant construction and spare parts also have high cost, whether imported or indigenously produced. In the case of imported equipment, a stiff import duty adds considerably to the cost. In the case of imported fertilizers, India is about as far away from its sources of supply as is possible, so that shipping costs add considerably to the landed price.

Nevertheless, by reason of the scarcity of foreign exchange, India must seek self-sufficiency in fertilizer production, even though it is high cost production. Moreover, even at the relatively high prices, the economics of fertilizer use, particularly on the HYV is still favorable and extremely attractive.

In order to encourage lifting of fertilizer in advance of the manuring seasons the Central Fertilizer Pool allows off-season rebate. This helps to ensure timely availability of fertilizers to cultivators. The other promotional measures taken to encourage the use of fertilizers are:

a) subsidy on transport of fertilizers from factories/ports by road to destinations upto 500 km and (beyond 500 km in cases where wagon supply for rail transport is inadequate);

b) subsidy on transport cost of fertilizers to hilly and inaccessible areas; and

c) subsidy on cost of soil amendments to encourage their use.

b. Seeds

The demand for seed of the varieties first introduced such as Lerma Rojo and S. 64 is very limited. The price for these seeds is at the government procurement prices of $2.76 a bushel (Rs. 76 per quintal). The demand for seeds of newer varieties as they are introduced is very brisk. Examples of price quotations for deliveries in April through June of 1968 from UPAU are as follows:

Sonalika (S. 308)	Rs.175 per quintal ($6.36 per bushel)
S. 331	Rs.175 per quintal ($6.36 per bushel)
S. 227	Rs.500 per quintal ($18.16 per bushel)

As an example of the tremendous demand for new varieties when they are first introduced, it is reported that seeds of the triple gene dwarf wheats which are yet untested and not recommended, demand prices as high as Rs.500 a kilo.

Because the improved seeds represent a relatively small portion of total production costs and because there has been a conscious desire to see that better cultivators, those who can pay, get these seeds and use them correctly, the HYV seed prices

at first, the action has proven an asset since the producers and formulators of pesticide have followed a policy of setting up their own distribution outlets instead of relying on the State Governments.

Five years ago the Pesticide Association of India was founded. This organization is a moving force for the industry and has been instrumental in the formation of the recently authorized Pesticide Act. The Association has lobbied for the industry in securing tax reductions on imports of technical materials as well as on the finished products.

Generally the prices of commonly used pesticides in India are comparable with domestic prices in the United States. DDT 10% dust for example 7.5¢ per pound and BHC 10% is 5.0¢ per pound.

d. Equipment

1) Tractor prices are fixed by GOI, but there is apparently a black market trade of significant volume with appreciable markups. 35 h.p. tractors are available for equivalent of $2000-3000 depending upon model and extra equipment. Prices have been revised upward within the last year to counter-balance increasing ancillary costs.

2) Implements are available on open market and advertised prices are approximately 0.15¢ per pound of weight - relatively low by international standards. Seasonal premium prices of 10%-50% result from inadequate inventories of some tillage tools and threshing machines.

3) Seed-Fertilizer Drills are available on limited subsidy; one state supplied a thousand machines at 40% subsidy. All subsidy programs for agricultural implements are expected to be discontinued within next year.

4) Commercial Banks and Agro-Industries Corporations have begun to finance equipment purchases. Interest and service charges are on the order of 10% and payments are permitted over a 3 to 5 year period.

e. Irrigation (S. Singh, 1968)

"Water rates in India are not uniform; nor do the variations have any scientific basis. Generally, irrigation

Appendix S (continued)

managements used to fix the charge for the use of water as a particular proposition to the value of output. But the changes in price level during and after World War II radically altered this correlation between the water rates and value of output... They form roughly only 4-5% of an average of the gross income in the case of rice crops and 2-3% in the case of wheat crops."

The general criterion for investment sanction has been that a project was required to earn sufficient revenue so as to pay a minimum return after deducting working expenses on the sum and charge (defined as the capital cost of construction plus the areas of simple interest up to that year) in the tenth year after its opening. However, during 1965-66, the commercial account for irrigation works showed a net loss of Rs.38,750,000. Every state showed a net loss and six states showed working expenses alone, exceeding gross receipts."

Appendix S (continued)

Table

Prices paid by farmers for bagged material (1966-67)

(Rs. per MT of nutrient
Dollar equivalents in parenthesis
at Rs.7.5 to $1)

		Ammonium Sulphate	Urea	Single super-phosphate	Muriate of Potash
aa	United Kingtom	1305($174.00)	-	1110($148.00)	780*1/($104.60)
*,aa	USA	2130($284.00)	1807($240.90)	1740($232.00)	802 1/($106.90)
	Australia 3/	2137($284.90)	1592($210.90)	967($128.90)	870 1,*/($116.00)
*,a	West Germany	2115($282.00)	1195($266.00)	1702($226.90)	600 2/($80.00)
aa	India 4/	2827($376.90)	2152($286.90)	2025($270.00)	765 1/($102.00)

1/ Over 45% K_2O 2/ 50% K_2O 3/ Prices are for 20 ton lots 4/ 1965-66
aa : Prices at retail stores
* : No subsidies
a : Prices at nearest Railway station.

United Kingdom: Prices are for 6 ton lots. Subsidies are as under:

Ammonium sulphate	Rs.652.50 per metric ton of nutrient
Ammonium nitrate) Calcium ammonium nitrate)	Rs.502.50 per metric ton of nutrient
Single superphosphate	Rs.517.50 per metric ton of nutrient
Basic slag	Rs.345.00 per metric ton of nutrient

United States: Prices paid by farmers at varying points of delivery. Under agricultural conservation programme there is cost-sharing arrangement with farmers for fertilizers as well as other requisites, but this is not considered as subsidy.

Australia: Prices are for Yarraville, except calcium ammonium nitrate (ammonium nitrates) and urea which are ex-works. Subsidies paid to fertilizer manufacturers on:

Ammonium sulphate:	Rs.981.75 per metric ton of nutrient
Ammonium nitrate and Urea:	Rs.660.75 per metric ton of nutrient
Superphosphate:	Rs.2250.00 per metric ton of nutrient

India: No uniform subsidy was given throughout India in 1966-67. In some States a subsidy of 25% of cost was granted on phosphate fertilizers. Another subsidy covers cost of transport of fertilizer in hilly areas and areas difficult of accession. In other areas, a subsidy of 25% of cost was allowed on nitrogenous fertilizer and 50% on phosphatic fertilizers.

Source: FAI, 1968a. Prices of individual fertilizers for past five years are also available in this source.

F-275

Appendix T

Costs for cultivation of paddy - 1966-67

The attached table provides guess estimates of the costs of production of paddy in 1966-67 in some States of India. The table is derived by inflating the data from Farm Management Studies conducted in West Bengal (1954-57), Madras (1954-57), Andhra Pradesh (1957-60), Orissa (1957-60), Bihar (1960-61), Madhya Pradesh (1962-63) and Kerala (1962-63). The components of the factor costs are derived as follows:

1. Human labor - Physical labor inputs per hectare in 1966-67 is assumed same as obtained in F.M.S. Season average wage rate in 1966-67 is compiled from the various issues of the Agricultural Situation in India. Physical human labor input (in days/hectare) is multiplied by the wage rate to obtain human labor cost per hectare.

2. Bullock labor - Actually this could be obtained only when we have some information about the cost per day for a pair of bullocks for cultivation purpose. Since data on this regard are not available we have tried to approximate it by using the index for food articles as inflator, the latter being assumed as an index for the cost of maintenance of a pair of bullocks. The estimates would likely to have a positive bias.

3. Seed - The index number of wholesale price of rice during the peak marketing period (Nov.-Feb.) is used as an inflator to obtain the cost of seed per hectare.

4. Manures and fertilizer - Annual average price index of fertilizer is used as an inflator

5. Depreciation
6. Land Revenue
7. Irrigation charges
8. Interest paid on crop loans
11. Interest on owned fixed capital
12 Miscellaneous

Each of these items constitutes a small fraction of the total cost in F.M.S. data. They are assumed constant over years.

9. Rent on leased land
10. Rental value of owned land

The general price level index is used as an inflator.

13. Total cost - Total of items (1) to (12)

14. Paid out costs for owners
15. Paid out costs for tenants.
16. Total costs excluding the imputed value of the family labor

Assumed to be in the same proportion of the total cost as in F.M.S.

17. Output figure refers to the production year 1964-65.

Appendix T (Contd.)

Costs for Cultivation of Wheat - 1966-67

(1)	U.P. Meerut and Muzaffarnagar		PUNJAB Amritsar and Ferozepur		PUNJAB Karnal, Rohtak and Jind Tehsil		MAHARASHTRA Ahmednagar		MAHARASHTRA Nasik		RAJ. Pali
	Irrigated (2)	Unirrigated (3)	Irrigated (4)	Unirrigated (5)	Irrigated (6)	Unirrigated (7)	Irrigated (8)	Unirrigated (9)	Irrigated (10)	Unirrigated (11)	(12)
1. Human Labor (Rs./Hect)	252.75	207.57	201.63	95.04	147.00	129.24	315.22	130.76	420.05	103.35	421.65
2. Bullock Labor "	464.30	381.20	227.50	118.19	172.18	144.73	141.66	67.66	209.52	72.31	395.80
3. Seed "	52.20	51.63	46.69	39.48	57.78	61.77	56.37	42.90	70.99	45.17	73.71
4. Manure and Fertilizer "	3.35	2.90	6.58	0.33	0.51	1.12	11.60	3.57	20.31	1.11	11.95
5. Depreciation "	27.00	22.00	14.80	6. 70	9.30	9.20	13.60	3.40	32.90	6.90	3.40
6. Land Revenue "	12.50	14.90	4.20	4.30	4.60	4.80	3.50	3.40	2.30	2.80	15.70
7. Irrigation Charges "	24.50	-	14.00	-	15.80	-	3.20	-	-	-	-
8. Int. paid on crop loans "	-	-	-	-	-	-	-	-	-	-	-
9. Rent on leased land "	-	-	137.70	69.50	24.50	12.20	11.20	8.00	6.80	7.20	-
10. Rental of owned land "	-	-	-	-	172.90	100.70	32.00	12.20	38.10.	18.00	58.80
11. Int. on fixed capital "	14.20	10.00	4.70	2.80	23.90	13.30	17.30	2.20	21.80	2.40	-
12. Misc. "	-	-	6.80	3.70	6.60	5.20	0.60	-	0.30	-	-
13. Total Cost "	850.80	690.20	664.60	340.04	635.07	482.26	606.25	274.09	823.07	259.24	981.01
14. Output (Quintal/Hect)	10.51	5.90	11.57	4.73	13.79	11.37	6.36	3.14	5.44	1.94	8.35
15. Cost per quintal	80.95	116.98	60.04	71.89	46.05	42.42	95.32	87.29	151.30	133.63	117.49
16. Procurement price in 1966-67	82-85	82-85	76-81	76-81	76-81	76-81					77-85

17. Minimum Support Price in 1966-67 Rs. 49.50 to 60.75 for all States in India.

F-277

Costs for Cultivation of paddy - 1966-67

(1)	West Bengal Aman (2)	West Bengal Aus (3)	Madras Irrigated paddy Sn. I (4)	Madras Irrigated paddy Sn.II (5)	Andhra pradesh Irrigated Paddy Sn. I (6)	Andhra pradesh Irrigated Paddy Sn.II (7)	Un-ir paddy (8)	Orissa Aman (9)	Bihar July Aug. (10)	M.P. June July (11)	Kerala April Nov. (12)
1.a. Human Labor (days/hectare)	120.07	127.24	288.19	241.98	116.21	110.19	101.61	101.19	94.58	92.98	157.67
b. Wage rate in 66-67 (Rs/day)	2.45	2.45	1.69	1.69	2.83	2.83	2.83	2.12	2.54	1.73	3.18
c. Human labor cost (Rs/hect)	294.17	311.74	487.04	408.95	328.87	311.84	287.56	214.52	240.23	160.86	501.39
2. Bullock labor cost (Rs/hect)	78.23	80.55	529.84	376.76	170.43	206.84	65.96	92.34	259.57	86.19	79.86
3. Seed (Rs/hect)	35.36	43.08	57.09	57.09	66.53	75.38	15.64	57.39	38.71	44.30	124.97
4. Manure & Fertilizers (Rs/hect)	7.57	17.43	147.10	116.46	27.86	82.86	39.52	9.80	6.59	4.72	18.04
5. Depreciation (Rs/Hect)	5.90	5.00	27.80	25.70	10.00	8.80	3.90	7.50	6.40	4.40	16.80
6. Land Revenue (Rs/hect)	14.70	11.60	4.90	4.10	28.30	18.30	8.40	1.30	8.10	2.40	6.30
7. Irrigation charges (Rs/hect)	-	-	4.10	5.40	4.70	2.90	-	-	13.10	5.80	34.50
8. Interest paid on crop loans(Rs/hect)	-	-	-	-	1.50	1.50	-	2.00	-	-	-
9. Rent on leased land (Rs/hect)	123.39	140.68	285.44	286.99	128.14	125.09	113.23	9.66	19.44	9.27	101.95
10.Rental value of owned land (Rs/hect)	133.88	70.73	99.87	92.10	562.41	386.30	283.24	76.28	138.54	103.75	305.56
11.Int. on owned fixed capital	-	-	-	-	3.90	2.90	1.70	-	-	6.70	4.40
12.Miscellaneous	5.50	3.70	9.00	6.80	-	0.70	-	-	-	0.60	11.50
13.Total Cost	821.22	814.20	1942.06	1624.02	1451.88	1336.43	923.59	574.10	827.80	523.70	1366.12
14.paid out costs for owners	294.76	244.21	-	-	651.20	732.14	414.53	322.57	561.12	273.96	934.46
15. " " " " tenants	499.90	393.31	1250.25	977.04	791.68	867.88	516.42	337.13	585.77	284.71	1034.04
16.Total cost excluding the imputed value of family labor	590.77	488.50	1474.86	1442.85	1411.23	1292.02	872.42	425.35	764.26	421.35	1365.59
17.Output (quintals/hectare)	15.40	13.00	25.36	21.77	21.76	19.54	12.03	11.65	19.42	11.24	21.18
18.Cost per quintal:											
i) with reference to (14)	19.14	18.78	-	-	29.93	37.47	34.45	28.94	28.89	24.37	44.12
ii) with reference to (16)	38.36	37.58	58.16	66.27	64.85	66.12	72.52	36.51	39.35	37.49	64.47

Appendix U

Incentive Prices Calculated by Modified Production Function Method
(Estimated Incentive Price and Realised Price on the Basis
of I.A.D.P. Data—1963-64*)

State	Gross income (Rs./Acre)		Operational cost** (Rs./Acre)		Yield (Qtls./Acre)	
	Demonstration	Control	Demonstration	Control	Demonstration	Control
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Crop: Paddy						
Andhra Pradesh	418.00	356.00	166.00	131.00	12.16	10.35
Bihar	420.54	252.00	155.98	80.46	11.54	6.90
Kerala	501.78	359.25	256.10	198.01	12.17	8.49
Assam	415.25	280.63	234.42	155.20	12.92	8.73
Madras	483.56	383.48	198.01	154.08	13.32	10.65
Madhya Pradesh	416.86	265.49	151.56	73.26	13.28	8.03
Mysore	833.20	662.00	206.18	176.68	20.83	16.55
Orissa	395.42	280.77	200.00	140.00	12.08	8.47
West Bengal	400.46	330.92	217.05	191.77	13.87	11.79
Crop: Wheat						
Maharashtra	205.91	126.95	91.76	56.98	3.19	2.06
Punjab	577.86	406.81	209.16	157.90	11.70	8.29
Bihar	328.64	134.78	137.56	78.18	6.66	2.71
Gujarat	430.77	312.82	162.37	111.13	5.82	4.21
Crop: Jowar						
Maharashtra (Rabi)	103.36	63.46	58.69	30.68	2.76	1.48
Crop: Maize						
Bihar	588.72	219.07	206.24	108.48	13.49	6.20
Punjab - Desi	294.04	196.76	186.94	126.64	9.80	6.56
Hybrid	475.10	289.47	285.22	171.83	15.84	9.65
Crop: Gram						
Punjab	356.37	251.12	92.85	69.48	6.91	4.99
Bihar	208.52	98.67	89.16	52.85	4.42	2.16
Crop: Barley						
Bihar	266.76	112.33	148.37	72.50	5.67	2.75
Crop: Groundnut						
Gujarat	356.40	290.78	152.01	115.69	5.94	4.54
Punjab	391.27	276.12	116.42	89.64	7.93	5.52

Appendix U (Contd.)

Estimated Incentive Price and Realized Price on the Basis of I.A.D.P. Data—1963-64* (Contd)

State	Incentive Price (Rs./Qtl.) @0	@20%	@33%	@50%	Realised price (Rs./Qtl.)	Minimum price as recommended by the Jha Committee for 1964-65 season	1968-69 Procurement Price
(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Crop: Paddy							
Andhra Pradesh	32.15	35.86	38.32	41.41	34.37	38.00	46.00 (Akkullu)
Bihar	28.38	31.35	33.34	35.81	36.44	35.00	56.25 (Coarse)
Kerala	34.29	36.94	38.66	40.92	41.23	40.00	56.25 (Matta)
Assam	27.85	29.79	31.09	32.71	32.14	34.78	56.25 (Coarse)
Madras	32.09	35.53	37.83	40.70	36.30	38.50	45.00 (Kattai Samba)
Madhya Pradesh	25.89	28.78	30.71	33.12	31.39	35.00	52.00 (Gurmati)
Mysore	33.20	37.86	40.96	44.85	40.00	36.50	48.00 (Coarse)
Orissa	28.21	30.54	32.09	34.04	32.73	34.00	48.00 (Common)
West Bengal	25.68	27.69	29.03	30.70	28.87	37.50	56.25 (Common)
Crop: Wheat							
Maharashtra	50.72	35.11	58.03	61.69	64.57	48.00	70.00-74.00
Punjab	39.17	43.42	46.26	49.81	49.41	48.00	76.00-81.00
Bihar	29.13	30.83	31.96	33.38	49.31	48.00	71.00-81.00
Gujarat	62.56	69.49	74.00	79.89	74.02	48.00	73.00-83.00
Crop: Jowar							
Maharashtra (Rabi)	33.14	35.51	37.06	39.08	37.45	38.00	
Crop: Maize							
Bihar	23.47	25.11	26.18	27.57	43.64	36.00	
Punjab-Desi	26.23	27.66	28.59	29.81	30.00	36.00	
Hybrid	25.43	26.92	27.88	29.14	29.99	36.00	
Crop: Gram							
Punjab	39.72	44.98	48.39	52.86	51.57	-	
Bihar	30.54	32.61	33.96	35.72	47.18	-	
Crop: Barley							
Bihar	33.19	39.83	44.14	49.79	47.05	-	
Crop: Groundnut							
Gujarat	55.07	60.97	64.30	69.81	60.00	-	
Punjab	38.68	43.44	46.54	50.59	49.34	-	

Appendix U (Contd.)

*Data obtained from the Directorate of Extension, Ministry of Food, Agriculture, Community Development & Cooperation, Department of Agriculture, Government of India. The I.A.D.P. District in each State is given below:-

Andhra Pradesh--West Godavari, Bihar--Shahbad, Kerala--Alleppey, Assam--Cachar, Madras--Thanjavur, Madhya Pradesh--Raipur, Mysore--Mandya, Orissa--Sambalpur, West Bengal--Burdwan, Punjab--Ludhiana, Gujarat--Surat, Maharashtra--Bhandara

Demonstration--Use of "Package of Practices",
Control--Use of local practices.

**Operational cost includes money expenses on:

(i) Human labour (ii) Bullock labour (iii) Seed (iv) Manure and fertilizer
(v) Insecticides (vi) Irrigation (Water tax not included).

BIBLIOGRAPHY

A

Abbot, et al., 1962. J.C. Abbott, et al., Marketing - Its Role in Increasing Productivity. Rome: Food and Agriculture Organization, 1962.

Agarwala, 1964d. R. Agarwala, "Size of Holdings and Productivity: A Comment," Economic Weekly, April 11, 1964.

Agarwala, 1964b. R. Agarwala, "Further Comments," Economic Weekly, November 21, 1964.

Agricultural Economic Research Centre, 1961. Economics of Irrigation and Water Rates under Cauvery - Mettur Project. Madras: University of Madras, 1961.

AICRIP, 1967. Progress Report of the All-India Coordinated Rice Improvement Project, 1967.

Alagh, 1961. Y.K. Alagh, "Case for an Agriculture Income Tax," Economic Weekly, Sept. 1961, pp. 1533-38.

Anand, 1960. O.P. Anand, "Some Aspects of Optimum Benefits from Utilization of Irrigation Potential of Chambal Valley Project," Indian Journal of Agricultural Economics, Oct./Dec. 1960, pp. 19-32.

C. Anderson and Bowan, 1965. C. Arnold Anderson and Mary Jean Bowman, Education and Economic Development. Chicago: Aldine, 1965.

G. Anderson, 1969. Unpublished paper on Wheat Research by Glen Anderson of the Rockefeller Foundation, 1969.

Anderson and Dillon, 1968. J.R. Anderson and J.L. Dillon, "Economic Considerations in Response Research, American Journal of Agricultural Economics, Feb. 1968.

Anagol, 1969. J. Anagol, "A Strategy for Ayacut Development under Major Irrigation Projects," Economic and Political Weekly, Review of Agriculture, June 28, 1969, pp. A111-118.

Ansari, 1963. Nasim Ansari, "Some Economic Aspects of Irrigation Development in Northern India," International Journal of Agrarian Affairs, Oct. 1963, pp. 13-49.

Asana, 1966. R.D. Asana, "Possibilities of Improving Wheat Yields in Barani Conditions," Proceedings of the Fifth All-India Wheat Research Workers' Conference, Jaipur, August 17-22, 1966, pp. 85-88.

B

Balogh, 1961. T. Balogh, "Agricultural and Economic Development," Oxford Economic Papers (New Series), Feb. 1961, pp. 27-42.

Bardhon, 1964. K. Bardhon, "Further Comment," Economic Weekly, August 22, 1964.

Basu and Mukherjee, 1963. S.K. Basu and S.B. Mukherjee, Evaluation of Damodar Canals (1959-60): A Study of the Benefits of Irrigation in the Damodar Region. Bombay: Asia Publishing House, 1963.

Bean, 1969. Louis Bean, Report on Weather and Crop Relationships in India and the Feasibility of Forecasting, consultant's report to USAID, April 11, 1969.

Becker, 1962. Gary S. Becker, "Investment in Human Capital: A Theoretical Analysis," Journal of Political Economy, October 1962, Part 2, pp. 9-49.

Becker, 1964. Gary S. Becker, Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education. New York: NBER, 1964.

Bhattacharjee, 1960. J.P. Bhattacharjee, "Changing Characteristics of the Flow of Foodgrains from the Farmers," Agricultural Situation in India, January 1960, pp. 1079-86.

Bhattacharjee, 1961. J.P. Bhattacharjee, "Underemployment among Indian Farmers: An Analysis of its Nature and Extent Based On Data for Bihar, "Artha Vijnana, Sept. 1961.

Bhattacharjee, 1964. J.P. Bhattacharjee, "A Note on Cattle in India's Farm Economy," Indian Journal of Agricultural Economics, Vol.XIX, No.34.

Bhattacharjee, 1965. J.P. Bhattacharjee, "Mechanization in India - Its Economics," in Indian Society of Agricultural Economics, Indian Journal of Agricultural Economics 1940-64, Selected Readings, Bombay, ISAE, 1965.

Billings and Ray, 1968. Martin H. Billings and S.K. Ray, Projections of Potential Demand for Fertilizer 1970-71 and 1982-83, USAID, mimeographed.

Billings and Singh, 1969. Martin Billings and Arjan Singh, Conventional Energy as a Constraint to the Green Revolution, 1964-1984: The Punjab Case, USAID, 1969, mimeographed.

B (Contd)

Blyn, 1966. George Blyn, Agricultural Trends in India, 1891-1947: Output, Availability and Productivity. Philadelphia, University of Pennsylvania Press, 1966.

Bose and Clark, 1968. S.R. Bose and E.H. Clark, "Appropriate Pricing for Innovations: A Study of Mechanization in West Pakistan," paper prepared for International Seminar on Fiscal Incentives to Promote Agricultural Development, Istanbul, Turkey, 1968.

Brown, 1965. D.D. Brown, Estimation of Fertilizer Demand for India by District, 1965-70, April 23, 1965, mimeographed.

Brown, 1967. D.D. Brown, The Intensive Agricultural Districts Programme and Agricultural Development in Punjab, India prepared for Sorrento Conference, September, 1967.

Burt, 1966. Oscar Burt, "The Economics of Ground-water Control," Journal of Farm Economics, August, 1966.

C

Chambers, 1956. R.M. Chambers, "Mechanization of Rice Production," Tropical Agriculture, July 1956, pp. 182-9.

Chaudhri, 1961. S.C. Chaudhri, "Inter-state Trade in Agricultural Commodities," Agricultural Situation in India, XVII, July 1961.

Chauhan, 1960. Brij Raj Chauhan, "Rise and Decline of a Cash Crop in an Indian Village," Journal of Farm Economics, August 1960, pp. 663-6.

Clark, 1957. R. Clark, "The Economic Determinants of Jute Production," Monthly Bulletin of Agricultural Economics and Statistics, (FAO), Sept. 1957, pp. 1-10.

Cummings, 1967a. Ralph W. Cummings, Jr., Pricing Efficiency in the Indian Wheat Market, New Delhi: Inpex India Booksellers and Publishers, 1967.

Cummings, 1967b. Ralph W. Cummings, Jr., "Government Policy to Promote Food Self-Sufficiency in India," paper prepared for volume on Food Self-Sufficiency to be edited by S.C. Mathur, Head of the Department of Agricultural Economics, B.R. College, Bichpuri (Agra).

Cummings, 1968a. R.W. Cummings, Jr., "Effectiveness of Pricing in an Indian Wheat Market: A Case Study of Khanna, Punjab," American Journal of Agricultural Economics, Vol. 5, No. 3, August 1968, pp. 687-701.

Cummings, Herdt, and Ray, 1968. Ralph W. Cummings, Jr., Robert H. Herdt, and S.K. Ray, "New Agricultural Strategy Revisited," Economic and Political Weekly, October 26, 1968, pages A-15 through A-23.

Cummings, 1968b. R.W. Cummings, Jr., "Buffer Stocks" paper presented at Seminar on Buffer Stocks sponsored by Indian Society of Agricultural Economics at Bangalore, November 1-3, 1968.

Cummings and Ray, 1969a. Ralph W. Cummings, Jr., and S.K. Ray, "The New Agricultural Strategy - Contribution to 1967-68 Production" in Economic and Political Weekly, Quarterly Review of Agriculture, March 29, 1969, pp. A-7 to A-16.

Cummings and Ray, 1969b. Ralph W. Cummings, Jr. and S.K. Ray, A Fresh Strategy for Agricultural Development: Relative Contribution of Weather and New Technology to 1968-69 Foodgrain Production and Implications for Future Policy, June 30, 1969, unpublished.

D

Dandekar, 1964. V.M. Dandekar, "Prices, Production and Marketed Surplus of Foodgrains," Indian Journal of Agricultural Economics, XIX, (3-4), July-December 1964, pp. 186-195.

Dandekar, 1968. V.M. Dandekar, "Economic Theory and Agrarian Reform," in A.M. Khusro, ed., Readings in Agricultural Development. Bombay: Allied Publishers, 1968.

Dantwala and Donde, 1949. M.L. Dantwala and W.B. Donde, "The Uneconomic Cultivator," Indian Journal of Agricultural Economics, Vol. IV, No. 2.

Dantwala, 1953. M.L. Dantwala, "Notes on Some Aspects of Rural Employment," Indian Journal of Agricultural Economics, Vol. VIII, No. 2.

Dantwala, 1959. M.L. Dantwala, "Small Farmers, Not Small Farms," Indian Journal of Agricultural Economics, July-Sept. 1959.

Dantwala, 1966. M.L. Dantwala, "Principles and Problems of Agricultural Price Determination," Journal of the Indian Society of Agricultural Statistics, June 1966.

Dantwala, 1967. M.L. Dantwala, "Incentives and Disincentives in Indian Agriculture," Indian Journal of Agricultural Economics, April-June 1967, pp. 1-25.

Dantwala, Shah, et. al., 1969. M.L. Dantwala, C.H. Shah, et. al. Evaluation of Land Reforms (with special reference to the Western Region of India), Vols. I and II, Department of Economics, University of Bombay, 1969.

Das, 1968. P.K. Das, The Monsoons, New Delhi: National Book Trust, India, 1968.

Davidson and Mighell, 1963. J.R. Davidson and R.L. Mighell, "Tracing Farmers' Reactions to Uncertainty" Journal of Farm Economics, August 1963.

Day, 1965. R.H. Day, "Probability Distribution of Field Crop Yields," Journal of Farm Economics, August 1965.

Desai and Mehta, 1962. M.B. Desai and R.S. Mehta, "Abolition of Tenancy Cultivation," Indian Journal of Agricultural Economics, Jan./March 1962, pp. 127-34.

Desai, 1963. D.K. Desai, Increasing Income and Production in Indian Farming. Bombay: Indian Society of Agricultural Economics, 1963.

D (Contd)

Desai and Patel, 1968. D.K. Desai and D.A. Patel, "Developing Hybrid Seed Enterprise - An Induced Growth of High Yielding Varieties Programme in India," Indian Journal of Agricultural Economics, Conference Number 1, October-December 1968, pp. 113-124.

Desai and Tambad 1969a. D.K. Desai and S.B. Tambad, An Application of Transportation Model to Fertilizer Industry in India, Ahmedabad, Indian Institute of Management, 1969.

Desai, 1969b. D.K. Desai, "Lessons of IADP," Economic and Political Weekly, Review of Agriculture, June 28, 1969, pp. A-83 to A-90.

Deshpande, 1963. S.H. Deshpande, "Labour-Pooling in Cooperative Farms," Indian Journal of Agricultural Economics, April/June, 1963, pp. 22-32.

Divatia and Pani, 1968. V.V. Divatia and P.K. Pani, "Variations in Cereal Prices, 1951-52 to 1966-67, An Explanatory Model," Economic and Political Weekly, July 1968, pp. 1013-1029.

Donahue, 1964. R.L. Donahue, Report of Stanford Research Institute in Connection with the Bechtel Plan, 1964.

Donahue, 1966. Roy Donahue, Estimates of Fertilizer Consumption in India in 1970-71, New Delhi: The Fertilizer Association of India, June 1966.

Dorfman, et al., 1965. R. Dorfman, R. Revelle, and H. Thomas, "Water-logging and Salinity in the Indus Plain: Some Basic Considerations," Pakistan Development Review, Autumn 1965, pp. 331-70.

Dovring, 1959. F. Dovring, "The Share of Agriculture in a Growing Population," Monthly Bulletin of Agricultural Economics and Statistics, Food and Agriculture Organization of the United Nations, VIII (Aug-Sept. 1959), Nov. 8 and 9.

Dubey, 1963. V. Dubey, "The Marketed Agricultural Surplus and Economic Growth in Underdeveloped Countries," Economic Journal, Dec. 1963, pp. 689-702.

Dutia, 1961. B.P. Dutia, "Uncertainty, Capital Use and Firm Household Relationship," Indian Economic Journal, April 1961.

Dutia, 1966. B.P. Dutia, "Guidelines for Determining Support Prices for Agricultural Products," Artha-Vikas, April 1966.

E

Eckaus, 1955. R.S. Eckaus, "Factor Proportions in Underdeveloped Countries," American Economic Review, September 1955, Vol. 45, pp. 539-565.

Erlenkotter and Manne, 1967. D. Erlenkotter and A.S. Manne, Investments for Expanding the Capacity of India's Nitrogenous Fertilizer Industry, USAID, New Delhi, August 14, 1967.

Erlenkotter 1968. D. Erlenkotter, An Economic Analysis of Small-Scale Fertilizer Plants in India, USAID, New Delhi, mimeographed, 1968.

Erlenkotter and Lubell, 1969. D. Erlenkotter and H. Lubell, Additional Aid for Socially Oriented Government Programs, Economic Affairs Division, USAID/New Delhi, April 1969, mimeographed.

Epstein, 1962. T.S. Epstein, Economic Development and Social Change in South India. Manchester: University of Manchester Press, 1962.

F

FAI, 1968a. Fertilizer Association of India, Fertilizer Statistics, 1967-68, New Delhi, 1968.

FAI, 1968b. Fertilizer Association of India, Report on the Development of the Fertilizer Industry, August 1968.

Falcon, 1962. W.P. Falcon, Farmer Response to Price in an Underdeveloped Area - A Case Study of West Pakistan, unpublished Ph.D. thesis, Harvard University, 1962.

Falcon, 1963. W.P. Falcon, "Real Effects of Foreign Surplus Disposal in Underdeveloped Economics: Further Comments," Quarterly Journal of Economics, May 1963, pp.323-326.

Falcon, 1964. W.P. Falcon, "Farmer Response to Price in a Subsistence Economy: The Case of West Pakistan," American Economic Review, May 1964, pp. 580-92.

Falcon and Gotsch 1966. W.P. Falcon and C.H. Gotsch, Relative Price Response, Economic Development and Technological Change: A Study of Punjab Agriculture. Economic Development Report No. 11 (Cambridge: Project for Quantitative Research on Economic Development and the Development Advisory Service, Harvard University, 1966).

Fei and Ranis, 1961. J.C.H. Fei and G. Ranis, "A Theory of Economic Development," American Economic Review, September 1961, pp. 533-565.

Fliegal, Roy, Sen, and Kivlin, 1968. F. Fliegel, P. Roy, L. Sen, and J. Kivlin, Agricultural Innovations in Indian Villages, Hyderabad: National Institute of Community Development, 1968.

Ford, 1967. The Ford Foundation IADP, Ludhiana District Analysis of Bench-Mark and Assessment Surveys Under the IADP Crop-cutting Schedules, November 1967, unpublished.

Foster and Wood, 1967. P. Foster and D. Wood, Economic Aspects of Manufacturing Fertilizer in Small Plants in India, Department of Agricultural Economics, Allahabad Agricultural Institute, Allahabad, U.P., mimeographed, 1967.

Fox, Sengupta, and Thorbecke, 1966. K.A. Gox, J.K. Sengupta, and E. Thorbecke, The Theory of Quantitative Economic Policy, Amsterdam, North-Holland Publishing Co., 1966.

Freeman, 1967. W.H. Freeman, Rice Improvement paper presented at USAID, Agricultural Conference, New Delhi, December 5, 1967.

G

Gadgil, 1955. D.R. Gadgil, "Organization of Agricultural Production: Structure and Size of the Unit," Indian Journal of Agricultural Economics, Vol. X, No. 1.

Gandhi, 1966. Ved P. Gandhi, Tax Burden on Indian Agriculture, Cambridge: Harvard Law School International Tax Program, 1966.

Gandhi, 1968. Ved P. Gandhi, "Taxes, Subsidies, and Agricultural Production (India)," paper presented at the International Seminar on Fiscal Incentives to Promote Agricultural Development held in November 1968 at Istanbul, Turkey.

Gandhi, 1969. Ved P. Gandhi, Agricultural Taxation Policy: Search for a Direction, February 1969, unpublished paper.

Giles, 1967. G.W. Giles, Toward a More Powerful Agriculture distributed by Planning Cell, Agricultural Department, Government of West Pakistan, mimeographed, November 1967.

Gill, 1966. K.S. Gill, "Modes, Costs, and Problems of Transporting Farm Produce in Punjab," Agricultural Marketing, Directorate of Marketing and Inspection, GOI, October 1966.

Gill, 1969, K.S. Gill, Wheat Market Behaviour in Punjab, Department of Economics and Sociology, Punjab Agricultural University, Ludhiana, 1969.

Gould, 1963. P.R. Gould, "Man Against His Environment: A Game Theoretic Framework," Annals of the Association of American Geographers, Sept. 1963.

Gotsch, 1966. Carl H. Gotsch, Aggregate Water Response Curves: Some Inconclusive Evidence, unpublished manuscript, Cambridge, 1966.

Gotsch, 1968. Carl H. Gotsch, "A Programming Approach to Some Agriculture Policy Problems in West Pakistan," The Pakistan Development Review, Summer 1968, pp. 192-225.

Griliches, 1958a. Zvi Griliches, "The Demand for Fertilizer: An Economic Interpretation of a Technical Change," Journal of Farm Economics, August, 1958, pp. 591-607.

Griliches, 1958b. Zvi Griliches, "Research Costs and Social Returns: Hybrid Corn and Related Innovations," Journal of Political Economy, LXVI, No. 5 (October, 1958), pp. 419-31.

G (Contd)

Griliches, 1964. Zvi Griliches, "Research Expenditures, Education, and the Aggregate Production Function," American Economic Review, December, 1964, pp. 961-74.

Groves and Madhavan, 1962. H.M. Groves and M.C. Madhavan, "Agricultural Taxation and India's Third Five Year Plan," Land Economics, Feb. 1962, pp. 56-64.

Gupta and Majid, 1962. S.C. Gupta and A. Majid, Farmer's Response to Prices and Marketing Policies Affecting Sugarcane and Paddy. Delhi: Agro-Economics Research Centre, University of Delhi, 1962.

H

Harberger, 1965. A.C. Harberger, "Investment in Men Versus Investment in Machines: The Case of India," in C.A. Anderson and M.J. Bowman (ed.), Education and Economic Development, Chicago: Aldine Publishing Company, 1965, pp. 11-50

Harbison and Myers, 1964. Frederick Harbison and Charles A. Myers, Education, Manpower, and Economic Growth. New York: McGraw-Hill, 1964.

Heady, 1961. Earl O. Heady, "Public Purpose in Agricultural Research and Education," Journal of Farm Economics, August 1961, pp. 566-81.

Hendrix, et. al. 1966. W.E. Hendrix, et. al, Agriculture in 26 Developing Nations, Foreign Agricultural Economic Report No. 27, Economic Research Service, USDA.

Hendrix, Naive, and Adams, 1968. W.E. Hendrix, J.J. Naive, and W.E. Adams, Accelerating India's Foodgrain Production 1967-68 to 1970-71, Foreign Agricultural Economic Report No. 40, U.S. Department of Agriculture, Economic Research Service, 1968.

Hendrix, 1969. W.E. Hendrix, Approaches to Agricultural Development in India, (1949-1965), Progress, Regional Differences and Associated Factors (A Progress Report) 1969, unpublished.

Hendrix and Sen, 1969. W.E. Hendrix and B. Sen, "Institutional-Economic Relations in Transforming Traditional Agriculture," draft paper, March 24, 1969.

Herdt and Mellor, 1964. Robert W. Herdt and John W. Mellor, "The Contrasting Response of Rice to Nitrogen: India and the United States," Journal of Farm Economics, February 1964, pp. 150-60.

Herdt, 1968. Robert W. Herdt, Agricultural Research Expenditures in India, unpublished, 1968.

Herrman, 1966. Louis F. Herrman, Agricultural Price Policy in India, Directorate of Economics and Statistics, Ministry of Food and Agriculture, GOI, 1966.

Hindustan, 1968. Hindustan, 1968. Hindustan Lever Ltd., "Rural Marketing in India, speech delivered by V.G. Rajadhyaksha, Chairman, at the annual General Meeting of Hindustan Lever Limited, held at Bombay on Thursday, April 24, 1969.

H (Contd)

Hirsch, 1961. Leon V. Hirsch, Marketing in an Underdeveloped Economy: The North Indian Sugar Industry. Englewood Cliffs, N.J. Prentice-Hall, 1961.

Holst, 1967. Willem Holst, "Twenty-year Projection of India's Foodgrain and Fertilizer Demand and Supply," Volume II of The World Food Problem, Report of the President's Science Advisory Committee, Washington, D.C. 1967.

Hopper 1955, W. David Hopper, "Seasonal Labour Cycles in an Eastern Uttar Pradesh Village," Eastern Anthropologist, VIII, Nos. 3 and 4 (March-April 1955), pp. 141-51.

Hopper 1965a. W. David Hopper, "Allocation Efficiency in a Traditional Indian Agriculture," Journal of Farm Economics, 47: 611-624, August 1965.

Hopper, 1965b. W.D. Hopper, "Planning Yardsticks for Fertilizer and Irrigation," Agricultural Situation in India, September 1965, pp. 463-477.

Hopper, 1965c. W.D. Hopper, "Mainsprings of Agricultural Growth in India," Indian Journal of Agricultural Sciences, June 1965, pp iii-xxvii.

Hopper, 1967. W.D. Hopper, "The Economics of Fertilizer Use - A Case Study in Production Economics," Indian Journal of Agricultural Economics, Vol. XVII, No. 4.

Hopper, 1968a. W. David Hopper, "Explorations into the Production Economics of High Yielding Varieties," in volume honoring Dr. V.G. Panse, Contributions in Statistics and Agricultural Sciences, Indian Society of Agricultural Statistics, New Delhi, 1968.

Hopper, 1968b. W. David Hopper, "Regional Economic Report on Agriculture," Vol. I, Asian Agricultural Survey, Asian Development Bank, Manila, March 1968.

Hopper and Freeman, 1969. W. David Hopper and Wayne H. Freeman, "From Unsteady Infancy to Vigorous Adolescence, Rice Development," Economic and Political Weekly, Review of Agriculture, March 29, 1969, pp. A-17 to A-21.

Hopper, 1969. W. David Hopper, "The Promise of Abundance" paper prepared for the Regional Seminar on Agriculture sponsored by the Asian Development Bank, Sydney, Australia, April 10-12, 1969.

H (Contd)

Hsieh and Ruttan, 1967. S.C. Hsieh and V.W. Ruttan, "Technological Institutional and Environmental Factors in the Growth of Price Production: Philippines, Thailand and Taiwan," Food Research Institute Studies, Vol. 7 No. 3 (1967).

Hussain, 1964. S.M. Hussain, "A Note on Farmer Response to Price in East Pakistan," Pakistan Development Review, Spring 1964, pp. 93-106.

I

IARI, 1968. Indian Agricultural Research Institute, Five Years of Research on Dwarf Wheats, IARI, New Delhi, 1968.

India, 1954. Government of India, Studies in the Economics of Farm Management, 1954-55, 1955-56, 1956-57. Directorate of Economics and Statistics, Ministry of Food, Agriculture, Community Development, and Cooperation, July 1968.

India, 1957. Government of India, All-India Rural Credit Survey, Bombay: Reserve Bank of India, 3 part, 1957.

India, 1959. Government of India, Report on Enquiry into the Pace and Pattern of Market Arrivals of Foodgrains (Season 1958-59). Directorate of Economics and Statistics, MFA.

India, 1963. Government of India, Indian Agriculture in Brief, Ministry of Food and Agriculture, Sixth Edition, 1963.

India, 1964a. Government of India, Fourth Five Year Plan, A Draft Outline, Planning Commission, 1966.

India, 1964b. "Fertilizer Practices followed by the Farmers," (data are taken from notes prepared by IARS), Agricultural Situation in India, Vol. XIX, No. 3, June 1964, pp. 213-220.

India, 1964c. Office of the Registrar General, Report of the Expert Committee on Population Projections, GOI, 1964.

India, 1965a. Government of India, Report of the Committee on Fertilizers, (The Sivaraman Committee), Ministry of Food and Agriculture, 1965.

India, 1965b. Government of India, Report of the Fourth Five Year Plan Working Group on Manures and Fertilizers (1965-66 to 1970-71), Ministry of Food and Agriculture, 1965.

India, 1965c. Government of India, Fourth Five Year Plan, A Draft Outline, Planning Commission, 1965.

India, 1965d. Government of India, Economic Survey, 1965-69.

India, 1965e. Government of India, Report of the Agricultural Prices Commission on Price Policy for Kharif Cereals for 1965-66 Season, GOI, May-July 1965, page 37-46 "Rice Zone Policy: A Note of Dissent by Dr. Raj Krishna."

India, 1966a. Government of India, Growth Rates in Agriculture 1949-50 to 1964-65, Economic and Statistical Adviser, Ministry of Food and Agriculture, 1966, Mimeographed.

India, 1966b. Government of India, Cost of Distribution of Foodgrains through Public Agencies, 1965-66, Agricultural Prices Commission.

India, 1966c. Government of India, Indian Agriculture in Brief, 7th edition, Directorate of Economics and Statistics, Ministry of Food, Agriculture, Community Development, and Cooperation.

India, 1966d. Government of India, Farm Management in India: A Study based on recent investigations, Directorate of Economics and Statistics, Ministry of Food, Agriculture, Community Development and Cooperation, 1966.

India, 1966e. Government of India, Draft Report of the National Rodent Control Committee, appointed by the Ministry of Health and Family Planning, 1966.

India, 1966f. Committee on Transport Policy and Coordination Final Report - A Summary.

India, 1967b. Summary of Findings and Recommendations of the Committee on Losses of Foodgrains during Post harvest Handling, V.G. Panse Chairman, 1967. Mineographed.

India, 1967c. Government of India, Report of the Agricultural Prices Commission on Price Policy for Kharif Cereals for 1967-68 Season (Ministry of Food, Agriculture, Community Development, and Cooperation, 1967).

India, 1967d. Government of India, Evaluation Study of the High Yielding Varieties Programme, Kharif 1967, Program Evaluation Organization, Planning Commission, to be published.

India, 1967e. Government of India, Evaluation Study of the High Yielding Varieties Programme, Rabi 1967, Program Evaluation Organization, Planning Commission, to be published.

India, 1967f. Government of India, Comparative Study Conducted by the National Productivity Council on Mechanized and Non-mechanized Farms in Delhi, Machinery Division, Ministry of Food, Agriculture, Community Development, and Cooperation, mimeographed.

India, 1968a. High, Medium, and Low Rainfal Areas, 1964-65, Directorate of Economics and Statistics, Ministry of Food, Agriculture, Community Development, and Cooperation, 1968, mimeographed.

India, 1968b. Indian Agriculture in Brief, 9th edition, Directorate of Economics and Statistics, Ministry of Food, Agriculture, Community Development and Cooperation, 1968.

India, 1968d. Government of India, Report of the Working Group for the Formulation of the Fourth Plan (1969-70 to 1973-74) - Proposals on Fertilizers and Manures, Ministry of Food, Agriculture, Community Development and Cooperation, 1968.

India, 1968e. Government of India, Indicative World Plan (India), Ministry of Food, Agriculture, Community Development, and Cooperation, preliminary draft, unpublished, 1968.

India, 1968f. Government of India, Estimated Fertilizer Requirements for the Next Five-Year and Ten-Year Periods (i.e., 1973-74 and 1978-79), Perspective Planning Division, Planning Commission, 1968

India, 1968g. Government of India, Report on the High Yielding Varieties, 1966-67, Directorate of Economics and Statistics, Ministry of Food, Agriculture, Community Development and Cooperation.

India, 1968h. Government of India, Review of the Food Situation in India Department of Food, Ministry of Food, Agriculture, Community Development, and Cooperation, July 1968.

India, 1968i. Government of India, Bulletin on Food Statistics, February 1968. Directorate of Economics and Statistics, Ministry of Food, Agriculture, Community Development, and Cooperation.

India, 1968j. Government of India, Seed Review Team Report, 1968, Ministry of Food, Agriculture, Community Development, and Cooperation, 1968.

India, 1968k. Area, Production, and Yield of Principal Crops in India, 1949-50 to 1967-68, Directorate of Economics and Statistics, Ministry of Food, Agriculture, Community Development and Cooperation, 1968.

India, 1969a. Government of India, Report of the All-India Rural Credit Review (Vankatappiah) Committee, Reserve Bank of India, to be published.

India, 1969b. Government of India, Report on the High Yielding Varieties Programme, [Kharif 1967-68], Directorate of Economics and Statistics, 1969.

India, 1969c. Report of the Department of Agriculture, 1968-69, Ministry of Food, Agriculture, Community Development, and Cooperation, 1969.

India, 1969d. Fourth Five Year Plan, 1969-74 Draft, Planning Commission, Government of India, 1969.

India, 1969e. Recent Developments in the Field of Agricultural Research and Education. Indian Council of Agricultural Research, Ministry of Food, Agriculture, Community Development, and Cooperation, 1969.

India, 1969f. Tenth Livestock Census, 1966, Economic and Statistical Adviser to the Government of India, Ministry of Food, Agriculture, Community Development, and Cooperation, New Delhi, 1969.

Indian Institute of Management (Ahmedabad), 1968. Indian Institute of Management, Planning and Implementation in Agriculture: Studies on High Yielding Varieties Programme, Ahmedabad, 1968

Vol. I : "Paddy ADT-27 in Madras State" by M. Meenakshi Malya and P.P. Madappa

Vol. II : "Mexican Wheat in Punjab State" by U.K. Gupta and K.B. Kothari

Vol. III : "Hybrid Maize in Madhya Pradesh" by D.K. Desai and A.V.S. Narayanan

Vol. IV : "Hybrid Bajra in Gujarat State" by D.K. Desai and D.A. Patel.

ISAE, 1960. Indian Journal of Agricultural Economics, 1960, "Taxation and Optimum Land Utilization", Indian Journal of Agricultural Economics, January-March, 1960, pp. 27-54.

ISAE, 1961. Indian Journal of Agricultural Economics, 1961, "Problems of Marketable Surplus in Indian Agriculture", Indian Journal of Agricultural Economics, January-March 1961.

ISAE, 1964. "Nature and Role of Risk and Uncertainty in Agriculture," selected papers, Indian Journal of Agricultural Economics, January-March 1964, pp. 69-167.

ISAE, 1968a. Indian Society of Agricultural Economics, Seminar Series VII, Seminar on Problems of Small Farmers. Bombay: Indian Society of Agricultural Economics, 1968.

ISAE, 1968b. Indian Society of Agricultural Economics, Indian Journal of Agricultural Economics, Vol. XXIII, No. 4, Conference Number, October-December 1968.

IRRI, 1967. International Rice Research Institute, "The Economics of IR-8" The IRRI Reporter, July 1967.

J

Jakhade and Majumdar, 1964. V.M. Jakhade and N.A. Majumdar, "Response of Agricultural Producers to Prices - The Case of Jute and Rice in India," Indian Journal of Agricultural Economics, July/Dec, 1964, pp. 204-9.

Jasdanwalla, 1966. J.Y. Jasdanwalla, Marketing Efficiency in Indian Agriculture, Bombay: Allied Publishers, 1966.

Jha and Jha, 1962. D. Jha and S.C. Jha, "Land Value as Measure of Primary Irrigation Benefit in Tribeni Canal," Indian Journal of Agricultural Economics, July/September 1962, pp. 69-73.

Jnkuu, 1969. Jnkuu, Review of Past Work on Marketing Research in India, review paper prepared by K.C. Agarwal, supervised by S.S. Gour, for all India Marketing Conference held at UPAU, Feb, 14-16, 1969.

Jodha, 1969. N.S. Jodha, "Drought and Scarcity in the Rajasthan Desert" Economic and Political Weekly, April 19, 1969, pp. 699-703.

Johnson, 1962. P.R. Johnson, "Do Farmers Hold a Preference for Risk" Journal of Farm Economics, Feb, 1962.

B. Johnston and Mellor, 1960. Bruce F. Johnston and John W. Mellor, "The Nature of Agriculture's Contributions to Economic Development," Food Research Institute Studies, November 1960, pp. 335-56.

B. Johnston and Mellor, 1961. Bruce F. Johnston and John W. Mellor, "The Role of Agriculture in Economic Development," American Economic Review, September 1961, pp. 566-93.

E.A.J. Johnston, 1965. E.A.J. Johnston, Market Towns and Spatial Development in India. New Delhi: NCAER, 1965.

Jorgenson, 1961. Dale W. Jorgenson, "The Development of a Dual Economy," Economic Journal, June 1961, pp. 309-34.

K

Kahlon and Gill, 1967. A.S. Kahlon and D.S. Gill, "Case for Mechanizing Selected Agricultural Operations in Punjab," Agricultural Situation in India, March 1967, pp. 1085-1088.

Kahlon, 1968. A.S. Kahlon, Report on The Study of Impact of Changing Conditions on Grain Marketing Institutions and the Structure of Grain Markets in the Punjab, PAU, cyclostyled.

Kahlon and Kapur, 1968. A.S. Kahlon and T.R. Kapur, "Differences in the Form and Intensity of Input-Mix and Yield Levels on Small and Large Farm Organizations in the IADP District Ludhiana (Punjab) - Case Study, "Indian Journal of Agricultural Economics, January-March, 1968.

Kahlon and Kaul, 1968. A.S. Kahlon and J.L. Kaul, "Comparative Study of Economics of High-Yielding Varieties of Wheat - Punjab State," Indian Journal of Agricultural Economic, Vol. XXIII, No. 4, October-December, 1968, pp. 79-86.

Kaldor, 1956. N. Kaldor, Indian Tax Reform: Report of a Survey. New Delhi: Ministry of Finance, GOI, 1956.

Kaneda, 1969. Hiromitsu Kaneda, Economic Implications of the Green Revoluation and the Strategy of Agricultural Development in West Pakistan, Research Report No. 78, Pakistan Institute of Development Economics, Karachi, 1969.

A.R. Khan and Chowdhury, 1962. A.R. Khan and A.H.M.N. Chowdhury, "Marketable Surplus Function: A Study of the Behavior of West Pakistan Farmers," Pakistan Development Review, Autumn 1962, pp. 354-76.

M.I. Khan, 1963. Md. Irshad Khan, "Development of Institutional Agricultural Credit, in Pakistan," Pakistan Development Review, Spring 1963, pp. 66-97.

N.A. Khan, 1963. N.A. Khan, "Resource Mobilization from Agriculture and Economic Development in India, Economic Development and Cultural Change, October 1963, pp. 42-54.

Khatkhate, 1962. D.R. Khatkhate, "Some Notes on the Real Effects of Foreign Surplus Disposal in Underdeveloped Economies," Quarterly Journal of Economics, May 1962, pp. 186-96.

Khatkhate, 1963. D.R. Khatkhate, "Money Supply Impact of National Currency Counterpart of Foreign Aid: An Indian Case, "Review of Economics and Statistics, February 1963, pp. 78-83.

Khusro, 1961. A.M. Khusro, "Cooperative Farming: Fundamental Considerations," in A.M. Khusro and A.A. Agarwal, The Problem of Co-operative Farming, Bombay: Asia Publishing House, 1961.

Khusro, 1962. A.M. Khusro, An Analysis of Agricultural Lands in India by Size of Holding and Tenure, mimeographed, Institute of Economic Growth, 1962.

Khusro, 1963a. A.M. Khusro, "Taxation of Agricultural Land: a Proposal," Economic Weekly, February, 1963.

Khusro, 1963b. A.M. Khusro, Location and Economics of Storage for Major Foodgrains in India, Part I, Institute of Economic Growth, 1963, cyclostyled.

Khusro, 1964. A.M. Khusro, "Returns to Scale in Indian Agriculture," Indian Journal of Agricultural Economics, Silver Jubilee Number, July-December, 1964.

Khusro, 1969. A.M. Khusro, The Economics of Buffer Stock and Storage of Major Foodgrains in India. Institute of Economic Growth, Delhi, 1969, mimeographed.

J. Krishna and Desai, 1964. Jai Krishna and D.K. Desai "Economic Models of Farm Planning Under Uncertainty", Indian Journal of Agricultural Economics, January-March, 1964.

J. Krishna and Rao, 1968. Jai Krishna and M.S. Rao, "Dynamics of Acreage Allocation for Wheat in Uttar Pradesh - A Study in Supply Response," Indian Journal of Economics, Vol. XXIII, No. 1.

J. Krishna, 1968, Jai Krishna, "Supply Response and Support Prices - A Model for Determining Support Prices for Agricultural Commodities," Agricultural Situation in India, January-February 1968, pp. 1087-1095.

R. Krishna, 1959. Raj Krishna, "Agrarian Reform in India: The Debate on Ceilings," Economic Development and Cultural Change, April 1959, pp. 258-78.

R. Krishna, 1961. R. Krishna, "Land Reform and Development in Southern Asia," in Walter Forelich, ed., Land Tenure, Industrialization and Social Stability, Milwaukee: Marquette University Press, 1961.

R. Krishna, 1962a. Raj Krishna, "A Note on the Elasticity of the Marketable Surplus of a Subsistence Crop," Indian Journal of Agricultural Economics, XVII, No. 3, 1962, pp. 79-85.

R. Krishna, 1962b. Raj Krishna, "The Optimum Firm and the Optimum Farm," The Economic Weekly, October 6 and 13, 1962.

R. Krishna, 1963a. Raj Krishna, "The Optimality of Land Allocation: A Case Study of the Punjab," Indian Journal of Agricultural Economics, Vol. XVIII, No. 1, January-March 1963, pp. 63-73.

R. Krishna, 1963b. Raj Krishna, "Farmer Response in India-Pakistan: A Case Study of the Punjab Region, "The Economic Journal, LXXIII, September 1963, pp. 477-87.

R. Krishna, 1964. Raj Krishna, Cotton Production and Price Policy Since Independence, University of Delhi, Institute of Economic Growth (Delhi, 1964).

R. Krishna, 1965a. Raj Krishna, "Some Production Functions for the Punjab," in Indian Journal of Agricultural Economics 1940-1964, Selected Readings: Bombay: ISAE, 1965.

R. Krishna, Raj Krishna, "The Marketable Surplus Function for a Subsistence Crop: An Analysis with Indian Data," Economic Weekly, XVII, 5, 6 and 7 (February 1965)

R. Krishna, 1967a. Raj Krishna, "Chapter 4. The Economic Environment," in Millikan and Hapgood (ed.), No Easy Harvest, The Dilemma of Agriculture in Underdeveloped Countries. Boston: Little, Brown and Company, 1967.

R. Krishna, 1967b. Raj Krishna, Government Operations in Foodgrains," Economic and Political Weekly, Sept, 16, 1967, pp. 1695-1706.

R. Krishna, 1967c. Raj Krishna, "Agricultural Price Policy and Economic Development," in Southworth and Johnston (ed.), Agricultural Development and Economic Growth, Ithaca, N.Y.: Cornell University Press, 1967.

R. Krishna, 1969. Raj Krishna, "Models of the Family Farm" in Clifton R. Wharton, Jr., ed. Subsistence Agriculture and Economic Development. Chicago: Aldine Publishing Co. 1969.

T.N. Krishnan, 1965. T.N. Krishnan, "The Marketed Surplus of Foodgrains," Economic Weekly, Annual Number, February 1965.

A.P. Kulkarni, 1965. A.P. Kulkarni, "Price Spread for Groundnut in Two Regulated Markets", Seminar Series V, Marketing of Agricultural Commodities. Bombay: Indian Society of Agricultural Economics, 1965.

S.Kuznets, 1956. Simon Kuznets, "Quantitative Aspects of the Economic Growth of Nations," appearing in supplements to Economic Development and Cultural Change, beginning with October 1956.

L

Ladejinsky, 1964. W. Ladejinsky, "Agrarian Reform in Asia," Foreign Affairs, April 1964, pp. 475-87.

Ladejinsky, 1965. W. Ladejinsky, "Tenurial Conditions and the Package Programme, " Mainstream, March, 1965.

Ladejinsky, 1969. W. Ladejinsky, "The Green Revolution in Punjab: A Field Trip, "Economic and Political Weekly, Review of Agriculture, June 28, 1969, pp.A-73 to A-82.

Lakshmanan, 1967. P.P. Lakshmanan, "Transport of Paddy from the Farms to the Markets in India, "Agricultural Situation in India, July 1967, pp. 361-368.

Lakshmanan, 1967. P.P. Lakshmanan, "Estimates of Inter-State Road Movements of Wheat in India," Agricultural Situation in India, November 1967.

Lavania and Dixit, 1968. G.S. Lavania and R.S. Dixit, "Economics of High-Yielding Varieties in Package District, Aligarh," Indian Journal of Agricultural Economics, October-December 1968, pp. 93-103.

Lele and Mellor, 1964. Uma Lele and John W. Mellor, Estimates of Change in Foodgrains Production in India, 1949-50 to 1960-61, Cornell University, International Agricultural Development Bul. No. 2 (1964).

Lele, 1967. Uma Lele, "Market Integration: A Study of Sorghum Prices in Western India," Journal of Farm Economics, Feb.1967, pp. 147-59.

Lele, 1968a. Uma Lele, "The Traders of Sholapur," in John W. Mellor, et. al., Developing Rural India, Ithaca, N.Y., Cornell University Press, 1968.

Lele, 1968b. Uma Lele, Working of Grain Markets in Selected States, India, 1955-56 to 1964-65, Occasional Paper No. 12, USAID, Press Research Project, Cornell University, 1968.

J.P. Lewis, 1963. J.P. Lewis, Quiet Crisis in India: Economic Development and American Policy. Bombay: Asia Publishing House, 1963.

S.R. Lewis, 1967. Stephen R. Lewis, Jr., "Agricultural Taxation in a Developing Economy," in Southworth and Johnston (ed.), Agricultural Development and Economic Growth. Ithaca, N.Y., Cornell University Press, 1967, pp. 453-392.

W.A. Lewis, 1954. W. Arthur Lewis, "Economic Development with Unlimited Supplies of Labour," Manchester School of Economic and Social Studies, May 1954, pp. 139-192.

W.A. Lewis, 1955. W. Arthur Lewis, The Theory of Economic Growth. London: Allen and Unwin 1955.

Long, 1968. M.F. Long, "Why Peasant Farmers Borrow", American Journal of Agricultural Economics, November, 1968.

M

Madalgi, 1967. S.S. Madalgi, "Government Operations in Foodgrains: Comment II," Economic and Political Weekly, October 14, 1967, pp. 1872-1874.

Madalgi, 1968. S.S. Madalgi, "Hunger in Rural India: 1960-61 to 1964-65," Economic and Political Weekly, Annual Number, January 1968, pp. 61-68.

Mahalanobis, 1955. P.C. Mahalanobis, Draft Recommendations for the Formulation of the Second Five Year Plan, 1956-61, March 17, 1955.

Malone, 1965. C.C. Malone, "Some Responses of Rice Farmers to the Package Program in Tanjore District, India, Journal of Farm Economics, May 1965.

Majumdar, 1960. N.A. Majumdar, "Economic Development with Surplus Labour," Indian Economic Journal, VIII, No. 3, January 1960, pp. 284-316.

H.H. Mann, 1955. Harold H. Mann, Rainfall and Famine: A Study of Rainfall in Bombay Deccan 1865-1938, Bombay: Indian Society of Agricultural Economics, 1955.

K.S. Mann, 1967. K.S. Mann, An Analysis of the Expected Shifts in Cropping Pattern of the Punjab (India) Resulting from the Introduction of High-Yielding Varieties of Crops, Punjab Agricultural Univ., 1967.

K.S. Mann, 1968. K.S. Mann, "Scope for Adoption of High-yielding Varieties and Improved Technology in Punjab Agriculture," Agricultural Situation in India, April 1968, pp. 3-9.

Manne, 1967. J.S. Manne, "The Impact of Public Law 480 on Prices and Domestic Supply of Cereals in India," Journal of Farm Economics, February, 1967, pp. 131-146.

Marglin, 1962. S.A. Marglin, "Objectives of Water Resource Development: A General Statement," in Arthur Maass, et.al., Design of Water Resource Systems. Cambridge: Harvard Univ., Press, 1962.

Marglin, 1965. S.A. Marglin, "Insurance for Innovators," Appendix B in David Hapgood and Max F. Millikan, eds., Policies for Promoting Agricultural Development, Cambridge, Mass.: Center for International Studies, M.I.T. 1965.

Marriott, 1955. McKim Marriott, ed., Village India: Studies in the Little Community. Chicago: University of Chicago Press, 1955.

Mathur and Ezekiel, 1961. P.N. Mathur and H. Ezekiel, "Marketable Surplus of Food and Price Fluctuations in a Developing Economy," Kyklos, 1961, pp. 316-406.

Mathur and Kulkarni, 1965. P.N. Mathur and A.R. Kulkarni, "Some Observations on the Working of a Regulated Market: A Preliminary Review," Seminar Series V. The Marketing of Agricultural Commodities. Bombay: The Indian Society of Agricultural Economics, 1965.

D. Mazumdar, 1959. Dipak Mazumdar, "The Marginal Productivity Theory of Wages and Disguised Unemployment" Review of Economic Studies, XXVI, No. 71 (June 1959), pp. 190-98.

D. Mazumdar, 1963. Dipak Mazumdar, "On the Economics of Relative Efficiency of Small Farmers, " Economic Weekly, Special Number, July 1963.

D. Mazumdar, 1965. Dipak Mazumdar, "Farm Size and Productivity," Economica, May 1965.

Mazumdar (S.K) and Parpia, 1966. S.K. Mazumdar and Parpia, "Possible Losses of Foodgrains in India," Vijnan Karmee, Journal of the Association of Scientific Workers of India, April 1966, pp. 5-11.

Mehren, 1967. George Mehren, "One Dollar for Research," International Agricultural Development, September 1967, No. 35.

Mehta, 1969. B.C. Mehta, "Inter-Sectoral Balance in Fourth Plan: A Demonstration Exercise," Economic and Political Weekly, Feb. 8, 1969, pp. 327-330.

Mellor and Stephens, 1956. John W. Mellor and R.D. Stephens, "The Average and Marginal Product of Farm Labour in Under-developed Economies," Journal of Farm Economics, Aug. 1956, pp. 780-791.

Mellor and Moorti, 1961. John W. Mellor and T.V. Moorti, "Farm Business Analysis of 30 Farms," Midhakur, Agra District, U.P., 1959-60 Research Bulletin I, Balwant Vidyapath, Bichpuri, India April 1961.

Mellor, 1962. John W. Mellor, "Increasing Agricultural Production in Early Stages in Economic Development: Relationshps, Problems, and Prospects," Indian Journal of Agricultural Economics, April/June 1962, pp. 29-46.

Mellor, 1963. John W. Mellor, "The Use and Productivity of Farm Family Labor in the Early Stages of Agricultural Development," Journal of Farm Economics, XLVII, August 1963, pp. 517-535.

Mellor and De Ponteves, 1964. John W. Mellor and Bruno De Ponteves, "The Effect of Growth in Demand for Milk on the Demand for Concentrate Feeds, India, 1951-1976," Indian Journal of Agricultural Economics, July-Dec. 1964.

Mellor and Lele, 1965. John W. Mellor and Uma Lele, "Alternative Estimates of the Trend in Indian Foodgrains Production During the First Two Plans," Economic Development and Cultural Change, Jan. 1965, pp. 217-32.

Mellor, 1966. John W. Mellor, The Economics of Agricultural Development, Ithaca, N.Y.: Cornell University Press, 1966.

Mellor, 1967a. John W. Mellor, "Toward a Theory of Agricultural Development," in Southworth and Johnston (ed.), Agricultural Development and Economic Growth, Ithaca, N.Y., Cornell University Press, 1967, pp. 21-60.

Mellor and Dhar, 1967. John W. Mellor and Ashok Dhar, Determinants and Development Implications of Foodgrain Prices, India, 1949-50 to 1963-64, Occasional Paper Number 3, Cornell University - USAID Prices Project, December 4, 1967.

Mellor, 1967b. John W. Mellor, "Toward a Theory of Agricultural Development," in Southworth and Johnston (ed.) Agricultural Development and Economic Growth, Ithaca, N.Y.: Cornell University Press, 1967.

Mellor, 1968a. J.W. Mellor, "What Happened to Agricultural Production in India?" (Review of Blyn), Economic Development and Cultural Change, January 1968.

Mellor, 1968b. John W. Mellor, "The Functions of Agricultural Prices in Economic Development," Indian Journal of Agricultural Economics, January-March 1968, pp. 23-37.

Mellor, 1968c. John W. Mellor, et al., Developing Rural India, Ithaca, N.Y.: Cornell University Press, 1968.

Minhas and Srinivasan, 1966. B.S. Minhas and T.N. Srinivasan: "New Agricultural Strategy Analyzed," Yojana, January 26, 1966, pages 1-5.

Minhas, 1968. B.S. Minhas, "Growth with Stability: A Framework for Agricultural Planning," Economic and Political Weekly, Special Number, July 1968, pp. 1035-1040.

Mitra, 1963. A Mitra, "Tax Burden for Indian Agriculture," in R. Braibanti and J.J. Spengler (eds.), Administration and Economic Development in India, Durham: Duke University Press, 1963, pp. 281-303.

Mohammad, 1963. Ghulam Mohammad, "Some Physical and Economic Determinants of Cotton Production in West Pakistan," Pakistan Development Review, Winter 1963.

Mohammad and Beringer, 1963. Ghulam Mohammad and C. Beringer, "Water-logging and Salinity in West Pakistan: An Analysis of the Revelle Report," Pakistan Development Review, 1963, pp. 250-78.

Mohammad, 1964. Ghulam Mohammad, "Water logging and Salinity in the Indus Plain: A Critical Analysis of Some of the Major Condusions of Revelle Report," Pakistan Development Review, Autumn 1964. pp. 357-403.

Mohammad, 1965. Ghulam Mohammad, "Private Tubewell Development and Cropping Patterns in West Pakistan," Pakistan Development Review, Spring 1965, pp. 1-53.

Moorti, 1969. T.V. Moorti, Economics of Different Types of Irrigation in Aligarh District, U.P., draft of thesis submitted for Ph. D. at UPAU, 1969.

Moseman, 1964. Albert H. Moseman, ed., Agricultural Sciences for the Developing Nations, American Association for the Advancement of Science, Pub. No. 76, Washington, 1964.

Mukhati, 1966. Bela Mukhoti, "Agrarian Stmucture in Relation to Farm Investment Decisions and Agricultural Productivity in a Low-Income Country - The Indian Case, " Journal of Farm Economics, Dec. 1966, pp. 1210-1215.

Mukhoti, 1968. Bela Mukhoti, "Reply," American Journal of Agricultural Economics, November 1968, pp. 1044-8.

Murty, 1967. B.R. Murty, "Response of Hybrids of Sorghum and Pennisetum to Nitrogen," Journal of the Post-Graduate School, June 1967, Vol. 5, No. 1, pages 149-157.

N

Naik, 1968. K.C. Naik, A History of Agricultural Universities: Educational, Research and Extension Concepts for Indian Agriculture, New Delhi. A Committee on Institutional Co-operation (CIC) - U.S. Agency for International Development Project, 1968.

Nakajima, 1965. Chihiro Nakajima, The Subsistence Farmer in Commercial Economics, (Paper presented at the A/D/C Seminar on Subsistence and Peasant Economies, Honolulu, Hawaii, 1965).

Narain, 1961. Dharm Narain, Distribution of the Marketed Surplus of Agricultural Produce by Size - Level of Holding in India, 1950-51. Institute of Economic Growth, Occasional Paper Number 2. Delhi. Asia Publishing House, 1961.

Narain, 1965. Dharm Narain, Impact of Price Movements on Areas Under Selected Crops,in India, 1900-1939. Cambridge, University Press, London 1965.

National Council, 1959. National Council of Applied Economic Research, Criteria for Fixation of Water Rates and Selection of Irrigation Projects. Bombay: Asia Publishing House 1959.

National Council, 1962. National Council of Applied Economic Research, Long Term Projections of Demand for and Supply of Selected Agricultural Commodities: 1960-61 to 1975-76, New Delhi: National Council of Applied Economic Research, 1962.

Naylor, 1963. P.E. Naylor, "Control of Waterlogging and Salinity in West Pakistan", International Journal of Agrarian Affairs, October 1963, pp. 1-12.

Neale, 1965. Walter C. Neale, et al, "Kurali Market: A Report on the Economic Geography of Marketing in Northern Punjab", Economic Development and Cultural Change, January 1965, XIII, pp. 129-68.

Nichols, 1960. William H. Nichols, Southern Tradition and Regional Progress. Chapel Hill: University of North Carolina Press, 1960.

Nightingale, 1969. R. W. Nightingale, The Modernization Decision in Indian Urban Fluid Milk Markets. Occasional Paper No. 17 Department of Agricultural Economics, Cornell University, April 1969.

NIS, 1969. National Institute of Sciences, Symposium on Planning for Drought Areas, New Delhi, May 4-6, 1969, Abstracts of Papers.

Nurkse, 1953. Ragnar Nurkse, Problems of Capital Formation in Underdeveloped Countries, Oxford University Press, 1953.

Olson, 1960. R.O. Olson, "Impact and Implication of Foreign Surplus Disposal on Underdeveloped Economies - Discussion," Journal of Farm Economics, December 1960, pp. 1042-45

Onate, 1967. Burton T. Onate, Risk and Uncertainty: Distribution of Rice Yields, International Rice Research Institute, Los Banos, Philippines, mimeographed, (date uncertain, 1967).

Owen, 1966. W.F. Owen, "The Double Development Squeeze on Agriculture," American Economic Review, March 1966, pp. 43-71.

Oury, 1965. Bernard Oury, "Allowing for Weather in Crop Production Model Building," Journal of Farm Economics, Vol. 47, No. 2, May 1965.

Oury, 1967. Bernard Oury, Program Windex for the Systematic Calculation of a Weather Index to be Used in Agricultural Production Analysis, Economics Department Working Paper No. 3, IBRD, August 14, 1967.

Oury, 1968. Bernard Oury, Time Series Analysis of West Punjab District Wheat Production Data (Lahore District), Economics Department Working Paper No. 19, IBRD, June 19, 1968.

Oury, 1969. Bernard Oury, Supply Estimation and Production by Regression and Related Models, paper presented at East-West Seminar on Economic Models and Quantitative Methods for Decisions and Planning in Agriculture, Kesztholy, Hungary, June 24 - July 3, 1969.

P

Paglin, 1965. Morton Paglin, "Surplus Agricultural Labor and Development: Facts and Theories," American Economic Review, September 1965, pp. 815-832.

Pandey and Cochrane, 1969. V.K. Pandey and W.W. Cochrane, The Development and Analysis of Representative Wheat Farms, March 13, 1969, mimeographed.

Panikar, 1961. P.G.K. Panikar, "Rural Savings in India," Economic Development and Cultural Change, Oct. 1961, pp. 64-86.

Panse, 1961. V. G. Panse, "Food Availability and Requirements for India," Bulletin of the International Statistical Institute, 23rd Session, Paris 1961.

Panse, Abraham, and Lellavathi, 1964. V.G. Panse, T. P. Abraham, and C.R. Lellavathi, Yardsticks of Additional Production of Certain Foodgrain, Commercial and Oilseed Crops, New Delhi: Institute of Agricultural Research Statistics, ICAR, 1964.

Panse, Amble, and Abraham, 1964. V. G. Panse, U.N. Amble, and T.P. Abraham, "A Plan for Improvement of Nutrition of Indian Population," Indian Journal of Agricultural Economics, April-June, 1964.

Parikh, 1965. A.K. Parikh, "Demand for Nitrogenous Fertilizers - An Econometric Study", Indian Journal of Agricultural Economics, July-September, 1965.

Parthasarthy, 1969. G. Parthasarathy, Fertilizer Use on Paddy Plots - I.R.8 and Traditional: A Study of Individual Farms in Visakhapatnam District, Andhra Pradesh, paper presented at seminar on Research Needs for Agro-Industries, Bombay, May 30-31, 1969.

Patwardhan, 1960. V. N. Patwardhan, "Dietary Allowances for Indians, Calories and Proteins, " Indian Council of Medical Research, Special Report, series 35.

Porter, 1959. R. C. Porter, "Risk, Incentive, and the Technique of the Low Income Farmer, "Indian Economic Journal, July 1959.

Pradhan, 196 . S.N. Pradhan, A Comparison of the Performance of Bullock-drawn and Tractor Equipment in Cultivation of High Yielding Varieites, Central Rice Research Institute, Cuttack.

PSAC, 1967. Report of the President's Science Advisory Committee, The World Food Problem, U.S. Government, Washington, D.C., 1967.

R

Raj, 1959. K. N. Raj, "Employment and Unemployment in the Indian Economy," Economic Development and Cultural Change, VII, No.3 (April 1959), pp. 258-79.

Raj, 1960. K.N. Raj, Some Economic Aspects of the Bhakra Nangal Project: A Preliminary Analysis in Terms of Selected Investment Criteria, New Delhi: Asia Publishing House, 1960.

Randhawa, 1963. N.S. Randhawa, Regional Programming Models for Agricultural Development Planning in India, unpublished Ph.D. Thesis, Iowa State University, 1963.

Randhawa and Heady, 1964. Narinder S. Randhawa and Earl O. Heady, "An Interregional Programming Model for Agricultural Planning in India, "Journal of Farm Economics, Feb. 1964, pp. 137-49.

A.P.Rao, 1967. A.P. Rao, "Size of Holding and Productivity," Economic and Political Weekly, Nov. 11, 1967, pp. 1989-1991.

C.H.H.Rao, 1962. C.H. Hanumantha Rao, "The Optimum Firm and the Optimum Farm: A Comment," The Economic Weekly, November 10, 1962.

C.H.A. Rao, 1963. C.H.A. Rao, "Farm Size and the Economies of Scale," The Economic Weekly, December 14, 1963.

C.H.H. Rao, 1965. C.H. Hanumantha Rao, Agricultural Production Functions, Costs and Returns in India. Bombay, Asia Publishing House, 1965.

C.H.H. Rao, 1966. C.H.H. Rao, "Alternative Explanations of the Inverse Relationship between Farm Size and Output Per Acre in India," Indian Economic Review, October 1966.

V.K.R.V. Rao, 1952. V.K.R.V.Rao, "Investment, Income and the Multiplier in an Underdeveloped Economy," The Indian Economic Review, Feb. 1952.

V.K.R.V. Rao, 1962. V.K.R.V. Rao, "Agricultural Production and Productivity During the Plan Periods," Indian Journal of Agricultural Economics, Vol. XVII, No. 1

Rath and Patvardhan, 1967. N. Rath and V.S. Patvardhan, Impact of Assistance Under PL 480 on Indian Economy. Bombay: Asia Publishing House, 1967.

Raup, 1963. P. Raup, "The Contribution of Land Reform to Agricultural Development: An Analytical Framework," Economic Development and Cultural Change, Oct. 1963, pp. 1-22.

Raup, 1967. P. Raup, "Land Reform and Economic Development" in Southworth and Johnston (ed), Agricultural Development and Economic Growth, Ithaca, N.Y.: Cornell University Press, 1967.

Ray, 1969. S.K. Ray, Demand for Food in India, 1968-69 to 1983-84, USAID/India, unpublished working paper, January 1969.

Reserve Bank, 1963. "Agricultural Income Tax in India", Reserve Bank of India Bulletin, Aug. 1963, pp. 1022-33.

Revelle, 1964. White-House - Department of Interior Panel on Water-logging and Salinity in West Pakistan, Report on Land and Water Development in the Indus Plain (The Roger Revelle Report), Washington: U.S. Govt. Print. Off., 1964.

Rosen, 1967. George Rosen, Democracy and Economic Change in India. Berkeley: University of California Press, 1967.

Rudra, 1964. Ashok Rudra, "Relative Rates of Growth," The Economic Weekly, November 7, 1964.

Rudra, 1968a. A. Rudra, "Farm Size and Yield Per Acre", Economic and Political Weekly, Special Number, July 1968, pp. 1041-1044.

Rudra, 1968b. A. Rudra, "More on Returns to Scale in Indian Agriculture," Economic and Political Weekly. October 1968.

Russell and Brinegar, 1969. M.B. Russell and G.K. Brinegar, The Development and Adoption of Production Technology, a Report prepared from studies conducted in India during the period of December 9, 1968 to February 1, 1969 for USAID, April 15, 1969, unpublished.

S

Sahota, 1965. Gian S. Sahota, An Analysis of the Causes of the Secular Decline in the Relative Price of Fertilizer, unpublished Ph.D. dissertation, University of Chicago, February 1965.

Sahota, 1968. Gian S. Sahota, Fertilizer in Economic Development, Frederick A. Praeger, Inc., New York, 1968.

Saini, 1969. G. R. Saini, "Size, Productivity, and Returns to Scale," Economic and Political Weekly, Review of Agriculture, June 1969, pp A-119-to A-122.

Saran, 1968. Ram Saran, "Buffer Stocks in Foodgrains," paper submitted at the Seminar on Buffer Stocks sponsored by the Indian Society of Agricultural Economics in Bangalore, Nov. 1968.

Sastri, 1964. A.V.K. Sastri, "An Application of Input-Output Analysis to Indian Agriculture," Indian Journal of Agricultural Economics, April-June 1964, pp.52-56.

Schultz, 1953. T.W. Schultz, The Economic Organization of Agriculture, New York: McGraw-Hill, 1953.

Schultz, 1960. T.W. Schultz, "Impact and Implications of Foreign Surplus Disposal on Underdeveloped Economies - Value of U.S. Farm Surplus to Underdeveloped Economies," Journal of Farm Economies, December 1960, pp. 1019-1030.

Schultz, 1963. T.W. Schultz, Economic Value of Education, New York: Columbia Univ. Press, 1963.

Schultz, 1964. T.W. Schultz, "The Doctrine of Agriculture Labor of Zero Value," Transforming Traditional Agriculture, New Haven, Conn. Yale University Press, 1964.

Schultz, 1967. T.W. Schultz, "Comment" on Mellor in Southworth and Johnston (Ed.), Agricultural Development and Economic Growth, Ithaca, N.Y., Cornell University Press, 1967, pp. 61-65.

Schultz, 1968. T.W. Schultz, Production Opportunities in Asian Agriculture: An Economist's Agenda, Department of Economics, The University of Chicago, Agricultural Economics Paper No.68:12, Presented at Michigan State University on June 20, 1968.

Srinivas, 1968. M. N. Srinivas, "The Politics of Scarcity," Times of India, July 12 and 13, 1968

Srivastava, 1969. A.K. Srivastava, Impact of P.L. 480 Food Imports on the Indian Economy, Ph.D. Thesis submitted to Lucknow University, 1969.

A.K.Sen, 1959. A.K. Sen, "The Choice of Agricultural Techniques in Underdeveloped Countries," Economic Development and Cultural Change, April 1959, pp. 279-85.

A.K.Sen, 1962. A.K. Sen, "An Aspect of Indian Agriculture," Economic Weekly, Annual Number, 1962.

A.K.Sen, 1964a. A.K. Sen, "Size of Holdings and Productivity", Economic Weekly, Annual Number 1964.

A.K.Sen, 1964b. A.K. Sen, "A Reply", Economic Weekly, May 3, 1964.

A.K.Sen, 1966. A.K. Sen, "Peasants and Dualism with or without Surplus Labour," The Journal of Political Economy. Vol. LXXIV, No.5, Oct. 1966, pp. 425-450.

B.Sen, 1969. B. Sen, Interregional Distribution of the New Technology and Some Implications, unpublished note, USAID, 1969.

B.Sen, 1969. A Note on Intersectoral Balance Models and Their Implications for Development Policy, note prepared for USAID, 1969.

S.R.Sen, 1960. S.R. Sen, "Impact and Implications of Foreign Surplus Disposal on Underdeveloped Economies - The Indian Perspective," Journal of Farm Economics, Dec. 1960, pp. 1031-1041.

S.R.Sen, 1967. S. R. Sen, "Growth and Instability in Indian Agriculture," Agricultural Situation in India, January 1967, pp. 827-839.

C.H. Shah, 1965. C.H. Shah, "Shifters of Market Supply of Farm Products," Seminar Series - V, Marketing of Agricultural Commodities. Bombay: Indian Society of Agricultural Economics,1965.

V.H.Shah, 1967. V.H. Shah, "An Analysis of the Response of Hybrid Maize to Nitrogen," Journal of Post-Graduate School, June 1967, Vol. 5, No. 1, pp.158-168.

Sharma, 1965. P. S. Sharma, "A Study of the Structural and Tenurial Aspects of Rural Economy in the Light of 1961 Census," Indian Journal of Agricultural Economics, Oct-Dec. 1965.

Shingarey and Waghmare, 1968. M.K. Shingarey and R.E. Waghmare," A Study into Economics of Cultivation of Taichung Native-1 Paddy in Kolaba District of Maharashtra," Indian Journal of Agricultural Economics, Oct.-Dec. 1968, pp. 61-65

Shivamaggi, 1963. H.B. Shivamaggi, "Provision of Credit for Small Cultivators: Reconsideration of the Problem," Indian Journal of Agricultural Economics, July-Sept. 1963.

Shivamaggi, 1968. H.B. Shivamaggi, "Trends in Purchase and Sale of Farm Lands, Case for a Lower Ceiling," Economic and Political Weekly, Annual Number, January 1968, pp. 69-76.

Shukla, 1965. Tara Shukla, Capital Formation in Indian Agriculture. Bombay: Vora and Co. Publishers Private, 1965.

H.S.Singh, 1965. H.S. Singh, "Price Movements and Degree of Market Integration - A Study of Groundnut and Jowar Markets," in ISAE, Seminar Series-V, Marketing of Agricultural Commodities, Bombay 1965.

I.J.Singh and Sharma, 1969. I.J. Singh and K.C. Sharma, "All-India Coordinated Fertilizer Experiments on Wheat," Economic and Political Weekly, June 21, 1969, pp. 1009-1011.

K.Singh and Sharma, 1967. Kartar Singh and V.K. Sharma, "What it Costs to Produce a Quintal of Wheat," Indian Farmers Digest, Vol. 1, No. 1, pp. 45-48.

S. Singh, 1968. Saran Singh, "A Note on Irrigation Rates in India," paper presented at the International Seminar on Fiscal Incentives to Promote Agricultural Development held in November 1968 at Istanbul, Turkey.

Sisodia, 1968. J. S. Sisodia, "Some Economic Aspects of High-Yielding Varieties Programme of Indore District," Indian Journal of Agricultural Economics, Oct.-Dec. 1968. pp. 103-113.

Sonachalam, 1963. K.S. Sonachalam, Benefit-Cost Evaluation of Cauvery - Mettur Project, New Delhi: Planning Commission, GOI, 1963.

Sovani and Rath, 1960. N.V. Sovani and Nilkanth Rath, Economics of Multi-purpose Dams - Report of an Inquiry into the Economic Benefits of the Hirakud Dam. Bombay. Asia Publishing House, 1960.

Sprague, 1964. E.W. Sprague, "Research to Improve Production of Corn in Asia," In A.H. Moseman, ed., Agricultural Sciences for the Developing Nations, American Association for the Advancement of Science, Pub. No. 76 (Washington, 1964).

Stern, 1962. Robert M. Stern, "The Price Responsiveness of Primary Producers," The Review of Economics and Statistics, XLIV, May 1962, 202-207.

Stevens, 1965. Robert D. Stevens, Elasticity of Food Consumption Associated with Changes in Income in Developing Countries, U.S. Department of Agriculture, Economic Research Service, Foreign Agricultural Economic Report No.23 (Washington, March 1965).

Sukhatme, 1961. P.V. Sukhatme, "The World's Hunger and Future Needs in Food Supplies," Journal of the Royal Statistical Society, Series A. Vol. 124, Part 4.

Sukhatme, 1962. P.V. Sukhatme, "The Food and Nutrition Situation in India," Indian Journal of Agricultural Economics, Vol. XVII, Nos. 2 & 3, April 1962.

Sundaram, 1968. T.R. Sundaram, "Resource Position of Small Farmers," in Indian Society of Agricultural Economics, Seminar on Problems of Small Farmers. Bombay: ISAE, 1968.

Swaminathan, 1968. M.S. Swaminathan, "New Frontiers in Unirrigated Farming," Economic Times, December 28, 1968.

T

Tang, 19 Anthony Tang, Economic Development of the Southern Piedmont.

Tedford, 1964. J.R. Tedofrd, "Analytics of Decision Making", Journal of Farm Economics, Dec. 1964.

Thamarajakshi, 1969. R. Thamarajakshi, "Intersectoral Terms of Trade and Marketed Surplus of Agricultural Produce, 1951-52 to 1965-66," Economic and Political Weekly, Review of Agriculture, June 28, 1969, pp A-91 to A-102.

Thapar, 1968, "Pilot of Rural Change: Agricultural Universities", The Times of India, March 29, 1968.

H.Theil,
Theil, 1956. /."On the Theory of Economic Policy," American Economic Review, Papers and Proceedings, XLVI (May 1956), pp. 360-66

Thorner and Thorner, 1957. Daniel and Alice Thorner, "Types of Employer-Labourer Relationships in Indian Agriculture," Indian Journal of Agricultural Economics, Vol. XII, No.2

Tinbergen, 1955. J. Tinbergen, On the Theory of Economic Policy. Amsterdam: North-Holland Publishing Company, 1952; revised edition 1955.

Tolani, 1964. N.P. Tolani, Social Investment Deicisions: An Operational Model for Choosing Between a Fertilizer Plant and and Irrigation Project in Underdeveloped Countries, Ph.D. dissertation., Cornell University, 1964.

Tolani and Stanton, 1965. N.P. Tolani and B.F. Stanton, Social Investment Decisions: An Operational Procedure for Choosing Between a Fertilizer Plant and an Irrigation Project in a Region or Country. Ithaca: Dept. of Agr. Econ., Cornell University, June 1965, mimeographed.

U

UPAU, 1969a, Socio-Economic Behavior of Progressive Farmers in North-Western U.P., UPAU Research Project, final results not released as yet.

UPAU, 1969b, UPAU, Research on Wheat Marketing, review paper prepared for All-India Marketing Conference held at UPAU, February 14-16, 1969.

UPAU, 1969c. UPAU, Review of Marketing Research in Paddy, review paper prepared for All-India Marketing Conference held at UPAU, February 14-16, 1969.

UPAU, 1969d. UPAU, Market Research Review on Animal Products, review paper prepared for All-India Marketing Conference held at UPAU, Feb. 14-16, 1969.

USAID, 1964. Crop Production and Fertilizer Requirements, 1964-65 to 1965-76, USAID/India, mimeographed report, 1964.

USAID, 1968. USAID, Study of the Market for Fertilizer, (prepared for the Indian Farmers Fertilizer Cooperative Ltd.), by team headed by T.L. Cranmer, USAID, New Delhi, September 1968.

USAID, 1969a. USAID, Supply Projections for Agricultural Commodities 1968-69 to 1983-84, Staff Discussion Paper, Agricultural Economics Division, January 29, 1969.

USAID, 1969b, USAID internal staff paper on Wheat prepared for AID/Washington, March 3, 1969.

USAID, 1969c, USAID internal staff paper on Rice prepared for AID/Washington, March 10, 1969.

V

Venkataram and Ramana, 1968. J.V. Venkataram and R. Ramana, "Economic Aspects of High Yielding Crops - Hybrid Jowar," Indian Journal of Agricultural Economics, Oct.-Dec., 1968 pp. 134-138.

Venkataramanan, 1958. L. S. Venkataramnan, A Statistical Study of Indian Jute Production and Marketing with Special Reference to Foreign Demand, unpublished Ph.D. dissertation, Univ. of Chicago, 1958.

Venkataramanan, 1965. L. S. Venkataramanan, The Theory of Futures, Trading. Bombay: Asia Publishing House, 1965.

W

Weaver, 1967. Thomas Weaver, Irrigation and Agricultural Development in Raipur District, Madhya Pradesh, India, unpublished Ph.D. dissertation, Cornell University, 1967.

Weaver, 1968. T. Weaver, "The Farmers of Raipur," in John Mellor, et al., Developing Rural India, Ithaca, N.Y.: Cornell University Press, 1968.

Wharton, 1967. Cliffton R. Wharton, Jr., "The Infrastructure for Agricultural Growth," in Southworth and Johnston (ed.), Agricultural Development and Economic Growth, Ithaca, N.Y., Cornell University Press, 1967, pp. 107-131.

Wharton, 1968. Cliffton R. Wharton, Jr., Risk, Uncertainty and the Subsistence Farmer: Technological Innovation and Resistance to Change in the Context of Survival, paper presented at the joint session of the American Economic Association and Association for Comparative Economics, Chicago, Illinois, December 28, 1968.

Wise and Yotopoulos, 1968. J. Wise and P. Yotopoulos, "A Test of the Hypothesis of Economic Rationality in a Less Developed Economy: An Abstract," American Journal of Agricultural Economics, May 1968.

Witt, 1960. L. Witt, "Impact and Implication of Foreign Surplus Disposal on Underdeveloped Economies - Value of U.S. Farm Surpluses to Underdeveloped Economies - Discussion," Journal of Farm Economics, December 1960, pp. 1046-1051.

Wolf, 1955. Charles Wolf, Jr., "Institutions and Economic Development," American Economic Review, Dec. 1955, pp. 867-83.

Wolpert, 1964. J. Wolpert, "The Decision Process in a Spatial Context, "Annals of the Association of American Geographers, Dec. 1964.