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GREEN REVOLUTION IN BANGLADESH : ITS NATURE AND IMPACT ON INCOME DISTRIBUTION

Mahabub Hossain*

October 1987

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The study was carried out by The Bangladesh Institute of Development Studies in collaboration with The International Food Policy Research Institute.

Preface

The 'Seed-fertilizer-water' technology popularly known as the 'Green Revolution' has opened up great opportunities of increasing foodgrain production in land scarce countries. The diffusion of the new technology is the key to maintaining the food population balance in Bangladesh, since there is little scope of increasing production by expanding cultivated land. Bangladesh has made some progress in the adoption of the new technology and the potential for further diffusion is vast. But questions are raised about the possible adverse impact of the new technology on economic conditions of the poor. It is widely believed in Bngladesh that the new technology widens income disparity and accentuates poverty. This apprehension is largely based on the results of early studies on green revolution in India.

The present study attempts an indepth investigation into the characteristics of the new technology in rice production in Bangladesh and its impact on agricultural productivity and rural income distribution. The study is based on two large household surveys, one carried out by the International Fertilizer Centre (IFDC) during 1979-82 and the other by the Bangladesh Institute of Development Studies (BIDS) during 1982-83. The analysis was conducted during 1986-87 at the International Food Policy Research Institute (IFPRI), where the author worked as a visiting research fellow with a grant from the Ford Foundation, Dhaka. The support received from all these institutions in conducting this study is gratefully acknowledged.

I am indebted to Rehman Sobhan (Director General, BIDS) John Mellor (Director, IFPRI) and Raisuddin Ahmed for their encouragement and counsel at every stage of this research. I also wish to acknowledge the contribution of M.A. Quasem and Raisuddin Ahmed who collaborated with me in the design and implementation of the BIDS Survey. Joachim Von Braun, R.W. Herdt, J.C. Flinn, Pranab Bardhan, Keijiro Otsuka Steve Jones and Noel P. Magor read an earlier draft and the present version benefits greatly from their comments. I am also grateful to Andrew Bernard for his able research assistance and deep interest in the study. The author alone, however, is responsible for any remaining error or inadequacy.

Mahabub Hossain

CONTENTS

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LIST OF TABLES

LIST OF SUPPLEMENTARY TABLES

1. SUMMARY

A major constraint to increasing food production in Bangladesh is the stagnant supply of land. There is little scope for expanding cultivable land beyond the current level of 9.0 million hectares with which the country feeds more than 100 million persons. The cultivated land area remained unchanged since the independence in 1971, although the population increased by about 50 per cent since then. The growth of cereal production since the early seventies has barely managed to keep the level of food imports at 10 per cent of the domestic demand. This was achieved with a respectable progress in the diffusion of the new agricultural technology, the modern seed varieties of rice and wheat and the use of chemical fertilizers.

Technological progress is the key to maintaining the food-population balance in the country - and the scope of further diffusion of the new technology is vast. Only about a third of the rice and wheat area has been covered with modern variety seeds, and the consumption of chemical fertilizers has reached to the level of 45 nutrient kg per hectare of land. But, following the results of the early studies on 'green revolution' in India, there is a widespread apprehension in the country that the diffusion of the new technology would contribute to worsening income inequality and deepening absolute poverty.

There have been few systematic and representative studies on Bangladesh examining the effect of technological change at the farm and economy levels. In 1979-82 a survey was carried out covering 2400 sample farms in 117 villages throughout the country; in 1981-82 a

second large survey was completed covering 16 villages. This study analyzed these two sets of survey data to assess the productivity and equity impact of the modern rice technology.

The yield of paddy is estimated at 3.3 tons per hectare for modern varieties compared to 1.6 tons for local varieties. Farmers used 199 days of labor per hectare in the cultivation of modern varieties compared to 137 days for local varieties. The new varieties absorbed about Tk 5500 (at 1984/85 prices) per hectare in cash costs compared to about Tk 2000 for local varieties, but the estimated profit was about Tk 5700 per ha for the former compared to Tk 2600 for the latter. In Bangladesh, where land is so scarce, and the size of landholding so small, high profit per hectare is important. But costs per ton of output is a more conclusive measure of profitiability. The cost per ton of paddy output was Tk 3700 for local varieties and Tk 3000 for the new varieties, clearly demonstrating that the value of increased output exceeded the increased costs of growing the modern varieties. The net return to family labor was Tk 87 per day for modern varieties and 75 for local varieties, compared to the agricultural wage rate of Tk 24 per day.

The small farmers and tenants adopted the new technology as readily as the medium and large ones. Farmers operating less than one ha of land allocated 52 per cent of their rice land to modern varieties, compared to 45 per cent for those with 1 to 2 ha and 42 per cent for those with over two hectares of land. The yield per hectare was also higher on smaller farms. But profits and family income was lower on smaller farms, because they paid about 25 per cent higher water charges, and about 10 per cent higher wage rates than the large ones. The profits were substantially less on rented land for the obvious reason that the tenant has to pay 50 per cent of the gross produce as rent, and bear all costs of inputs. But the profits per ha on tenant farms were higher for the modern varieties compared to the local varieties. The diffusion of the new technology thus increases incomes for all groups of farmers, but also increases the inequality in the distribution of agricultural incomes among farm households.

To get an overall indication of the effect of new technology on income distribution, the survey villages were divided into two equal groups according to the degree to which the new technology was used. In the advanced villages 54 per cent of the land was irrigated and farmers allocated 61 per cent of the land to modern rice varieties compared to eight and five per cent, respectively for backward villages. The difference in fertilizer use was eight times between the two groups of villages. In advanced villages total household income was 29 per cent higher, and per capita income 22 per cent higher, compared to the backward villages. The comparison of the pattern of income distribution for all rural households (including the landless) however, shows a neutral effect of the new technology. The Gini concentration ratio of household income was the same (0.39) in the two groups of villages, the concentration ratio measured along the per capita income scale was however slightly higher in the advanced villages (0.36) than in the backward ones (0.34). The comparison of the income for the two groups of villages in the per capita income scale shows that the relative position of the bottom 40 per cent of the households remained unchanged while the top 10 per cent gained relatively at the expense of the middle 40 per cent. The proportion of population living below the poverty line was 32 per cent in the advanced villages compared to 47 per cent in the backward villages.

The positive effect of the new technology on alleviation of poverty was the result of substantial increases in income of the functionally landless households (with less than 0.2 ha of land, who are the bottom one-third of the households in the landholding scale) through higher employment and wages. The annual income for this group of households was about Tk 14,300 in the advanced villages compared to Tk 9,700 in the backward villages, the per cent difference was almost as much as the large landowners (with over two ha of land). The farmers used 45 per cent additional labor in growing modern varieties, and irrigation, by increasing cropping intensity about one-third, also increased the demand for labor. But as income increases, higher income households substitute leisure for labor and supply less labor in the market. The increased labor demand is met by more employment for the functionally landless in the advanced villages and from lower income households from backward villages. Total employment was four per cent higher in the advanced villages; for the functionally landless group it was 26 per cent higher. The new technology also puts a significant upward pressure on the wage rate, which is another factor behind the increases in incomes of the poor. The wage rate for agricultural labor was about 25 per cent higher in the advanced villages - than in backward ones.

The growth of income from the new technology expands the market for non-farm goods and services. In the backward villages households spent about 60 per cent of the marginal budget on crop and forestry sector output, which are land based, in the advanced villages the share was 47 per cent. The marginal budget share of rural services, which are mostly labor based, and in which the poor are more involved, was about 18 per cent in advanced villages compared to 7.5 per cent in backward villages. The expenditure pattern thus appears to be another mechanism through which some benefits of the new technology trickles down to lower income groups.

The increased incomes, however, do <u>not</u> promote capital accumulation in agriculture or in non-farm activities. The rate of directly productive investment is estimated at 7.3 per cent of total expenditure in the advanced villages compared to 11.7 per cent in the backward villages. The high income group spends proportionately more for improvement of housing and for transfers, such as purchases of land. Households in advanced villages acquired about 32 per cent of the land through the market compared to 25 per cent for backward villages. The impact of the new technology on the land market may be a potential source of further concentration of landholding and greater inequality in the distribution of agricultural incomes.

Thus, there is a case for siphoning off some of the surplus accumulated through technological diffusion, from the upper income groups. This may be achieved through higher agricultural taxation and the cost recovery of public investment in agriculture. It may be advisable to withdraw subsidies on irrigation which mostly benefit the large and medium landowners. A reallocation of public investment from major irrigation projects to small scale projects with pumps and tubewells, to the extent it is technically feasible, may also save resources, because the cost recovery from large scale projects has been proved to be extremely difficult. The government will need additional resources from domestic sources for irrigation investment, and strengthening agricultural research, extension and credit institutions - for promoting further diffusion of the new technology. The present low levels of cereal prices in international markets and political pressure from cereal-surplus developed countries suggest that it may be increasingly difficult for the government to mobilize foreign aid for this purpose.

2. INTRODUCTION

There are few countries in the Third World where technological progress is of higher importance in maintaining the food-population balance than in Bangladesh. The country now supports a population of about 104 million persons with a density of about 700 persons per square kilometer. The growth rate of population which has started declining only recently is still about 2.3 per cent per annum. Since per capita income is extremely low, nearly two-thirds of the income is spent on food. The income elasticity of demand for food (mostly rice) is variously estimated at 0.53 to 0.73.[1/] Thus, if the country has to achieve a modest growth of per capita income of about two per cent per annum, which has been the experience since it gained independence from Pakistan in 1971, food production has to grow at over 3.4 per cent to avoid further increase in cereal imports, which currently run at about 10 per cent of domestic demand.

But agriculture does not have resources to meet that challenge. Practically all cultivable land is in use and the pressure of increasing population has reduced the average size of farm holding from 3.53 acres in 1960 to 2.25 acres in 1983/84.[2/] The increase in the intensity of land use through raising additional crops during a year (cropping intensity) which has been the major source of growth of crop production till the late sixties, has slowed down considerably in recent years. Nearly 85 per cent of the cropped land is devoted to the production of cereals, indicating little scope of diversion of land from non-food to food crops. Since Bangladesh was densely populated decades earlier (density of 200 persons per km^2 in 1901), the possibility of increasing production through additional use of labor in individual crop varieties might also have bee exhausted by farmers long ago.

Thus, rapid technological progress is the key to maintaining the food population balance in the country. This was recognized by the government in the early sixties. At that time farmers rarely used modern agricultural inputs such as chemical fertilizers and irrigation. Fertilizer application was limited to tea gardens and government experimental farms and irrigation was practiced on about seven per cent of the land, using labor intensive indigenous methods. The major constraint to the application of modern agricultural inputs was the flooding of land during the rainy season and the lack of irrigation facilities during the dry season. Recognizing that farmers would not come forward to make lumpy investments on modern irrigation equipment because of the small farm size and the scattered and fragmented nature of holdings, the government set up the Water Development Board (BWDB), with the responsibility of developing the water resources of the country through multipurpose flood control, drainage, and irrigation projects. At the same time the Agricultural Development Corporation (BADC) was established for procurement and distribution of modern irrigation equipment, chemical fertilizers, and improved seeds among farmers at highly subsidized prices.

Thanks to the efforts of these institutions, Bangladesh experienced some progress in the use of the modern agricultural inputs over the last quarter century. The modern varieties (MV) of rice seeds developed in international research stations were made available to farmers for dry season crops (boro) in 1968 and wet season crops (aman) in 1970, but their diffusion really picked up after the mid seventies (Chapter 2). By 1984/85 the area irrigated by modern methods increased to about one-fifth of the cultivated land. Irrigation, along with flood control and improved drainage, facilitated the spread of modern input responsive MVs, which now cover about one-fourth of the cropped land and about one-third of sown area under cereal crops. The expansion of irrigation and the shift of cropped land from traditional to MVs have been the major factor behind rapid growth in the level of fertilizer consumption which has risen from insignificance in the early sixties to about 18 kg of nutrients per acre of cropped land by 1984/85, despite the gradual withdrawal of subsidy on this input since the mid seventies.[3/] The above figures also indicate that the potential for further increase in production through diffusion of the modern technology is still vast. It largely depends on the capacity of the government to accelerate investment on irrigation, flood control, and drainage, which determines the expansion of the other two elements of the modern technology, MV seeds and chemical fertilizers (Chapter 6).

In Bangladesh, however, the modern technology is widely believed to be contributing to worsening income inequality and deepening absolute poverty.[4/] This view is prevalent among the development thinkers and policy makers in the country as well as among the donor community which finances most of the investment on water resource development. The growth in crop production in the post-independence period (1971-85) has been faster than during the previous two decades (1950-71),[5/]

but studies based on household expenditure surveys show that absolute poverty afflicts two-thirds to four-fifths of the rural population and that it worsened alarmingly during the seventies.[6/] Other indirect evidences of the deteriorating economic conditions of the rural poor in the seventies are downward trends in the real wages of agricultural laborers and in the intake of energy and protein. The results of the national nutrition surveys show that the per capita daily energy intake has declined by about nine per cent between 1962-64 to 1975-76 period and another seven per cent by 1981-82.[7/]

In view of the above observations, concerns are expressed about the role of the modern technology in improving the condition of the poor. The hypothesis is that the impact of production growth from application of the modern technology is felt much more on the increase in land and labor productivity, which is appropriated mainly by the higher income groups, than on the generation of new employment or on the increase in wage rate from which the poor may gain. The impression is obtained by early studies on green revolution in India which argued that although the new agricultural technology is scale neutral, the small farmers cannot participate in its diffusion as much as the large ones because (i) the new crop varieties require a large amount of investment on purchased inputs which the poor cannot affort (ii) small farmers have little access to financial institutions from which working capital can be borrowed on reasonable terms. Also, by making agricultural enterprises more profitable for larger farmers, the new technology forces tenants off the land as tenancy evictions follow, and the new inflated surplus of the rich is used to buy out the marginal and small landholders, forcing them to landless. The net result, it is argued, is a rapid increase in the inequality of income and asset distribution and a worsening of rural poverty.[8/]

A contrasting view which is only recently being appreciated is that the new technology may benefit the poor in the long run by (i) reducing the cost of production and thereby lowering the prices of food and (ii) generating more employment in non-farm sectors by keeping real wages low and stimulating demand for non-farm goods and services.[9/] Since most of the income of the poor originate from labor and their marginal propensity to consume food is very high, these indirect effects of the technological progress are considered to be highly favourable. According to this view, if poverty increases, it is because of late and slow technological progress such that its favourable effects cannot outweigh the unfavorable effects of high population growth;[10/] and delays in adopting new technology will result in even more accentuation of poverty.

The above hypotheses regarding the nature and impact of the new agricultural technology have not yet been rigorously tested for Bangladesh. A large number of village studies have been undertaken to look into the impact of farm size and tenancy on productivity and they provide information on adoption of MVs and use of fertilizer for different groups of farms.[11/] But the studies are not based on any rigorous and systematic treatment of sufficiently large and disaggregated data, and so the results are speculative and conjectual in nature, and also the results do not show any consistent pattern. The few rigorous attempts that have been made are based on data collected from one or two villages and for the period of the early seventies when the technology had not progressed very far. And, the impact of the technology on employment and its indirect effects on non-farm activity and on income distribution among rural households is poorly documented. Obviously an indepth investigation into the characteristics of the new technology and its impact on productivity and income distribution is overdue. This is the objective of this study.

Two large household surveys have been conducted in recent years which provide disaggregated information that from the basis of this study. The first survey was conducted by the International Fertilizer Development Centre in collaboration with the Bangladesh Agricultural Research Council for studying the distributional consequences of fertilizer use. This is the most comprehensive farm survey conducted so far in the country. The survey work started with the 1979 monsoon season crops and continued for 10 consecutive seasons up to the 1982 aman season crops. A multistage random sampling method was used in the survey which ultimately covered 2400 sample farms and about 10,000 sample plots in 117 villages from 20 Upazilas scattered throughout 16 to 21 Bangladesh (old) districts. The survey collected detailed input-output data for all crops disaggregated by the type of technology used and the information was collected at the plot level. We do not have access to the plot or farm level data but detailed disaggregated information was presented at the crop and technology level in the published reports of the survey,[12/] which has been used here for analyzing the nature of the modern varieties of rice vis-a-vis the traditional ones (Chapter 4).

The second survey was conducted by the International Food Policy Research Institute in collaboration with the Bangladesh Institute of Development Studies for evaluation of the development impact of the infrastructure created under the food for work program in the country.[13/] The survey was conducted in 16 selected villages scattered through the four administrative divisions in the country and represent the principal ecological zones. A census of all households in the selected villages were carried out to serve as the sample frame for the study. The households were classified into eight groups based on the size of the landholding (four groups) and the occupation of the head of the household (agriculture and non-agriculture). A proportionate random sample was then drawn from each stratum so as to have 40 households in each village. The total sample size thus consists of 640 households and about 5200 plots operated by them. A few sample households could not be included in the analysis due to missing observations and doubtful information. The authors was involved in the design and implementation of the survey.

The field work was conducted during September 1981 to January 1983 administering five sets of structural questionnaire collecting information on the pattern of land use at the level of the plot for 1981 calendar year, cost and returns for various crops grown during 1982 at the farm level, and employment, income, investment, and consumption at the household level for 1982. The disaggregated household and plot level data have been analyzed here to investigate the impact of the modern technology on productivity, employment, and incomes (Chapters 5 to 9).

The villages studied represent a wide range of levels of development of the modern rice technology (Table 1). In five villages, less than five per cent of the cropped area was covered by the modern varieties of rice, while in four others more than 70 per cent of the area has been covered. The variation is mainly the result of the access of the villages to irrigation facilities, which have been developed mainly by the government during the last two decades and mostly through foreign assistance. In four of the villages, irrigation facilities were almost non-existent, two of them located in the coastal district of Khulna, where salinity of the water makes irrigation development difficult. In three other districts, some of the area is irrigated by indigenous methods (swing baskets and dhones). At the other end, in five villages more than 50 per cent of the cultivated land had irrigation facilities, three of them located in Comilla, where irrigation facilities were developed early (in the sixties) by the Comilla cooperative movement. The consumption of chemical fertilizer ranges from almost insignificant in the villages in Khulna to nearly 130 kg of materials per cropped acre in the villages in Comilla, and the level of consumption is highly related to the proportion of area under the modern varieties of rice.

One of the methods used in this paper to assess the impact of the technology is to compare the mean values of the variables in the technological developed and underdeveloped villages. Since in Bangladesh only about one-fifth of the area had irrigation facilities at the time of the survey, we used that figure for classifying the villages into two groups. This also divides the sample into two equal

TABLE 1

BASIC CHARACTERISTICS OF THE VILLAGES UNDER STUDY

Name of the village	District	Average size of land owned (acres)	Average house-hold size	Per cent of land irrigated	Area under modern variety (per cent of cropped land)	Fertilizer Consumption (kilograms of materials per acre of cropped land)	Per cent of crop area under tenancy
Developed Area:		2.26	6.52	53.8	61.4	82.2	16.0
Chasapara	Comilla	2.14	6.80	66.9	99.5	126.4	16.4
Illashpur	Comilla	1.67	6.78	56.3	73.2	133.6	21.1
Khunta	Comilla	1.80	6.23	83.3	83.2	130.4	15.0
Harishpur	Jessore	3.72	6.68	52.9	81.0	94.3	27.1
Rawtora	Pabna	0.98	6.89	58.0	46.9	65.1	2.5
Rajarampur	Dhaka	2.61	5.40	32.9	33.9	22.2	17.1
Charkhamar	Dhaka	2.50	6.40	42.4	25.7	30.3	4.7
Bandabeel	Kushtia	2.65	6.79	36.3	24.7	32.4	13.5
Underdeveloped Area:		2.26	6.35	8.0	5.2	10.8	15.9
Govindapur	Dhaka	2.36	5.43	20.4	13.8	14.1	7.8
Sayedpur	Dhaka	2.03	6.30	8.8	3.2	6.9	12.9
Patgari	Pabna	1.77	6.68	12.6	10.4	13.1	5.0
Roakuli	Kushtia	3.41	6.63	3.8	4.0	18.1	3.6
Gobrapara	Jessore	3.62	7.53	3.9	nil	7.9	19.5
Khejurdanga	Khulna	1.61	5.62	13.8	17.2	30.1	14.0
Birhat	Khulna	1.64	6.25	nil	nil	1.0	36.2
Taliamara	Khulna	1.45	5.05	nil	nil	1.3	45.7

size groups, with eight villages and 317 households in each group. In the developed villages nearly three-fifths of the cropped land was sown with the modern varieties of rice compared to only five per cent in the underdeveloped villages. The former group used 82 kgs of fertilizer materials per acre of cropped land compared to 11 kgs for the latter group (Table 1).

The pattern of distribution of land for the sample households is shown in Table 2. About 30 per cent of the households own up to 0.5 acres, which is considered in Bangladesh as functionally landless. This category is estimated by the recent Agricultural Census of Bangladesh (1983-84) at 46 per cent (it includes urban households). At the other end, about 10 per cent of the households own more than five acres, and may be considered as large farmers in the Bangladesh standard. Their proportion for the country as a whole is estimated at 8.5 per cent. The average size of landownership for the sample is 2.26 acres, compared to 2.00 acres for Bangladesh. Thus the degree of landlessness is lower and the amount of land owned is higher for the sample than in Bangladesh. The pattern of land distribution is, however, very similar in the technological developed and underdeveloped villages. The two groups have the same average size of landownership, and the same proportion of landless households. The proportion of large farmers and their share of total land is, however, slightly higher in the developed villages. The proportion of area cultivated by tenants varies widely across villages, but the average for the two groups of villages are similar (Table 1).

TABLE 2

THE PATTERN OF DISTRIBUTION OF LANDOWNERSHIP IN THE SAMPLE

Landownership group (acres)	Number of samples	Percent of households	Percent of land owned	Percent of population	Average size of land owned (acres)
Developed Area	317	100.0	100.0	100.0	2.26
Up to 0.5	97	30.6	2.0	25.6	0.17
0.51 - 2.0	103	32.5	16.6	29.6	1.16
2.01 - 5.0	80	25.2	36.1	28.6	3.24
5.01 - 7.5	20	6.3	16.7	8.2	5.9
7.51 and above	17	5.4	28.6	8.0	12.07
Underdeveloped Area	317	100.0	100.0	100.0	2.26
Up to 0.5	94	29.7	2.0	23.1	0.15
0.51 - 2.0	111	35.0	17.4	33.8	1.13
2.01 - 5.0	81	25.6	38.1	29.1	3.37
5.01 - 7.5	17	5.4	14.8	6.6	6.24
7.51 and above	14	4.4	27.7	7.4	14.17
Total Sample	634	100.0	100.0	100.0	2.26
Up to 0.5	191	30.1	2.0	24.4	0.15
0.51 - 2.0	214	33.8	17.0	31.7	1.14
2.01 - 5.0	161	25.4	37.1	28.8	3.31
5.01 - 7.5	37	5.8	15.7	7.4	6.10
7.51 and above	31	4.9	28.1	7.8	13.02

As a background to the detailed micro-level analysis which follows, Chapter 3 given an overview of the technological progress in Bangladesh, and its impact on agricultural growth and on trend in relative prices, using national level data for the 1950-85 period. The characteristics of the modern varieties of rice vis-a-vis the traditional ones, in terms of the use of various inputs and the implications on the cost of production and profits, are described in Chapter 4, using detailed input-output information provided by the IFDC survey. The impact of the technology on the productivity of land and labor and the efficiency of resource use is analyzed in Chapter 5 through estimation of production functions and profit functions. Chapter 6 studies the impact of farm size and tenure on the adoption of the new technology in order to assess the consequences of the technological progress on the distribution of income among various groups of farmers. About a third of the rural households in Bangladesh are landless and a half own less than 0.5 acres, these households depend on the labor market for employment and income. In order to complete the assessment of equity implications of the technological diffusion, Chapter 7 traces the employment effects by analyzing the supply of and the demand for labor for different groups of households in the technologically advanced and backward villages. The chapter also estimates labor supply functions with disaggregated household level information and estimates the effect of technological change on the agricultural wage rate. The issue of the indirect effects of the new technology on generation of employment and income for the poor through expansion of the market for non-farm goods and services is taken up in Chapter 8. The chapter also analyzes the investment behavior of different landholding groups, and the impact of the growth of income on the land market. The effect of the technology on the level and distribution of income and on alleviation of rural poverty is summarized in Chapter 9. The implications of the major findings of the study for policies to promote rural development are discussed in Chapter 10.

Chapter 2 Notes

1. For various estimates of the income and expenditure elasticity of the demand for food for Bangladesh see, W. Mahmud, "Foodgrain Demand Elasticities of Rural Households in Bangladesh: An Analysis of Pooled Data", The Bangladesh Development Studies, 7, (No.1, 1979); Bangladesh Bureau of Statistics, Report of the Bangladesh household Expenditure Survey, 1981-82, Dhaka, (March 1986): 34-39; R. Ahmed, Agricultural Price Policies under Complex Socio-economic and Natural Constraints", Research Report No. 27 (Washington DC, IFPRI, 1981): 52-56.

2. Bangladesh Bureau of Statistics, (Report of the 1983-84 Census of Agriculture and Livestock, Dhaka, Ministry of Planning, 1986).

3. For details of the development in the field of fertilizer consumption, see International Food Policy Research Institute and Bangladesh Institute of Development Studies, Fvertilizer Pricing Policy and Foodgrain Production Strategy in Bangladesh, Technical Annex, (Washington DC, 1985).

4. See, for example, Mosharraf Hossain, A. Rashid, and S. Jahan, Rural Poverty in Bangladesh: A Report to the Like Minded Group, (Dhaka University, 1986); van Schendel, W., Peasant Mobility: The Odds of Peasant Life in Bangladesh, Assen, (The Netherlands, 1981).

5. Mahabub Hossan, "Agricultural Development in Bangladesh: A Historical Perspective", The Bangladesh Development Studies, 12 (December 1984): 29-57.

6. Azizur R. Khan, "Poverty and Inequality in Rural Bangladesh". In ILO (ed) Poverty and Landlessness in Rural Asia, ILO, (Geneva, 1977); Q.K. Ahmad and Mahabub Hossain", An Evaluation of Selected Policies and Programs for Alleviation of Rural Poverty in Bangladesh". In R. Islam (ed) Strategies for Alleviating Poverty in Rural Asia, ILO (ARTEP, Bangkok, 1985).

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8. For a detailed articulation of this view, see Keith Griffin, The Political Economy of Agrarian Change: An Essay on the Green Revolution, Harvard University Press, (Cambridge, Massachusetts, 1964) and Andrew Pears, Seeds of Plenty, Seeds of Want: Social and Economic Implications of the Green Revolution" Clarendon Press (Oxford, 1980). For a detailed empirical study reporting the early results of the new agricultural technology in India, see B. Farmer (ed) Green Revolution, Macmillan, London, 1977.

9. For this view, see John W. Mellor, "Determinants of Rural Poverty: The Dynamics of Production, Technology, and Price", in J.W. Mellor and G.M. Desai (ed) Agricultural Change and Rural Poverty, The Johns Hopkins University Press (Baltimore and London, 1985); and "Food Price Policy and Income Distribution in Low-income Countries", Economic Development and Cultural Change, 27 (October 1976): 1-26.

10. This is supported by M.L. Dantwala, "Technology, Growth, and Equity in Agriculture", in J.W. Mellor and G.M. Desai (ed) op. cit, 110-123.

11. A survey of the results of these studies can be obtained from R.W. Herdt and L. Garcia, "Adoption of Modern Rice Technology: The Impact of Size and Tenure in Bangladesh" (mimeo), International Rice Research Institute, (Manila, 1982).

12. International Fertilizer Development Centre, Agricultural Production, Fertilizer Use, and Equity Consideration: Results and Analysis of Farm Survey Data, 1979-80 and 1982-84, (Alabama, 1982, 1984).

13. Bangladesh Institute of Development Studies and International Food Policy Research Institute, Development Impact of the Food for Work Program in Bangladesh, A report submitted to the World Food Program, Rome, (Washington DC, 1985).

3. TECHNOLOGICAL PROGRESS AND GROWTH OF CROP PRODUCTION - A MACRO PICTURE

Resource Base and the Need for Technological Progresss

The continuous high growth of population has made Bangladesh an extreme land scarce country and land can no longer be counted as an important source of growth of agricultural production. The total area of the country amounts to 35 million acres of which about 60 per cent is cultivated and most of the remaining land is under forests, rivers, and homestead (Table 3.1). There has been very little increase in cultivated land since the early fifties (see Figure 1), and by the end of the sixties, a type of equilibrium has been reached in the land use pattern, which has changed very little since. At present, the waste land which can be reclaimed for cultivation is only 1.9 per cent of the total land.

The effective supply of land could, however, be raised through growing additional crops on the same land during the year. This was indeed one of the means by which production was increased from this limited resource base. In the yearly fifties, only one-fourth of of the total land was cropped more than once during the year. The intensity of cropping increased very rapidly in the sixties from about 130 per cent in 1960/61 to 148 per cent by 1969/70. The cropping intensity continued to increase in the post-independence period but the rate of increase has slowed down. (see Figure 1 and Table 3.2). Further increase would depend on the expansion of irrigation facilities which allow the growing of additional crops on seasonally fallow land during the dry winter season (boro).

TABLE 3.1

CHANGES IN THE PATTERN OF UTILIZATION OF LAND, 1950-84

Use of land	1950-53		1967-70		1980-84	
	Area (mill ac)	Per cent ot total	Area (mill ac)	Per cent of total	Area (mill ac)	Per cent of total
Cultivated land	20.7	58.7	21.7	61.5	21.3	60.0
Current fallow	1.6	4.4	0.8	2.1	1.3	3.6
Cultivable waste	2.1	5.8	0.9	2.5	0.7	1.9
Forest	5.5	15.7	5.5	15.7	5.3	15.0
Not available for cultivation (rivers, canals, homestead, etc.	5.4	15.3	6.4	18.2	6.9	19.2
Total land	35.3	100.0	35.3	100.0	35.4	100.0

Source: Central Statistics Office, 25 years of Pakistan in Statistics, (government of Pakistan, Karachi, 1972).

Bangladesh Bureau of Statistics, Statistical Pocket Book of Bangladesh, 1984-85, (Government of Bangladesh, Dhaka, 1985).

TABLE 3.2

CHANGES IN THE INTENSITY OF USE OF LAND, 1950-84

Intensity of use	1950-53		1967-70		1980-84	
	Area (mill ac)	Per cent of total cultivated land	Area (mill ac)	Per cent of total cultivated land	Area (mill ac)	Per cent of total cultivated land
Single cropped	14.6	70.5	12.6	58.1	11.4	53.5
Double cropped}	6.1	29.5	7.9	36.4	8.2	38.5
Triple cropped}			1.2	5.5	1.6	7.5
Total cropped area	26.8	129.5	32.0	147.4	32.7	153.5

Source: Same as in Tabale 3.1

The majority of the people continue to depend on land for their livelihood because of limited expansion of non-agricultural sectors, inhibited partly by the small size of internal markets for non-agricultural goods and services, perpetuated by low-levels of income. The value added generated by manufacturing is only about 10 per cent of the gross domestic product, and the share of construction, trade and transport services is another 20 per cent. The 1983/84 Labor Force Survey has recorded that only eight per cent of the civilian labor force is employed in manufacturing, 17 per cent in construction, trade and transport services, and 12 per cent in other services.[1/] Agriculture still provides employment to about 60 per cent of the labor force.

Owing to the population pressure and lack of non-agricultural employment, the land is cultivated in very small holdings. Also holdings are fragmented into a large number of scattered plots due to application of the islamic laws of inheritance of property. The 1977 agricultural census found that two-fifths of the farm had more than 10 fragments. The small farm defined as holding under 2.5 acres is the dominant production unit. With the traditional technology, such a farm is incapable of proucing a subsistence income, so most of the small farmers also work as agricultural wage laborers and engage themselves in various non-farm activities during slack agricultural seasons to augment the income from farming. The proportion of the small farms has increased from about a half in 1960 to over two-thirds by 1984 and they now cultivate about a third of the total land (Table 3.3). During the same period, the proportion of large farm declined from 10 to 5 per cent and the area operated by them from two-fifths to

TABLE 3.3

CHANGES IN THE PATTERN OF DISTRIBUTION OF LANDHOLDING, 1960-84

Size of farm (acres)	Percent of holding		Percent of area operated		Average size of farm	
	1960	1983	1960	1983	1960	1983
Under 1.0	24.3	40.4	3.2	7.8	0.47	0.44
1.0 - 2.5	27.3	29.9	13.0	21.2	1.68	1.60
2.5 - 5.0	26.3	18.0	26.4	27.5	3.55	3.45
5.0 - 7.5	11.4	6.8	19.3	17.6	6.00	5.91
7.5 - over	10.7	4.9	38.1	25.9	12.60	11.85
All Farms	100.0	100.0	100.0	100.0	3.54	2.26

Source: 1960 Census of Agriculture, Vol II, East Pakistan, Agricultural Census Organization, Government of Pakistan, Karachi, 1962. Bangladesh Bureau of Statistics, Report of the 1983-84 Census of Agriculture and Livestock, Dhaka, 1986.

to one-fourth of the total land. The above characteristics of the landholding imply that there are few farmers who can generate enough surplus for reinvestment in agriculture, particularly in indivisible assets such as irrigation equipment.

While land is extremely scarce, Bangladesh is known to have an abundant water resource, the planned use of which for agricultural production was almost non-existent even by the early sixties. Three major rivers, the Ganges, the Brahmaputra, and the Meghna and their numerous tributaries flow through Bangladesh and discharge huge volumes of water. Heavy rainfall and geological structure produce excellent supplies of ground water, which in most regions are available up to a depth of about 12 meters and at less than six meters in large parts of the country and hence can be developed with relatively low cost. The recently completed National Water Plan estimates that nearly sixty per cent of the land can be irrigated by development of surface water through water conservation measures and withdrawing of streamflows from rivers.[2/] The ground water resource potential is estimated, on the basis of 75 per cent usable recharge, at 17,140 Mm^3 which can irrigate about 9.4 million acres or about 45 per cent of the cultivated land. Currently only about a fifth of the total land is irrigated. Obviously, there is a vast potential for further development of water resources in the country.

The new varieties of rice and wheat, developed by the international agricultural research stations and introduced to the farmers in Bangladesh in the late 1960s, opened up the possibility of increasing the supply of food on the limited land through development of water resources. The new varieties produce a substantially higher amount per unit of land compared to the traditional varieties, but they need careful water management and application of chemical fertilizer in large amounts, without which they fare no better compared to the traditional varieties. Thus, production could be increased from the shift of land from traditional to the modern varieties which are popularly known as the "seed-fertilizer" technology, provided the land has access to flood control, drainage, and irrigation facilities. At the same time, the expansion of irrigation facilities would increase the effective supply of land during the dry winter season when a large proportion of land is kept fallow due to inadequate moisture in the soil.

The diffusion of new technology supported by the development of water resources is thus the key to maintaining the food population balance in the country.

Diffusion of the Modern Technology

The New Seeds

Rice seed improvement management experiments have been conducted at the Dhaka Research Station since 1911. But a set of modern varieties were imported in the late 1960s to support the accelerated food production program sponsored by the Ford Foundation.[3/] During the 1970s, large quantity of modern variety seeds were imported from IRRI in the Philippines and from India.

In 1970 the Bangladesh Rice Research Institute (BRRI) was set up to develop varieties better suited to local growing conditions. By 1983, BRRI introduced 16 short duration modern varieties. The newer varieties have yield rates similar to the earlier ones but are superior with respect to disease resistance and grain quality. Rice is grown in three distinct seasons, aus (early monsoon; April to August), aman (monsoon; August to December), and boro (dry season; January to May). The new varieties have been introduced in all three seasons. In addition, a number of improved wheat varieties have been imported from CIMMYT and India and multiplied in the seed multiplication farms of the Bangladesh Agricultural Development Corporation (BADC) for distribution among farmers. The most popular wheat variety is Sonalika, bred in India using materials from CIMMYT and its predecessors based on "Mexican" material.[4/]

The official statistics on the expansion of area under the modern seed varieties of rice and wheat are reported in Table 3.4. The figures show that the use of the new seeds was negligible up to the end of the sixties, but picked up rapidly within the 1970-74 period which was followed by a period a stagnation during 1974-78 period. The expansion, however, resumed during 1978/79 and continued through 1984/85 at a rate of about 600,000 thousand acres per year, which doubled the area covered by the new seeds within a period of seven years. The apparent stagnation in the MV area in the mid-seventies may, however, be statistical rather than real. The Ministry of Agriculture set up "Task Forces" in 1974 and 1975 to evaluate the progress of MV aman and wheat programs and the field investigation by the tax force revealed substantial over-reporting of HYV aman acreage and a minor under-reporting of MV wheat acreage.[5/] Recognizing that the early information on MV expansion was over reported, the Bangladesh Bureau of Statistics made substantial downward adjustments in the area under aman and boro MVs for 1974/75 to 1976/77.[6/] In view of this adjustment in official series, one could argue that the diffusion of the new seed varieties has proceeded steadily since their introduction in the late sixties.

By 1985 nearly one-third of the cereal area had been covered by the new seeds. Nearly two-thirds of the MV area are cropped during the overalpping boro and aus seasons when the crops are grown with irrigation. Now about 97 per cent of the area under wheat has been covered by MVs, which has expanded largely at the expense of minor dry season crops such as oilseeds and pulses. The MV wheat area however comprises only 15 per cent of the MV cereal area. For rice,

TABLE 3.4

EXPANSION OF AREA UNDER MODERN VARIETY SEEDS, BY SEASON, 1967-85

Year	Rice MVs			Wheat	Rice and Wheat	
	Boro season (000 ac)	Aus season (000 ac)	Aman season (000 ac)	(000 ac)	Total area (000 ac)	As a per cent of total rice & wheat area
1967-68	156	-	-	-	156	0.6
1968-69	361	17	-	-	378	1.5
1969-70	580	42	30	-	652	2.5
1970-71	857	79	200	-	1,136	4.6
1971-72	793	121	625	-	1,539	6.7
1972-73	1,087	163	1,378	52	2,680	11.1
1973-74	1,455	329	2,043	72	3,899	15.8
1974-75	1,630	699	1,240	82	3,651	14.9
1975-76	1,588	872	1,376	217	4,053	15.7
1976-77	1,339	902	1,045	289	3,574	14.2
1977-78	1,586	981	1,233	388	4,187	16.6
1978-79	1,650	1,055	1,694	583	4,892	19.4
1979-80	1,788	995	2,154	1,015	5,953	22.7
1980-81	1,845	1,208	2,376	1,413	6,842	25.4
1981-82	2,219	1,166	2,361	1,277	7,022	25.8
1982-83	2,671	1,176	2,653	1,231	7,729	28.2
1983-84	2,635	1,235	2,628	1,475	7,973	28.3
1984-85	3,040	1,151	2,669	1,622	8,482	31.5
1985-86	2,998	1,191	2,906	1,291	8,386	31.0

- Negligible

Source: Bangladesh Bureau of Statistics, Yearbook of Agricultural Statistics, (Various issues), and Monthly Statistical Bulletin of Bangladesh, (Various issues).

the coverage is about 78 per cent for the boro season, 16 per cent for the aus season, and 20 per cent for the aman season. A major constraint to expansion of MV area during the aman season is that more than two-thirds of the area remains under deep water throughout the season and is not suitable for growing the dwarf MVs.

Development of Irrigation Facilities

Before modern irrigation was introduced in Bangladesh, cultivators used to irrigate boro paddy by lifting surface water through such traditional devices as swing baskets and dhones. It is estimated by the 1960 agricultural census that in 1959/60, nearly seven per cent of the cultivated land received irrigation by these traditional methods, mostly concentrated in the depressed basins of Sylhet, Mymensingh, and Rajshahi districts, where surface water was available at a height of 1-2 meters below the field during the driest months of the year. The subsequent development of modern irrigation has partly replaced these traditional sources of irrigation, the area under which has reportedly declined from about 1.5 million acres in 1970/71 to 0.9 million acres by 1984/85.[7/]

The initiative for the development of modern irrigation facilities had been taken by the government since farmers were unwilling or unable to make large lumpsum investments on irrigation equipment. The major constraint has been the small average size of farms and the scattered fragmented holdings. During 1976-84 period the government spent Tk 7720 million per year for development activities in the agriculture sector, of which Tk 3200 million (42%) was spent for irrigation and flood control. The projects were financed mainly with foreign aid.

The earliest approach of the government to expand irrigation facilities was through construction of large scale multi-purpose irrigation, flood control, and drainage projects implemented by the Bangladesh Water Development Board. A number of major projects were implemented during the sixties and seventies, which have been largely successful in protecting coastal and river belt areas from saline water intrusion and floods, but they played only a minor role in the irrigation development of the country; the area irrigated by such projects constitute only about one-tenth of the total area irrigated in the country. The provision of irrigation through the water development board projects has been costly since both the capital and current cost are borne almost entirely by the government.8/

Most of the irrigation development in Bangladesh has taken place through use of small scale equipment such as low lift pumps (LLP), deep tubewells (DTW), and shallow tubewells (STW). Up to the mid seventies, the expansion followed upon subsidized rental of one to two cusec capacity low lift pumps to farmers' cooperatives (Table 3.5). The number of pumps under operation rose quickly from about 3,000 in 1965/66 to about 35,000 by 1973/74, but the expansion since then has been slow. From 1978/79, the government has started selling pumps to individual farmers and cooperatives. The subsidy still remains at about 30 per cent of the procurement cost.9/

The promotion of ground water development started late, beginning in 1967/68 and moved at a slow pace through 1977/78. Initially, deep tubewells were rented to bonafide farmers' cooperatives which formed water users groups with contiguous plots amounting to at least 50

TABLE 3.5

DEVELOPMENT OF MODERN IRRIGATION FACILITIES, 1960-85

Year	Units of Irrigation Equipment under Operation (000)			Area Irrigated by modern methods/a		Total area irrigated	
	Low lift pumps	Deep tube wells	Shallow tube wells	000 ac	As a per cent of cultivated land	000 ac	As a per cent of cultivated land
1960/61	1.4	-	-	62	0.3	1,433	7.0 b/
1965/66	3.4	-	-	200	0.9	n.a.	n.a.
1969/70	17.9	1.0	-	830	3.8	2,613	12.0
1973/74	35.3	1.5	1.0	1,501	7.2	3,201	15.3
1974/75	35.5	2.7	2.4	1,564	7.5	3,562	17.0
1975/76	36.4	3.8	4.0	1,606	7.6	3,458	16.5
1976/77	28.2	4.5	5.4	1,341	6.6	3,004	14.7
1977/78	36.7	7.5	12.3	1,951	9.4	3,223	15.8
1978/79	35.9	9.3	17.0	2,295	11.0	3,903	18.9
1979/80	37.4	9.8	22.4	2,638	12.6	4,226	20.3
1980/81	36.1	10.1	38.4	3,033	14.3	4,520	21.4
1981/82	38.2	11.5	66.5	3,626	17.1	5,076	23.9
1982/83	42.2	13.8	104.1	4,036	19.0	5,345	25.1
1983/84	43.7	15.5	109.7	4,313	20.2	5,432	25.4
1984/85	49.8	16.7	137.0 c/	4,579	21.5	5,483	25.7

a/ Figures for shallow tubewell is includes those fielded by the Bangladesh Krishi Bank as estimated in the BADC report on Sale of Shallow Tubewells in the North-west and South-eastern districts of Bangladesh (mimeo, Dhaka , BDC, 1984). The area irrigated as reported in this table exceeds the figure provided by the Bangladesh bureau of Statistics because of this discrepancy, as the later did not include the area irrigated by these shallow tubewells.

b/ For 1959/60, as estimated by the 1960 Pakistan Census of Agricultur

c/ This figure is low compared to a World Bank estimate - which shows that in 1986 there were more than 170,000 shallow tubewells in the country.

Source: BADC, Annual Report (Various Issues) and Ministry of Finance, Bangladesh Economic Survey, Various Issues.

acre in area. The group would bear the operation cost and pay a pump rental to BADC which was highly subsidized. Beginning in 1978/79, the government started selling DTWs to groups and private individuals at a subsidy of about 70 to 80 per cent. The number of DTWs increased from 800 in 1970/71 to about 4,500 by 1976/77 and then more rapidly to about 16,700 by 1984/85.

The spurt of expansion of irrigation, however, began with the promotion of small capacity (less than 0.5 cusec) shallow tubewells since the mid seventies. From the very beginning, these were sold to farmers almost at cost price, but most of the purchases were financed by loans from the Bangladesh Krishi (agricultural development) Bank, a large proportion of which were not repaid. The sales of shallow tubewells increased rapidly during the 1979-83 period but slackened since then.[10/] The tubewells now account for over a half of the total irrigated area in the country.

The official statistics on area irrigated by different methods is known to be of dubious quality. The figures provided by different agencies in charge of development of irrigation are not consistent with the figures published by the Bangladesh bureau of Statistics which probably underestimates the area irrigated by shallow tubewells sold through the private sector by the Bangladesh Krishi Bank. It is also reported in a number of field surveys that some of the equipments sold to farmers may be used for non-agricultural purposes.[11/] The margin of error, however, may not be very large, as the 1983-84 agricultural census estimates the irrigated area at 1.62 million ac, against the official estimate of the area irrigated by modern methods at 1.75 million ac for that year.

The time series on irrigated land, compiled from the figures released by the BADC, BWDB, and the Ministry of Finance are represented in Table 3.5. It will be noted that modern irrigation was almost negligible even by the end of the sixties and its development has been fast up since 1977/78. Still, only about one-fourth of the cultivated area is irrigated and about one-fifth is irrigated by modern methods. The potential for further development of irrigation is thus considerable.

Economic analysis of various modes of water conducted by the National Water Plan on the basis of (a) the observed cropping pattern and input-output coefficients, and (b) shadow prices of inputs and output gives a rate of return on investment of 35 per cent for minor irrigation equipment.[12/] The incentive for farmers to invest in small scale irrigation equipment has also been examined by the National Water Plan using a cashflow analysis, at the existing terms of loans from the financial institutions. It shows that individual farmers have enough incentives to invest on shallow tubewells and low-lift pumps but for deep tubewells private investment is not financially feasible at existing terms, but investment through cooperatives provide ample financial incentives. In spite of the high profitability, the government achieved only 25 per cent of the planned targets for irrigation expansion during the First Five Year Plan (1973-78), and 71 per cent during the Second Five Year Plan (1980-84). The major constraints to expansion of irrigation seems to be (a) poor financial capacity owing to low level of income of the farmers, low tax-GNP ratio and the inability of the government to recoup the investment cost from the beneficiary, (b) low implementation capacity of public institutions which often leads to time and cost overruns in project implementation, (c) differential pricing of water by the BADC and BWDB and also for different equipments by BADC, which may dampen private initiatives for investment, (d) high unit costs of account of variable inputs due to low capacity utilization of equipment, (e) lack of proper zoning of areas suitable for different equipments which may result in improper siting leading to low capacity utilisation and (f) organizational problems in forming cooperatives of water users.

Fertilizer Consumption

Although chemical fertilizers were introduced in the country in the 1950s, their application was mostly limited to tea gardens and government experimental farms until the early sixties. With the objective of popularizing this new input to farmers, the BADC, a parastatal organization established for procurement and distribution of modern agricultural inputs to farmers, started selling fertilizers to farmers at highly subsidized prices. It is estimated that in 1968/69, the average rate of subsidy was about 58 per cent for urea and phosphate, and 67 per cent for potash.[13/] With rapidly increasing sales, the subsidy rates began to put a heavy burden on the government budget in the early seventies. This, together with an increase in the procurement cost of fertilizers, led the government to reduce subsidies. By 1983/84 the budgetary subsidy was reduced to about 25 per cent of the cost, and the economic subsidy valued at border prices was about 23 per cent in that year.[14/] At present, there is little subsidy on fertilizer. Over the 1972-84 period fertilizer prices increased by 20 per cent per annum, compared to a 10 per cent increase in the prices of crop output. Another policy change introduced since 1978 in handing over of distribution of fertilizers at the local level from BADC to private traders. Under the new system, traders can buy fertilizer from BADC sales centres at the government fixed prices and sell it to farmers at a market determined price. The BADC still keeps control over procurement of fertilizers and distribution to primary sales points and, for that purpose, it plans supply to maintain adequate stocks.

The trend in the consumption of fertilizers can be reviewed in Table 3.6. In 1960/61 the consumption was almost negligible at less than one kg of nutrient per acre of sown area. By the end of the sixties, the consumption increased to over 4 kg per acre, and it tripled within the next decade to about 13 kg by 1979/80. After a brief period of stagnation during the 1979-83 period, the consumption picked up again over the 1983-85 period. The sales in 1984/85 reached 1.26 million tons of fertilizers valued at about 5.3 per cent of the value added in crop production. Over the 1970-85 period, the trend rate of growth of consumption was about 10 per cent per annum.

Time series data on fertilizers application on crops is not available for Bangladesh. Trend in use in different seasons could, however, be constructed from BADC sales figures which are available by months. Fertilizer is applied on the main aman paddy crop during July to October period when no other fertilizer using crops are widely

TABLE 3.6

TREND IN THE CONSUMPTION OF CHEMICAL FERTILIZERS BY SEASON, 1960/61 TO 1984/85

Year	Total Fertilizer Sales (000 tons of materials)				Sales per unit of cropped land (Kg of nutrients per acre)	
	Aman	Boro	Aus	Total	Total	Boro season
1960/61	20	13	16	49	0.9	2.6
1965/66	45	28	35	108	1.7	5.3
1970/71	109	130	70	309	4.6	15.2
1973/74	109	200	81	386	5.9	22.1
1975/76	139	234	92	465	7.0	24.1
1976/77	154	227	140	521	8.0	24.9
1977/78	207	325	195	727	10.9	33.0
1978/79	256	358	140	754	11.1	35.7
1979/80	252	424	179	855	12.5	37.6
1980/81	265	429	195	889	12.8	35.2
1981/82	291	392	160	843	12.1	30.9
1982/83	245	507	216	968	13.7	38.0
1983/84	267	629	233	1129	16.1	47.3
1984/85	364	669	228	1260	18.1	44.8
1985/86						

Source: Compiled from BADC Annual Reports, and The Monthly Statistical Bulletin of Bangladesh, (Various issues) cultivated. November to March is the fertilizer application season for various rabi crops such as potato, wheat, mustard, sugarcane, and also boro paddy, which is grown under irrigated conditions. Aus paddy and jute are treated with fertilizer from April to June. The constructed time series on season-specific consumption of fertilizer, reported in Table 3.6, shows that the major focus of the growth of fertilizer consumption has been on the boro and rabi crops cultivated during the winter season. The major portion of the area under MVs are also cultivated during this season. These crops now account for about one-fourth of the sown area, but in 1984/85 sales during the season accounted for over a half of the total fertilizer sales in the country. The rate of application of fertilizer in the boro season crops at present is about 3.5 times higher than that for all crops taken together (Table 3.8). It is estimated elsewhere[15/] that the share of MV crops in total fertilizer consumption has increased from about 25 per cent in 1969/70 to over 61 per cent in 1983/84. Of the total increase in consumption over the 1977-84 period, 81 per cent was associated with the increased use on MVs and 51 per cent with increased use on irrigated land. Thus, MV seeds and irrigation have played an increasingly important role in the growth of fertilizer consumption in Bangladesh.

Complementarity of the Modern Technology Package[16/]

The time series data reviewed above show a high degree of complementarity between irrigation, fertilizer use and the diffusion of MV seed (Figures 2 and 3). But irrigation could be the leading input in the sense that adoption of MVs and application of fertilizers follows development of irrigation facilities. The following analysis based on regional level cross-section data for 1983/84, the latest normal year for which data are available, shows the nature of complementarity and the leading role of irrigation.

A large variation in the diffusion of the new technology is found among the regions in the country. By 1984/85 the proportion of land irrigated by modern methods has increased to over one-third in the districts of Bogra, Kushtia, and Chittagong, while it was still less than 15 per cent in the costal districts of Patuakhali, Barisal, Khulna, and Noakhali. Similarly the proportion of cereal area cultivated with MV seeds varied between 75 per cent in Chittagong to less than 20 per cent in Patuakhali, Barisal, Khulna, and Sylhet. Fertilizer consumption per acre of cultivated land varies from over 150 kgs of materials in the districts of Chittagong, Bogra and Kushtia to less than 50 kg in the districts of Patuakhali, Barisal, Khulna, Faridpur and Sylhet.

The relationship between the intensity of fertilizer consumption and the per cent of the net shown area irrigated is shown by regression equations in Table 3.7 estimated by the OLS method on the district level cross-section data. In order to reduce specification errors, which differ across districts, as annual rainfall, the level of land, and the average size of farm have been used as additional explanatory variables. The farm size variable was found to be statistically insignificant in all estimating equations and hence it was dropped. Since both too much and too little rainfall can effect fertilizer use, the absolute deviation

TABLE 3.7

ASSOCIATION OF FERTILIZER CONSUMPTION AND ADOPTION OF HYVs WITH IRRIGATION: ESTIMATES FROM DISTRICT LEVEL DATA, 1983/84

Dependent variables	Regression Coef. of Independent Variables					$\bar{R}^2$	'F' Statistics
	Constant term	% of cultivated area irrigated: Total	% of cultivated area irrigated: Modern methods	Rainfall deviation from normal[a]	% of medium high land		
A. Fertilizer consumption (kg. materials per hectare)							
i)	20.43 (0.43)	5.81 (5.31)		-0.22 (-0.29)	-0.54 (-1.57)	0.60	10.5
ii)	19.11 (0.54)		6.07 (7.71)	-0.30 (-1.18)	0.11 (0.20)	0.77	21.7
iii)	14.24 (0.83)		5.87 (8.11)			0.79	65.8
B. Percent of cultivated area under dry season HYV (Boro rice & wheat)							
i)	5.82 (1.79)	0.86 (5.92)		-0.07 (-1.52)	-0.03 (-0.26)	0.67	14.1
ii)	5.88 (1.31)		0.89 (8.83)	-0.03 (1.02)	-0.04 (-0.61)	0.82	30.5
iii)	2.44 (1.12)		0.89 (9.65)			0.83	93.2
C. Percent of cultivated area under wet season HYV (aus plus aman)							
i)	22.71 (-1.69)		0.49 (1.92)	0.16[a] (3.16)	-0.09 (-0.47)	0.41	5.4
ii)	22.71 (-2.27)		0.53 (2.28)	0.15[a] (3.23)		0.44	8.4

Figures within parentheses are estimated 't' values. The sample size is 20 Bangladesh (old) districts.

[a] The variable is measured by the amount of annual rainfall in the district.

of the rainfall in the district from the normal rainfall in Bangladesh has been used. The land level variable has been measured by the per cent of area under medium high land in the district, as recorded in the 1977 agricultural census. Two alternative irrigation variables have been used - total area irrigated and area irrigated by modern methods. Although most of the data are now available for 1984/85, the reference year for this analysis is 1983/84 which has been chosen because the 1984/85 aus and aman crops were affected by a number of abnormal floods during July-September 1984, while 1983/84 was a relatively normal year.

The estimated equations show that the structural factors (a) rainfall, and (b) land levels do not influence fertilizer consumption or adoption of MVs during the dry season. Both these variables are, however, strongly correlated with the level of irrigation. A better statistical fit is obtained with modern irrigation than with total irrigation. This is expected because traditional irrigation is practiced mostly in the depressed basins of the country and is the outcome of the natural endowment of land and water rather than of a conscious investment decision by the farmer or the state. The low lying areas remain unsuitable for growing any crop during the monsoon season and are used for growing local boro during the dry season when the water level is reduced, but deep flooding still does not allow adoption of MVs or economic use of fertilizer.

The estimated equations which contain only the statistically significant variables show that irrigation alone explains about 79 per cent of the regional variation in fertilizer consumption and about

83 per cent variation in the diffusion of MVs during the dry season. The elasticity of fertilizer consumption, with respect to irrigation, is estimated from the equation at 0.90 at the mean level of the use of these inputs and the elasticity of MV adoption during the dry season at 0.89.

The area covered by MVs during the wet season is, however, more strongly associated with rainfall than with irrigation. Only about 44 per cent of the interdistrict variation in the coverage of MVs during the wet season is explained by these two variables. It appears that some other important determinants have not been incorporated in the analysis. One such variable may be the duration of the monsoon, since early monsoon would facilitate adoption of aus MVs and districts receiving adequate rainfall during the late monsoon period (September-October) may have relative advantage in growing rainfed aman MVs. The depth of flooding may be another.

The relatively weak relationship between irrigation and the expansion of wet season MVs may be due to (i) MVs first spread in districts which have favorable endowment of rainfall and (ii) the low-lift pump irrigation initially spread to low lying areas where adequate surface water is available in the dry season, but deep flooding of such land during the wet season does not permit raising of dwarf MVs. With increased extraction of ground water resources by tubewells, irrigation facilities are now being extended to medium high and high land areas, which could be used for providing supplementary irrigation required for raising MV aus and aman crops.

Development and use of modern irrigation facilities require prior capital investment and institutional arrangements for the coordination of actions among many cultivators. The adoption of MV seeds and application of chemical fertilizers are, however, current production decisions undertaken by individual cultivators. These special attributes of irrigation and the high degree of complementarity among the three inputs in the new technology package suggest that the development of irrigation poses the key constraint to the diffusion of the modern technology in the country (more on this in Chapter 6).

Impact on Growth

What has been the impact of the technological progress on the growth of crop production? This section analyzes the official time series data on sown area and production of different crops for the period 1950-85 to see whether production growth has accelerated after the introduction of the new agricultural technology.

A large number of crops are grown in Bangladesh, but three crops - rice, wheat, and jute account for nearly 90 per cent of the total sown area. For the present analysis, we have selected rice and wheat (cereal group); and jute, sugarcane, tobacco, pulses, oilseeds, potato, and chilli (non-cereal group) . These crops accounted for about 94 per cent of the sown area during the 1980-85 period, so the exclusion of other crops should not seriously affect the results. The 1981/82 crop level harvest prices have been used as weights for valuation of production at constant prices. In Bangladesh, prices fluctuate widely from year to year particularly for minor crops, the production of which is highly responsive to changes in relative prices.[17/] The 1981/82 price level is chosen because it was found that for most of the crops, the level of price in 1981/82 was very close to the trend for the 1976-84 period.

The yield rates have been estimated by dividing the gross value of production with the sown area. For assessing the impact of the new technology on growth, we have divided the time series into two parts, 1950-71 and 1971-85 periods and compared the growth performance of the two periods. The crop year 1971/72 has been taken as the dividing line because (1) as noted earlier, there was little progress of the new technology up to the end of the sixties and (2) Bangladesh became independent from Pakistan in 1971 and it appears from a close scrutiny of the official series that a downward adjustment has been made in the crop yield figures since 1971/72.

To see whether the growth rate has accelerated in the latter period with the diffusion of the new agricultural technology, the following trend equation has been fitted on the data for the entire period (1950-85):

$$L_nY = a_0 + a_1D + b_0T + b_1DT + u$$

where Y is the variable for which the rate of growth is estimated, D is the dummy variable taking value one for the 1971-85 period and zero otherwise and T is time. The rate of growth for the 1950-71 period is given by b_0 and that for 1971-85 period is given by (b_0+b_1). The value of b_1 is expected to be positive if there has been an acceleration of growth during the 1971-85 period. The coefficient of the dummy variable, a_1, will indicate whether any adjustment has been made in the time series since 1971.

The growth rates derived from the estimated equations are presented in Table 3.8. The growth of production has accelerated from about 2.5 per cent per annum during the 1950-71 period to about 2.9 per cent during the 1971-85 period. This has taken place in spite of a deceleration in the growth of cropped land in the later period. The impact of technological progress should be felt on the growth of land productivity. It is estimated that the growth of yield rates has accelerated from 1.4 to about 2.0 per cent per annum for all crops. The acceleration coefficient is found to be statistically significant at about five per cent probability level.

TABLE 3.8

GROWTH IN CROP PRODUCTION BEFORE AND AFTER THE INTRODUCTION OF THE MODERN TECHNOLOGY

(figures in percent per annum)

Crops	Period	Cropped land	Yield per unit of land	Production
Cereal crops	1950-71	1.10	1.52	2.62
	1971-85	1.16	2.20	3.36
Non-cereal crops	1950-71	1.26	0.89	2.15
	1971-85	-0.73	1.26	0.53
All crops	1950-71	1.12	1.40	2.52
	1971-85	0.90	2.02	2.92

For investigation of the issue at hand, more important is to look at the cereal sector since the technological progress has taken place mainly in the production of rice and wheat. The production of cereals has grown at faster rates than the non-cereal crops and the difference in performance is particularly noticeable in the post-modern technology period. The growth of production for the cereal crops has accelerated from about 2.6 per cent per annum during the 1950-71 period to about 3.4 per cent during 1971-85 period. The acceleration in production is mainly on account of the growth in crop yields, i.e., land productivity which has increased from 1.5 to 2.2 per cent per annum. The acceleration in the growth of productivity in the post-modern technology period is almost twice was much for the cereals compared to the non-cereal crops. The acceleration coefficient for cereal yield is found to be statistically significant at 10 per cent probability level.

The technological progress in cereal crops, however, has had adverse effects on the production of non-cereal crops, many of which cannot compete with MV rice and wheat. The most seriously affected crops are jute, pulses, and oilseeds, the area under which declined consistently since the late sixties. Jute competes for land with aus rice, but owing to a secular declining in the price of jute relative to a price of rice, large fluctuation in its prices, and technological advances made in rice, some of the traditional jute land has been shifted to MV aus and boro crops. The expansion of cropped land under boro rice and wheat has been partly at the expense of pulses and oilseeds. It will be noted from Table 3.8 that the cereal crops have maintained the growth in cropped land at about 1.1 per cent per annum largely at the expense of the non-cereal crops, the area under which has declined absolutely at a rate of about 0.7 per cent per annum during the 1971-85 period.

Level and Fluctuation of Food Prices

Technological progress implies a downward shift in the cost function (Chapter 3), and depending on the nature of demand, some of the benefits may be shifted to consumers in the form of lower prices. It is argued in the literature that one of the important ways through which the technological progress indirectly benefits the poor is the lowering of the real food prices.[18/] So a relevant empirical question at this point is what happened to the prices of cereals compared to the non-cereal crops after the introduction of the modern technology.

Table 3.9 presents the estimates of the rate of increase in the retail prices of major commodities in the consumption basket for the 1950-71 and 1972-85 periods. Since there is considerable fluctuation in prices from year to year, the rates of growth have been estimated by fitting semi-logarithmic trend lines to the time series data. The rate of inflation, as measured by the trend rate of growth in the consumer price index, was only about three per cent per annum during the decades of the fifties and sixties but increased to about 11 per cent since the independence of the country. So in comparing the price changes for the two periods, one should look at relative rather that absolute increase in prices.

TABLE 3.9

CHANGES IN THE FOOD AND NON-FOOD CONSUMER PRICES IN THE PRE AND POST NEW TECHNOLOGY PERIODS

(Per cent per annum)

Commodities	1950-71			1972-85		
	Rate of increase	Standard error of estimate	Instability index (per cent)	Rate of increase	Standard error of estimate	Instability index (per cent)
Food:						
Rice	5.42	0.47	12.9	10.98	0.76	9.0
Pulses	3.89	0.47	12.8	12.16	1.47	14.5
Potato	1.05	0.47	12.2	5.56	1.40	15.8
Gur	3.51	0.59	17.0	8.99	1.24	14.1
Fish	2.32	0.58	15.8	16.56	1.93	13.6
Beef	3.86	0.27	7.6	16.17	2.51	16.9
Oil	3.43	0.55	15.5	8.89	0.82	9.6
Non-food:						
Firewood	4.98	0.49	14.0	10.98	0.68	9.0
Longcloth	1.52	0.58	13.8	9.21	0.66	5.7
Consumer price index	2.95	0.20	5.5	10.99	0.59	6.8

Source: Estimated by fitting semi-logarithmic trend lines on time series.

Notes : The retail prices are reported for major urban centres in Dhaka, Chittagong, Khulna, Rajshahi, Sylhet, and Rangpur. The figures in the table are based on the series for Dhaka. The consumer prices are for laborers in the industrial city of Narayangonj. The year, 1974/75, when famine conditions prevailed in the country was excluded in estimating trend for the later period.

During the two decades prior to the introduction of the new technology, the rice prices increased at a much faster rate (80 per cent higher) than the general rate of inflation in the country. In fact, among the major commodities in the consumption basekt, the price of rice increased at the fastest rate. The position, however, completely reversed in the post-modern technology period. The prices of rice increased at the same rate as the general rate of inflation in the country.[19/] Some of the commodities, such as pulses, beef, and fish, which experienced slower rates of increase in prices than rice during the earlier period had price increases at 10 to 50 per cent higher rates compared to rice during the later period. Only for oil, gur (raw sugar), and potato, did prices continue to increase at a slower rate. The lower prices for oil and gur may have been maintained by the government through imports of substitute commodities, soybean oil, and sugar and by distributing them to urban consumers through the rationing system and also by controlling the price of sugar which is produced in government owned mills. Potato is the only non-cereal food for which the long run growth in production has been faster than in cereals. The growth rate is estimated at 8.2 per cent for the 1950-84 period and 3.5 per cent for the 1971-85 period.

A general problem with agricultural prices in Bangladesh is that they are very unstable. The new crop varieties are less dependent on weather than the traditional ones, as the land on which they are grown generally have access to irrigation facilities. So with a large proportion of the production of cereals coming from the new varieties, the weather induced fluctuations in production and prices are expected to be reduced.[20/] Table 3.9 also presents a measure of the instability of consumer prices for the pre- and post new technology period. Following Cuddy and Della Valle,[21/] the instability index is derived as follows:

$$I = CV/(1-R^2)$$

where I is the index (per cent), CV is the coefficient of variation, (standard deviation as a percent of arithmetic mean) and R^2 is the adjusted coefficient of determination of the semi-log trend function. It will be noted from the estimates that although the rate of inflation has increased by over three times in the post-modern technology period, the instability index has not chnaged much. In general the prices are more unstable for the non-cereal food crops than for cereals. This has been the experience particularly in the post new technology period, when the prices of the important food crops, like potato and pulses have been more unstable compared to the earlier period. For rice, in which the technological progress has taken place, the degree of instability has been reduced; the index going down from about 13 per cent for the 1950-71 period to nine per cent for the 1972-85 period.

The slowing down of the increase in real prices of rice and its greater stability in the post-new technology period may not be entirely due to technological progress. The changes in government's monetary and fiscal policy can influence these variables. More important, the government has followed a price intervention policy for rice, declaring support prices and participating in markets through procurement after harvests and distributing cereals directly to consumers through various channels. The effect of technological progress can only be worked out after dissociating the effect of these other factors, which in itself is an important topic of research and has not been pursued in this study.

Conclusions

In Bangladesh Agricultural growth is constrained by limited availability of land. The amount of cultivated land has remained stagnant since the early fifties. At present the waste land which can be reclaimed for cultivation is only about two per cent. But Bangladesh has vast water resources which can be developed for adoption of the modern rice technology for increasing foodgrain production. In fact, the country has maintained the food population balance since its independence (1971) mainly through technological progress. About one-fifth of the cultivated land has been brought under modern irrigation mostly through public investment. This, together with improved flood control and drainage, has made possible an expansion of the modern varieties to about one-third of the sown area under cereals, and an increase in fertilizer consumption from 4.5 to 18.2 kg of nutrients per acre within the 1971-85 period. The growth of cereal production has accelerated from 2.6 per cent per annum during 1950-71 to 3.4 per cent during 1971-85 period, mostly due to the acceleration in the growth of crop yields. The productivity growth may have been one of the factors which has helped to keep the rice prices low. The retail price of rice which increased at about 80 per cent faster rate than the cost of living index during the 1950-71 period, has moved at par with the general rate of inflation during the 1971-85 period. There is still vast potential for further diffusion of the technology, the rate of exploitation of which may depend on undertaking appropriate policies by the government.

Chapter 3 Notes

1. Bangladesh Bureau of Statistics, Priliminary Report on Labor Force Survey, Dhaka, october 1984.

2. Master Plan Organization, National Water Plan Project Draft Final Report, Volumes I and II, Ministry of Irrigation and Flood Control, Dhaka, 1985.

3. Dana, G. Dalrymple, Development and Spread of High Yielding Rice Varieties in Developing Countries, Washington DC, Agency for International Development, 1986): p. 39.

4. Carl, E. Prey and Jock R. Anderson, Bangladesh and the CGIAR Centers: A Study of their Collaboration in Agricultural Research, Study Paper No. 8. (Washington DC, World bank, 1985): p. 43.

5. Bangladesh Agricultural Development Corporation, HYV Task Force Reports, 1974/75, Dhaka, 1977.

6. See, Mahabub Hossain, "Foodgrain Production in Bangladesh, Performance, Potential and Constraints", The Bangladesh Development Studies, 8 (Nos 1 & 2, 1980): p. 39-70.

7. Bangladesh Bueau of Statistics, Yearbook of Agricultural Statistics, 1982 and Monthly Statistical Bulletin, March 1986.

8. In 1976 the BWDB imposed a water rate at three per cent of gross produce which would cover only about a quarter of the operation and maintenance costs of these projects, but has had limited success in realizing the rates from the farmers. See S.R. Osmani and M.A. Quasem, Pricing and Subsidy Policies for Bangladesh Agriculture, Bangladesh Institute of Development Studies, Dhaka, 1985 (mimeographed); p. 134-137.

9. Ibid p. 291-296.

10. The reasons behind the recent slowdown of the sales of minor irrigation equipment have not yet been investigated thoroughly. It is conjectured that the tightening of disciplines regarding recovery of institutional loans and reduction in farmers' cash income due to low prices of jute may be the major factors. Further expansion may also be constrained by the factor that relatively large farms who can afford private investment on irrigation equipment have already been covered, and the government will have to tackle the more difficult problem of organization of the small and medium farms in cooperatives. The 1983-84 agricultural census found that only 89,000 rural households owned more than 15 acres of land (the command area of a shallow tubewell), and according to an World Bank estimate there are already more than 170,000 shallow tubewells in the country.

11. See for example, M.A. Hamid, Low-Lift Pumps under IDA Credit in South-East Bangladesh: A Socio-Economic Study, Rural Development Studies, Series 12, Rajshahi University.

12. Master plan Organization, National Water Plan Project: Draft Final Report, op. cit.

13. F. Kahnert, et al, Agriculture and Related Industries in Pakistan, Paris, (OECD Development Center, 1970).

14. Raisuddin Ahmed, "Structure, Dynamics, and Related Policy Issues of Fertilizer Subsidy in Bangladesh" in Bangladesh Institute of Development Studies and International Food Policy Research Institute joint report on Fertilizer Pricing and Foodgrain Production Strategy in Bangladesh, Technical Annex, (Washington DC, 1985).

15. Mahabub Hossain, "Fertilizer Consumption, Pricing and Foodgrain Production in Bangladesh", in BIDS IFPRI joint report, op. cit. p. 149-150.

16. This section draws heavily from Mahabub Hossain, "Irrigation and Agricultural performance in Bangladesh: Some Further Results", The Bangladesh Development Studies, Vol. 14, (No. 4, 1986), pp. 39-56. The main conclusions are also supported by James K. Boyce, "Water Control and Agricultural Performance in Bangladesh", The Bangladesh Development Studies, Vol. 14 (No. 4, 1986). pp. 1-35.

17. John, T. Cummings, "The Supply Response of Bangalee Rice and Cash Crop Cultivators", Bangladesh Development Studies 2 (October 1974): 235-251; Sultan H. Rahman, "Supply Response in Bangladesh Agriculture", The Bangladesh Development Studies, Vol. 14 (No. 4, 1986), pp. 57-100.

18. See John, W. Mellor, "Food Price Plocy and Income Distribution in Low-income Countries", Economic Development and Cultural Change, 22 (October 1978): 1-26; Yujiro Hayami and R.W. Herdt, "Market Price Effects of Technological Change on Income Distribution in Semi-Subsistence Agriculture", American Journal of Agricultural Economics, 59 (May 1977): 245-256. For Bangladesh the issue has recently been studied by Alauddin M. and C. Tisdell, "Market Analysis, Technical Change and Income Distribution in Semi-Subsistence Agriculture: The Case of Bangladesh", Agricultural Economics, Vol. 1, (No. 1. 1986): 1-18.

19. Since rice is a major commodity in the consumption basket it may be argued that the movement in the cost of living index is mainly determined by the rice prices. According to the 1983-84 Household Expenditure Survey, rice accounted for 32 per cent of the national consumption expenditure, so the rice price index and the CPI may not necessarily increase at the same rate.

20. In India, instability in cereal production increased greatly in the post-new technology period. Hazel however shows that about 82 per cent of the increased variation can be attributed to increases in the covariances of production between crops grown in the same and in different states, which cannot be blamed to improved technologies. Only six per cent of the variances of total cereal production was attributed to variances of individual crop yields measured at the state level. Peter B.R. Hazell Instability in Indian Foodgrain Production, Research Report No. 30, International Food Policy Research Institute, May 1982.

21. D.A. Cuddy and P.A. Della Valle, "Measuring the Instability of Time Series Data", Oxford Bulletin of Economics and Statistics, 40 (February 1978): 79-85.

Fig. 1: Trend in Cultivated Land and Cropped Area 1950-85

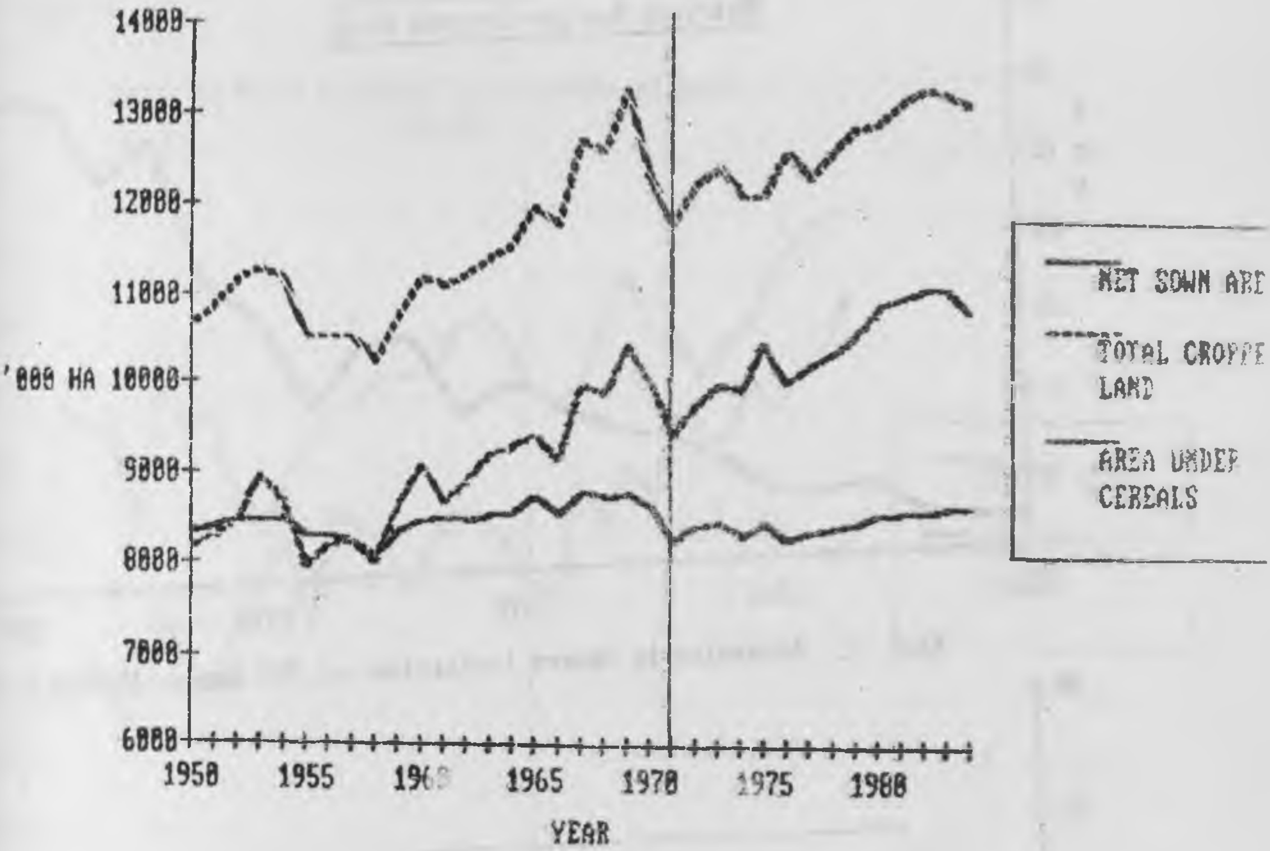


Fig. 3: Trend in Fertilizer Use, 1960-85

Fig. 2: Expansion in Modern Irrigation and HYV Seeds, 1960-85

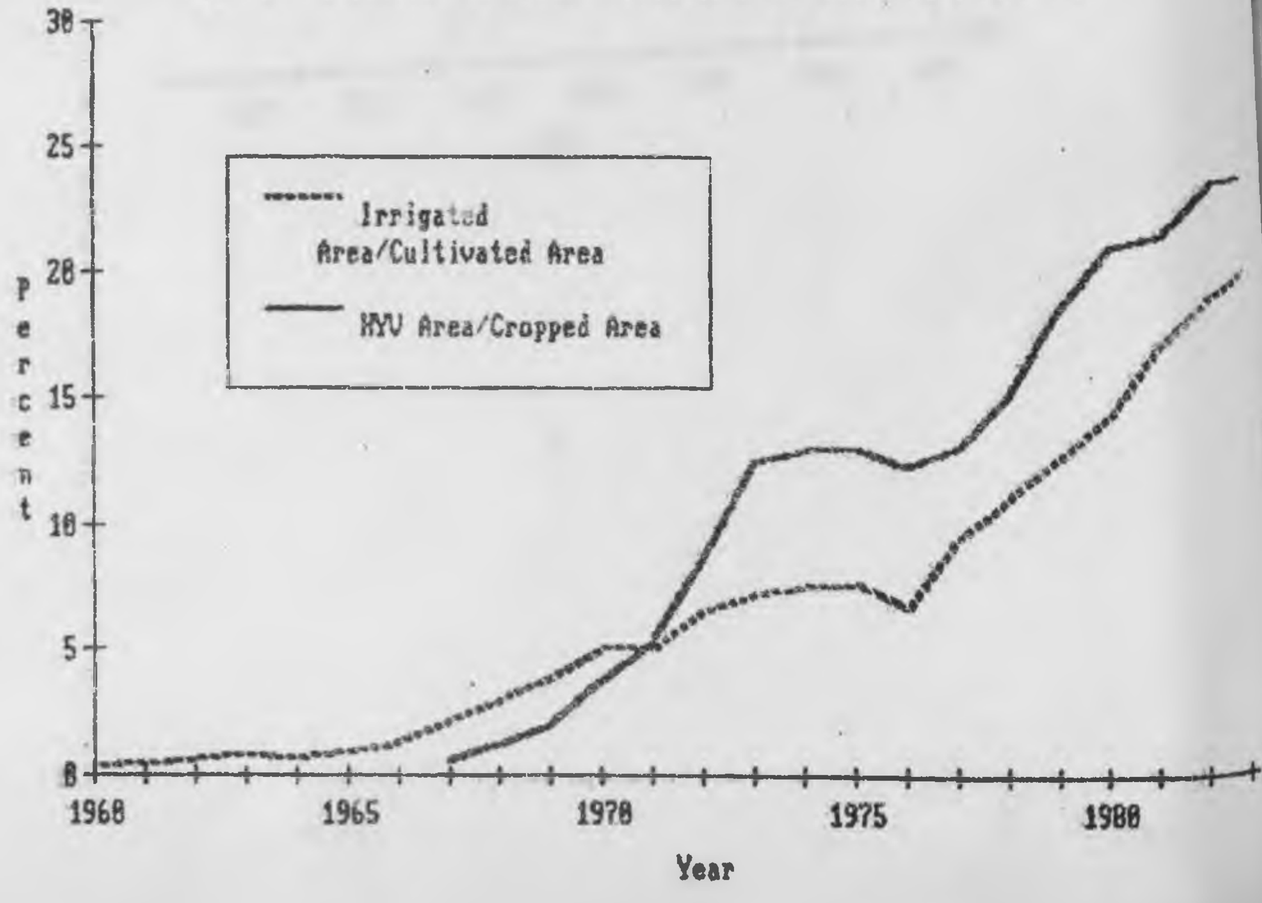
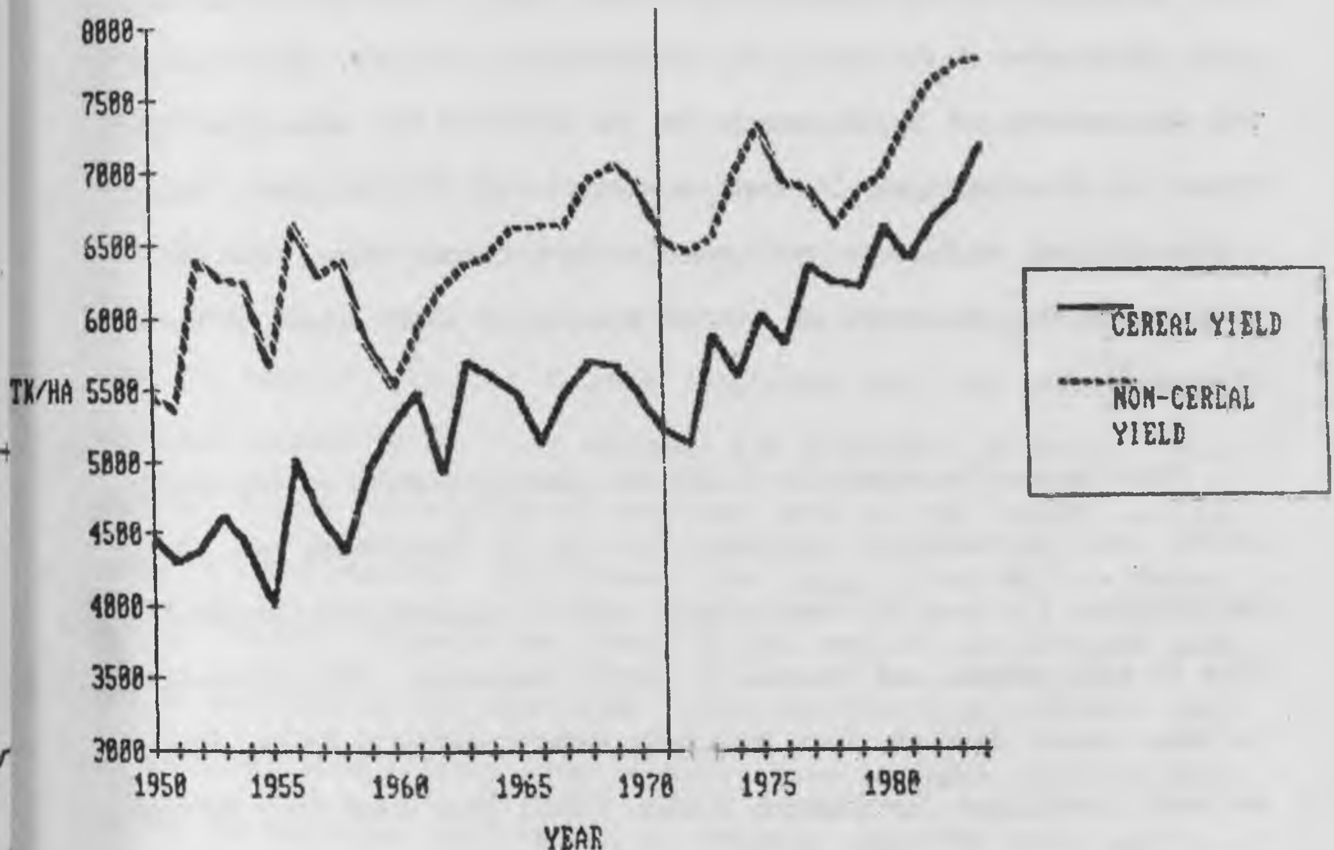


Fig. 4:

Trend in Yield of Cereal and Non-Cereal Crops
1950-85



4: THE NATURE OF ALTERNATIVE RICE TECHNOLOGIES

Introduction

The term "technology" is generally used to mean the application of knowledge involving the use of a combination of inputs for production of output through optimum use of the inputs. The new technology would thus means a change in the combination of inputs, their levels and the methods of application. It is important to understand the nature of these changes, because in underdeveloped agriculture, where endowments and real costs of resources vary across farms, the suitability for the acceptance of the new technology would depend on these changes.[1/]

This chapter documents in detail the characteristics of the alternative crop technologies currently in use in Bangladesh and their implications for cost of production, capital requirements, profitability of cultivation, and returns to family resources. The information is drawn mainly from the farm household survey conducted by the International Fertilizer Development Center (IFDC) from aman 1979 through boro 1982 seasons and is supplemented by the information collected by the Bangladesh Institute of Development Studies (BIDS) and the International Food Policy Research Institute (IFPRI) Survey. The IFDC survey is the largest household survey ever conducted in Bangladesh, covering 2400 randomly selected households from 16 out of 21 Bangladeshi old districts. The input-output information on crops was collected at the level of about 10,000 sample plots belonging to the selected households. Since farmers do not keep any records of their operation, the input use information collected at the plot level tends to be more reliable than those collected at the farm level. The findings of this study are expected to be representative for the country as a whole and the level of accuracy is as much as one can obtain by asking questions to farmers.

As noted earlier, the technological progress in Bangladesh is mainly confined to the production of rice and wheat. Wheat was an unimportant crop even up to the mid seventies, but a rapid increase in the area since 1975/76 has turned it into the third major crop after rice and jute. Wheat now occupies about five per cent of total cropped land, most of it under modern varieties. The scope of further expansion is, however, limited because Bangladesh soil and the duration of winter season is not very suitable for production of wheat. Rice occupies nearly four-fifths of the sown area in the country and is grown in three seasons. The monsoon rice, aman, harvested from November to January, accounts for about 46 per cent of the cropped land and 58 per cent of the rice land. About one-fourth of the aman land is broadcast seeded (deep water variety) sown in March when the land is dry and harvested in November and December when the water recedes. On this type of land, the depth of flooding prevents raising any other crop during the monsoon season. On the remaining aman land (medium-low and medium-high level), the crop is transplanted and the modern varieties have spread to about one-fourth of the area. The early monsoon rice, aus, harvested in July and August are mostly broadcast varieties sown in March-April on either very low or very high land. In some areas transplanted rainfed aus varieties are also grown.[2] This crop traditionally competes with jute and now accounts for about one-fourth of the total sown area in the country. MVs have spread to about one-sixth of the aus land and has tended to stagnate at that level since the late seventies. Aus MVs are mostly transplanted, but in some areas broadcast MVs are also grown. The remaining one-sixth of the rice land is under boro, the crop transplanted during December to February and harvested from April to June and is grown under irrigated conditions. The major impact of the new technology has been on this boro rice crop. The cropped area increased from 1.56 million acres in the late 1960s to about 3.89 million acres by 1984/85, facilitated by expansion of modern irrigation. Nearly four-fifths of the area under this crop is now under modern varieties. The traditional boro is grown on extremely low lying land which are unsuitable for growing any crop during the monsoon season owing to very high levels of flooding. Modern varieties of boro are grown on relatively high levels of land. Since boro and aus seasons are overlapping, MV boro competes with aus and jute whose cropped area has declined steadily in recent years and there is further possibility of MV boro substituting for aus crops. The exclusive focus on the alternative rice technologies in this chapter is dictated by the importance of rice and the great potential of the expansion of area under modern varieties.

Level and Fluctuation of Crop Yield

Bangladesh has little scope for increasing the supply of land (Chapter 2). For an individual farmer also, it is difficult to accumulate more land, even if he has the means to do so, because in the absence of adequate non-agricultural job opportunities, rural people tend to cling to their holding, and the market for land tends to be thin. Thus, for both the nation as well as the individual farmer, the only scope for increasing production is either through increasing the cropping intensity or increasing the crop yield. A new crop variety which has intrinsic capacity to produce more per unit of land would thus be widely accepted. It would give scope for increasing production from the limited land base, through the reallocation of land from the traditional to the new varieties.

Table 4.10 presents the findings of the two surveys on yield rates (output per unit of land) in the alternative crop varieties and compares them with the official statistics for the country as a whole. Since the yields vary considerably from year to year, the figures are presented as averages for a number of years which should give a relatively normal picture. The IFDC survey estimated the yield for three years from 1979-80 to 1981-82 and the BIDS/IFPRI survey for two years, 1981 and 1982. The survey estimates are very close to the official statistics, which supports the representativeness of the surveys. The modern varieties produce more output per unit of land than the traditional varieties in all three seasons; about 1.5 times higher during the aus season, three-fourths higher during the boro season, and about one-half higher during the aman season. On average, the yield of the new varieties is about 100 to 120 per cent higher than the traditional ones. The diffusion of the new technology thus contributes to a substantial increase in rice production from the limited land.

TABLE 4.1

ESTIMATES OF CROP YIELD FOR TRADITION AND MODERN VARIETIES OF RICE

(Tons of paddy per hectare)

Crops	Weight 1/	IFDC Survey Yearly average for 1980-82	BIDS/IFPRI Survey Yearly average for 1981 & 1982	Government Statistics Yearly average for 1982-85
Aus Season (early monsoon)				
TV	0.180	1.31	1.19	1.24
MV	0.037	3.15	3.23	3.25
Aman Season (monsoon)				
TV Broadcast	0.103	1.54	1.71	1.51
TV Transplanted	0.265	1.89	1.74	1.84
MV Trnasplanted	0.089	2.73	2.86	2.90
Boro Season (Dry winter)				
TV	0.026	1.96	2.49	2.30
MV	0.094	3.74	3.72	4.09
All Season 2/				
Traditional variety	0.574	1.65	1.60	1.61
Modern variety	0.220	3.23	3.29	3.47
Percent difference in MV and TV	-	96	106	116

1/ The area under the variety as a proportion of the total cropped area during 1985 for the country as a whole.

2/ Weighted averages.

A large majority of farmers in Bangladesh operate around or below the subsistence level and so they may respond not only to the average yield but also to the level of fluctuations in yield which makes investment in agricultural inputs a risky venture. Being risk averse, a farmer may be willing to sacrifice a substantial amount of expected income, as indicated by higher mean value of output in the modern varieties, in exchange for a low probability of falling below the subsistence level. The new crop varieties are less dependent on weather than traditional ones since the land has access to irrigation facilities, and during the monsoon season, they are generally grown on higher level land, which is less susceptible to floods. So the weather induced fluctuation in production is expected to be low for the new varieties. However, they may be more susceptible to pest attacks and the risk of crop damage on that account is expected to be higher. Also for rainfed MVs (e.g., aman MVs) water stress may reduce the yield more than in the case of a local variety.[3/]

The estimates of variation in crop yields at the farm level are not available from the IFDC survey. The estimates obtained from the plot (1981) and farm level (1982) data collected by the IFPRI/BIDS survey are presented in Table 4.2. The estimates of variation are expected to be lower at the farm than at the plot level as the fluctuation is reduced by summing over the data for a number of plots that the farm operates. In 1981, for which the estimates are obtained from the plot level data, the standard deviation of yield as a per cent of the arithmetic mean is found to vary between 32 to 79 per cent.[4/] But the magnitude of variation is, in general, lower for the modern varieties. For MV boro and aman it is 48 per cent, and for aus 32 per cent, compared to 69 per cent for traditional aman and 79 for

TABLE 4.2

VARIATION IN YIELD FOR TRADITIONAL AND MODERN VARIETIES OF RICE, 1981, 1982

Crop varieties	1981 (plot level data)				1982 (farm level data)			
	No. of plots	Mean yield (ton per ha)	Stand. deviation (ton/ha)	Coeff. of variation (percent)	No. of farms	Mean yield (ton per ha)	Stand. deviation (ton/ha)	Coeff. of variation (percent)
Aus Season:								
TV Broadcast	584	1.3	1.0	78	152	1.1	0.5	48
MV Transplanted	281	3.1	1.0	32	86	3.4	0.6	19
Aman Season:								
TV Broadcast	379	1.8	1.0	54	144	1.6	0.7	45
TV Transplanted	789	1.7	1.2	69	179	1.8	1.2	69
MV Transplanted	634	2.6	1.3	49	159	3.1	1.9	61
Boro Season:								
TV Transplanted	231	2.7	1.7	65	94	2.3	0.8	35
MV Transplanted	765	3.4	1.6	48	204	4.0	1.6	40

Source: BIDS/IFPRI Farm Survey.

traditional aus. For 1982 also, the magnitude of variation is lower in modern varieties for aus and aman seasons and is similar for the boro season. The boro crop was severely affected by hailstorm in April 1982 in two of the villages, where HYV boro is a major crop.

For 1982, information was also collected from farmers about the extent of crop damage from natural factors. During the year the aus crops were affected by draught in the villages in Kushtia and Jessore, the aman crops were affected by a flash flood in two villages in Comilla and the boro crops were affected by hailstorm in two villages in Dhaka and one village in Comilla. The farmer was asked to report the percentage by which the actual yield was lower than the expected yield given the application of inputs. The response is subjective but comparison of the figures for the traditional and modern varieties would indicate the direction of change. The findings also show a high degree of crop damage but it is lower for modern varieties compared to the traditional varieties of aus and aman (Table 4.3). For the boro season, however, the damage is reported to be lower for the traditional variety.

TABLE 4.3

FARMERS' PERCEPTION ABOUT THE EXTENT OF CROP DAMAGE, 1982

(In percent of expected yield)

Seasons	Traditional Variety		Modern Variety	
	Arithmetic mean	Standard error	Arithmetic mean	Standard error
Aus	45	2.2	32	2.6
Aman	38	2.0	33	2.1
Boro	21	2.6	28	2.0

Uses of Inputs

Family and Hired Labor

The estimates of labor input used per hectare of land in operations under different technologies, as obtained from the IFDC survey are presented in Table 4.4. The survey collected this information at the plot level for all seasons from Aman 1979 to boro 1982. The

TABLE 4.4

LABOR INPUT IN RICE CULTIVATION UNDER TRADITIONAL AND MODERN TECHNOLOGY, AVERAGES FOR 1980-82

(Days per hectare of cropped land)

Seasons & technology	Land preparation	Sowing & transplanting	Weeding & other cultural operations	Harvesting & threshing	All operations
Aus:					
Traditional	35	4	47	53	139
Modern	38	32	57	70	197
Aman:					
Traditional broadcast	28	2	37	61	128
Traditional transplanted	32	32	18	50	132
Modern transplanted	36	37	42	64	179
Boro:					
Traditional	32	41	61	69	203
Modern	39	43	65	71	218
All Seasons:					
Traditional	32	18	33	54	137
Modern	38	39	54	68	199
Increase in modern over traditional varieties (days)	6	21	21	14	62

Source: IFDC Survey.

figures in the table are averages for the three years estimates. The following features emerge from the table.

Farmers use more labor per unit of land in modern varieties compared to the traditional ones in all three seasons. The increase is about 42 per cent for the aus season, 36 per cent for the aman season, and seven per cent for the boro season. For all three seasons together, labor use per hectare is about 45 per cent higher under the modern varieties.[5/] The diffusion of the new technology will thus create more employment from the limited land base through reallocation of land from traditional to modern varieties.

The new varieties, however, economize on labor needed to produce a given amount of output. The amount of labor used to produce a ton of paddy was about 57 person days for the new varieties compared to 85 days for the traditional crops. The unit cost of production on account of labor would then be considerably less.

Only a small part of the increase in employment under the new varieties is due to harvesting and threshing of the additional yield. Employment mainly increases due to shifting from direct seeding to transplanting of seedlings. For all new varieties, seedlings are grown on a separate seed bed and then transplanted on the main fields. On the other hand, inadequate rain and moisture in the soil in the pre-monsoon season does not permit transplanting of seedlings for the aus crop and so the seeds are broadcast on the main field, which does not require much labor. For traditional aman varieties, the seedlings are transplanted but mostly in a random manner, while for new varieties, these are mostly transplanted in lines which requires more labor than random transplanting. The intensive intercultural operations such as weeding, irrigation, and fertilizer use also generate more demand for labor in the cultivation of the modern varieties. The use of labor in land preparation is only marginally higher. Table 4.5 shows that the modern varieties used 62 additional days of labor of which 34 per cent was generated during sowing and transplanting, 34 per cent during weeding and other intercultural operations, 22 per cent during harvesting and threshing and only 10 per cent during land preparation.

Transplanting and harvesting are busy agricultural operations when most of the farm households hire labor, although they may have surplus labor in the family during other times of the year. By raising labor requirements during these operations, the modern varieties would also increase the demand for hired labor. The IFDC survey did not collect information on the use of hired labor. The estimates obtained from the BIDS/IFPRI survey are presented in Table 4.14. Nearly two-fifths of the total labor used in rice cultivation came from hired workers and the proportion is almost the same under the traditional and the modern varieties. The new technology thus appears to be neutral with respect to the use of these two types of labor. During the boro and aus seasons, however, the modern varieties use proportionately more hired labor than family labor. The agricultural operations during these two seasons cover January to June period which are traditionally slack periods of agricultural activities. The diffusion of the new technology during these seasons would thus reduce the seasonality of underemployment particularly for the landless who provide hired labor. It will be noted from the table that the additional employment per unit of land generated by the modern

TABLE 4.5

USE OF HIRED LABOR UNDER TRADITIONAL AND MODERN VARIETIES OF RICE, 1982

Season & Variety	Hired labor (person days per hectare)	Family labor (person days per hectare)	Hired labor as percent of total labor
Aus Season:			
Traditional	40	99	29
Modern	82	115	42
Aman Season:			
Traditional broadcast	49	79	38
Traditional transplanted	54	78	41
Modern transplanted	74	105	41
Boro Season:			
Traditional	49	154	24
Modern	74	144	34
All Seasons:			
Traditional	49	88	36
Modern	75	124	38
Percent difference (modern over traditional)	53	41	2

varieties is proportionately more (53%) for hired labor than for family labor (41%). Thus, poor households who supply hired labor also benefit from technological progress. (See, also Chapter 7.)

Animal and Mechanical Power

In Bangladesh, bullocks and cows are widely used for performing heavy agricultural operations such as the ploughing and levelling land, transportation of harvests from the field to the yard of the homestead and threshing of the crop. The animals are used in pairs. The extent of use of animal power in the cultivation of different varieties of rice, as estimated by IFDC survey, is shown in Table 4.6. The figures are averages for 1979/80 to 1982/83 crop years for which the information was collected. For land preparation, the use of animal power is higher for transplanted varieties compared to

TABLE 4.6

USE OF ANIMAL AND MECHANICAL POWER UNDER TRADITIONAL AND MODERN TECHNOLOGY: AVERAGES FOR 1980-82

Season & technology	Animal Power (hours per pair per hectare)			Mechanical Power (hours/hectare)			
	Land preparation	Harvesting and threshing	Total	Land preparation	Irrigation	Threshing	Total
Aus Season:							
Traditional	282	59	341	nil	nil	14	14
Modern	304	64	368	nil	17	21	38
Aman Season:							
Traditional broadcast	220	89	309	nil	nil	19	19
Traditional transplanted	262	35	297	nil	1	21	22
Modern transplanted	284	59	343	nil	2	23	25
Boro Season:							
Traditional	252	89	341	nil	32	9	41
Modern	309	72	381	nil	75	22	97
All Seasons:							
Traditional	260	55	315	nil	2	18	20
Modern	298	65	363	nil	36	22	58
Percent difference (modern over traditional)	15	18	15	-	large	22	190

Source: Compiled from IFDC Survey.

the broadcasted ones but for harvesting and threshing no systematic pattern is observed. The average level of use under traditional crop varieties is about 315 hours per hectare for a pair of animals. On the basis of an eight hour working day, the employment for a pair of animals comes to about 40 days per hectare of land, which is less than one-third of the level of use of human labor (137 days).

The modern rice varieties generate more demand for animal power due to the practice of transplanting of seedlings and the transportation of additional harvest. The extent of increase is found at 15 per cent, about a third of the additional demand for human labor. The animal power used per ton of output is 105 pair/hours for the modern varieties, compared to 196 hours for traditional varieties.

In Bangladesh the market for animal labor is very thin partly because of the high seasonal pattern in the demand for their services. The BIDS/IFPRI survey collected information on cultivation expenses on account of hired animals during 1982 crop seasons. Only one-fourth of the farmers reported use of hired animals. The average level of use was equivalent to about 11 pair days for those hiring animals, and only three days for all farms. The practice of animal hiring was found more confined among the very small farmers, presumably because they cannot afford to invest on a pair of animals and bear the maintenance cost. Some large land owners, whose main occupation was non-agriculture, also hired animal power. Owing to the thinness of the market, most of the households who are engaged full time in farming have to keep at least a pair of draft animals, which remains substantially under-utilized. Thus, the animals are fixed costs and the cost per unit of output on this account can be reduced by increasing the rate of utilization. The diffusion of modern technology allows more intensive use of animals since an additional crop is grown on the same piece of land during the year.

In many parts of South Asia, diffusion of the new technology followed substitution of animal and human labor by machines. It is often mentioned as an important factor behind the negative distribution effect of the new technology although the impact of mechanization on labor use remains controversial.[6/] In Bangladesh mechanization of agricultural operations, except for irrigation, is rarely visible. In some parts of the country, a few farmers use small mechanical threshers (mostly in the Comilla, Noakhali, and Chittagong belt), and power tillers (mainly in Dhaka region in the cultivation of potato). The 1977 agricultural census noted that among 6.3 million farm holdings, only 35,000 used tractors and 12,000 used power tiller at sometime or other.[7/] Farmers reporting mechanical cultivation were only 0.66 per cent and the area cultivated was only 0.38 per cent.

The information on the use of mechanical power in alternative rice technologies, as estimated by the IFDC survey, is reported in Table 4.6. Mechanical power is used only for irrigation and threshing. For traditional varieties, the mechanical power was used only 20 hours per hectare, about three per cent of the level of use of animal power. Under moden varieties, the use is about three times more but most of the increase is due to power used for irrigation. For threshing, the level of use is only about one-fifth higher, and for land preparation mechanization is yet to be introduced even for the cultivation of the modern varieties.

Chemical Fertilizer and Manure

The use of chemical fertilizers is now widespread. The BIDS/IFPRI survey has found that nearly 87 per cent of the farmers used fertilizers, and in irrigated villages almost all farmers used it. Only in four out of 16 villages studied, was the diffusion limited to less than two-thirds of the farmers. Three of the villages are located in the coastal district of Khulna, which has saline soil and most of the land is single cropped with local transplanted aman. The other village is located on the Brahmaputra active flood plain, where most of the land is sown with deep water broadcast aman.

Many of the fertilizer using farmers, however, did not apply fertilizers on all plots. The application depends on the type of crop, and whether the plot has previously been treated with fertilizers. The farmers argue that once they apply fertilizer on a plot, for example to grow the high fertilizer-responsive MVs they will have to continue using fertilizer on the same plot even for growing a low fertilizer responsive local variety, otherwise yield would be less than normal. The IFDC survey found that during 1981/82, nearly 45 per cent of the land was not treated with fertilizers.

The findings of the two surveys on the extent of fertilizer use under alternative rice technologies are presented in Table 4.7. The figures indicate a clear dualism in fertilizer application. Less than one-fifth of the land under deep water aman and traditional boro are treated with fertilizer. These crops are grown on deep flooded land where local varieties are less fertilizer responsive and fertilizer use is less effective. Even on flood free land, only about a half of the plots are treated with fertilizers if they are sown with local varieties, but more than ninety per cent are treated if they are sown with modern varieties. The level of use on aus and boro season MVs are about six times higher compared to the substitute traditional variety, and on aman season MV, the level of use is about three times higher. On transplanted MV, the use of fertilizers has reached quite a high level -- over 280 kg of materials per hectare of land. The higher yield on modern varieties is thus achieved by substantially higher levels of use of chemical fertilizers per unit of land.

In order to increase soil fertility Bangladesh farmers also use manures and so a pertinent question is whether intensive fertilizer application in modern varieties has led to the substitution for the use of manures. The BIDS/IFPRI survey has found that nearly two-thirds of the farmers applied farm yard manure, while the IFDC survey has found that nearly one-third of the plots were treated with manure. The application of manure was more common in traditional varieties. The findings of the two surveys, however, do not agree on the magnitude of application of manure (Table 4.7). The IFDC surveyshows that the level of use is about 30 per cent lower under the modern varieties, while BIDS/IFPRI survey indicates that farmers used almost twice as much on modern varieties compared to the traditional ones (Table 4.7).

TABLE 4.7

USE OF CHEMICAL FERTILIZERS AND MANURE UNDER TRADITIONAL AND MODERN TECHNOLOGY, AVERAGES, 1980-82

Crops and Technology	Percent of plots treated (IFDC survey)		Level of use per hectare (IFDC survey)		Level of use per hectare (BIDS/IFPRI survey)	
	Ferti-lizer	Manure	Fertilizer (Kg of materials)	Manure (tons)	Fertilizer (Kg of materials)	Manure (Tk)
<u>Aus Season</u>:						
Traditional broadcast	45	61	47	4.46	47	158
Modern1/ boardcast	74	66	100	4.76		
Modern transplanted	98	29	282	1.50	238	218
<u>Aman Season</u>:						
Traditional broadcast	18	15	16	0.36	11	58
Traditional transplanted	54	24	54	0.62	45	10
Modern transplanted	84	9	169	0.43	208	23
<u>Boro Season</u>:						
Traditional transplanted	12	3	22	0.14	3	nil
Modern transplanted	96	34	288	1.54	322	219
<u>All Seasons</u>:						
Traditional	43	33	44	1.76	38	65
Modern	91	25	231	1.22	262	140

1/ According to the IFDC Survey, about one-fourth of the MV aus area was broadcast seeded. Information on this is not available for the country as a whole.

Irrigation and Pesticides

According to the IFDC survey, irrigation was rarely practiced in the cultivation of local aus and aman, but nearly two-thirds of the plots under traditional boro and about 90 per cent of the plots under modern boro were irrigated (Table 4.8). During the aman season, the modern varieties are grown basically under rainfed conditions. The intensity of use of irrigation, as measured by the average number of times of irrigation, is also the highest in the cultivation of modern varieties of boro.

TABLE 4.8

USE OF IRRIGATION AND PESTICIDES UNDER TRADITIONAL AND MODERN VARIETIES OF RICE, AVERAGES FOR 1980-82

Season & Technology	Per cent of plots irrigated	Mean number of times irrigated (average for plots)	Per cent of plots treated with pesticides	Average level of use (lbs) of pesticides per hectare
Aus Seasons:				
Traditional broadcast	nil	nil	3	*
Modern broad cast	3	*	9	0.64
Modern transplanted	61	5.4	19	1.33
Aman Season:				
Traditional broadcast	nil	nil	nil	nil
Traditional transplanted	5	0.1	*	*
Modern transplanted	14	0.8	17	0.65
Boro Season:				
Traditional	65	4.4	3	*
Modern	89	7.4	50	4.30

Source: IFDC Survey.

The market for irrigation is imperfect and the cost of irrigation per unit of land varies widely depending on the source of irrigation and on the type of ownership of irrigation equipment.

Irrigation was provided free of cost to farmers in two of the 16 villages under BIDS/IFPRI survey, as they happened to be under the Ganges-Kobtak project area implemented by the Bangladesh Water Development Board. Two of the villages used low lift pumps, rented to farmers' cooperatives by the Bangladesh Agricultural Development Corporation. In these villages the water charge paid by farmers varied from Tk 560 to Tk 800 per hectare. In three villages where irrigation has been practiced since the late sixties under the auspices of Comilla type cooperatives, a combination of low lift pumps, shallow tubewells, and deep tubewells have been used and the water charge came to about Tk 1600 per hectare. In another three villages, irrigation was recently introduced by private owners of shallow tubewells who sold water to owners of adjoining plots at a charge varying from Tk 3500 to Tk 4500 per hectare. Thus the water charge observed at the farm level in no way measures the level of irrigation input. The average water charge in the cultivation of modern varieties of boro comes to about Tk 1700 per hectare for the sample as a whole, about one-eighth of the gross value of output.

Pestcides are rarely used on local varieties but some use in MVs was noted (Table 4.8). the increase in cost on this account is only marginal. The highest level of use is on modern varieties grown during the aus and boro season. For these crops the cost on account of pesticides was reported at Tk 220 per hectare, only 1.5 per cent of the gross value of output.

Seeds

The amount of seed used per unit of land depends on whether the seed is broadcast or whether a separate seedbed is prepared to grow seedlings which are then transplanted on the main field. According to the Bangladesh Bureau of Statistics, the normal seed requirement for broadcast varieties is 80 to 92 kg per hectare, while for transplanted varieties, it is about 20-25 kg.[8/] The value of seedlings is, however, higher than the cost of seeds used, because of the adding of the cost of land and labor used in seedbed preparation. For traditional varieties, seeds are generally kept from the harvest, but for modern varieties a significant proportion of the seed may be purchased from markets or government centers (particularly if the seed is new in the area), and hence the cost may be higher.

The cost per unit of land was lower in transplanted varieties compared to the broadcast ones (Table 4.9).

Among transplanted crops, the seed-cost per unit of land is found to be higher for modern varieties by about 16 per cent for aman season and nearly 55 per cent for boro season. For all seasons together, the seed cost per hectare is almost the same, but because of higher yield, the cost per unit of output for MV is only about one-half of that for traditional varieties (Table 4.9).

TABLE 4.9

THE COST ON ACCOUNT OF SEEDS FOR TRADITIONAL AND MODERN VARIETIES OF RICE, 1982

Season & Technology	Cost per hectare	
	Taka	Cost as a per cent of output
Aus Season:		
Traditional	452	9.8
Modern	320	2.6
Aman Season:		
Traditional broadcast	433	6.5
Traditional transplanted	334	4.9
Modern transplanted	390	3.5
Boro Season:		
Traditional	264	2.7
Modern	408	2.8
All Seasons:		
Traditional	386	6.3
Modern	386	3.0

Source: BIDS/IFPRI Survey.

Unit Costs and profitability of Cultivation

This section estimates the effect of the changes in input-output relationships described above on the costs and profitability of rice cultivation. First, estimates are derived by applying national level prices on the average input-coefficients for the 1980-82 periods (IFDC Survey) except for seed for which the information is only available for 1982. In order to dissociate the effect of climatic factors, the average crop yield for the last three years (1982-85), as reported in official statistics, has been used for estimating the gross returns.

Then, BIDS/IFPRI survey data are used to estimate profits for different groups of farms at the farm specific prices of inputs and output.

National level infrmation on farm level prices of inputs is not available, except for wage rates. The IFDC survey estimated that for urea, which accounts for over 70 per cent of the chemical fertilizers consumed in the country, the farm level prices were higher than the officially fixed prices in the range of 2.8 to 10.7 per cent for the eight crop seasons for which the information was collected. In calculating fertilizer costs, we have assumed that farmers pay about 10 per cent higher than the official prices set by the government, the variable for which time series information is available. As mentioned earlier, the unit cost of irrigation varies across locations depending on the source of water. In order to standardize the cost, we have taken the weighted average water charges paid by irrigators to private owners of shallow tubwells, as found in a recent survey by Quasem et al,[9/] and using this as the standard, estimated the cost for other crops by appling the IFDC survey information on the mean number of times the crop is irrigated. For other time periods, the irrigation cost has been adjusted by the price index of diesel. The farm level price of manure is available from IFDC survey for 1980. Similarly, the cost of seed is available only for 1982 (Table 4.9). For other time periods, the manure and seed costs are derived by adjusting them by the price index of rice. It is reported by a 1980 survey of six villages in Comilla and Noakhali that the hiring charges for a pair of animals, along with the worker who operates them, is about 2.5 times higher than the wage rate paid to hired workers.[10/] On this basis, the cost of a pair of animals is assumed at 1.5 times the wage rate since the hired worker is included in the input of human labor. The family labor input is imputed by the wage rate of the hired labor.

The cost of mechanical power could not be included due to non-availability of information on rental charges for machines. In any case nearly two-thirds of the mechanical power input are on account of irrigation, the costs of which are included in irrigation charges. The unaccounted input is only about 20 hours per hectare (in threshing) the cost of which would be very low as a proportion of the value of output.

Land is an important fixed asset, but the opportunity cost of the investment in land has not been included in the cost of production. The justification is that unlike other fixed assets, land does not depreciate in value, particularly in contries where land is scarce. According to the Bangladesh Bureau of Statistics during the 1973-84 period, the price index of the single cropped unirrigated land (the type of land not affected by productivity raising investment) has increased at an annual rate of about 17.6 per cent compared to the rate of inflation of 11 per cent during this period, and 14 per cent rate of interest currently paid by the commercial banks on fixed deposits. Thus a person investing on land can get a higher return than the interest on the money deposited in banks, even if he keeps the land fallow. In this sense, the use of the land for cultivation does not involve any real cost to its owners. For tenants, however, the rent paid to the landowner is a real cost and has to be included in estimating their profits.

Another cost element which has not been included in the estimates in the rate of interest paid on working capital borrowed from outside. In Bangladesh farmers borrow for agricultural purposes from various institutional sources, which charge in general 16 per cent rate of interest per annum. Borrowings from informal sources for extremely short periods are widespread. These loans bear high rates of interest (10 per cent per month is common) and as such may not be used for financing production expenses. Also, the information on credit is available at the household level and it is dificult to apportion it to various crops. The IFPRI/BIDS survey found that the sample farmers borrowed on average Tk 370 per ha of cropped land during 1982 from institutional sources, which comprised only one-fourth of the total borrowing. The cost has not been included because of the problem of apportioning it to various crops.

The choice of an appropriate price for output is a problem. Here we have used the growers' price of paddy as reported by the Bangladesh Bureau of Statistics. The government also declares a procurement price for paddy in advance of the harvest at which the farmers can sell their produce at government operated purchasing centers. While it is estimated that nearly 40 per cent of the rice is currently marketed, the average procurement of the government over the last five years (1980-85) was only about two per cent of the domestic production. The use of growers' price thus appears more appropriate. Another problem is the quality differences for different varieties of rice. The grain of modern varieties of rice produced during the aus and boro seasons is coarse and fetches the lowest price in the market. Among traditional varieties aus and boro are coarse while aman grains are generally of superior quality and fetch the highest prices. Information provided by the Department of Agricultural Marketing shows that the average price of fine quality aman rice for the 1980-84 period was about 22 per cent higher than the price of IRRI rice.[11/] For the present calculation, we have applied the reported average growers' prices for traditional varieties of aus and boro and modern varieties of aman, and assumed prices to be 10 per cent higher for traditional aman and 10 per cent lower for modern varieties of aus and boro.

Estimates of costs and returns have been made at the price level for 1984/85, the most recent year for which the price information is available. The relative input-output prices have, however, undergone considerable changes over the last decade partly because of the government policy of gradual withdrawl of subsidies from the modern inputs such as fertilizers and irrigation, which are used more in the cultivation of modern varieties. So, some of the profitability gains of the new technology may have been eroded by such price changes. In order to see the effect of price changes on protifitability, we have also estimated costs and profits at 1975/76 price levels.

The estimates of costs and profits at 1984/85 level of prices are presented in Table 4.10. The "cash cost" includes the cost on account of seed, fertilizer, manure, irrigation, pesticides, and hired labor while the "total cost" also includes the imputed value of family and animal labor. Small farmers and tenants who have surplus family labor and low opportunity cost of employing it elsewhere, may give more weight to cash costs in making production decisions than to total cost, which is a more relevant variable for the large farmers who have high opportunity cost of family labor. The cash cost per unit

TABLE 4.10

COST OF PRODUCTION AND PROFITS UNDER TRADITIONAL AND MODERN VARIETIES, AT 1984-85 NATIONAL LEVEL PRICES

Season and Technology	Cash Costs		Total Costs		Estimated Profit	
	Tk per hectare	Tk per ton	Tk per hectare	Tk per ton	Tk per hectare	As a per cent of costs
Aus Season:						
Traditional	1818	1466	6234	5027	-86	-1
Modern	5239	1612	10248	3153	4256	42
Aman Season:						
Traditional broadcast	1820	1205	5585	3699	2645	47
Traditional transplanted	2003	1089	5678	3086	4357	77
Modern transplanted	3473	1198	8008	2761	6368	80
Boro Season:						
Traditional	3345	1454	9055	3937	2347	26
Modern	6936	1696	12686	3102	5565	44
All Seasons:						
Traditional	1974	1226	5990	3720	2564	43
Modern	5241	1513	10373	2993	5671	55
Percent difference (modern over traditional)	166	23	73	-20	121	12

of land also shows the working capital requirement and the small farmer may be in a more disadvantaged position to supply it than the large farmer, who would have higher amount of surplus (production over family consumption) and better access to financial institutions. In the cultivation of traditional varieties, the cash cost of production per unit of land is almost similar in the aus and aman season, but about three-fourths higher in the boro season, due to the requirement of irrigation. Per unit of output, however, the cost is the lowest for the aman season crops. In transplanted aman, the cost is about one-fourth lower than the aus (high land) or the boro (low land) varieties.

In the cultivation of MV, the cash cost per unit of land is about 1.7 times higher than the traditional varieties - 1.9 times for the aus season, 1.1 times for the boro season, and nearly three-fourths for the aman season. The modern varieties have higher yields, but per unit of output the cash cost is also higher in the cultivation of modern varieties. For all three seasons, the weighted average difference is about 23 per cent. The absolute cash cost on account of purchased inputs in Tk 1513 per ton of paddy for modern varieties and Tk 1226 for traditional varieties.

A different conclusion is reached if total cost of production is considered. The cost per unit of land is higher by about three-fourths in the cultivation of modern varieties compared to the traditional ones, but the cost per unit of output is lower by about one-fifth. The absolute cost per ton of paddy is Tk 3720 (US $ 124) for traditional varieties and Tk 3000 (US $ 100) for modern varieties. Compared to traditional aus, the main substitute crop which has the highest unit cost of production (US $ 168 per ton), the cost of cultivation of modern varieties is lower by about 40 per cent.

Since land is scarce, the farmer would be interested in maximizing the net return per unit of land. It is found that at the assumed average prices the profit (Gross return minus total cost) is negative in the cultivation of traditional aus vareity[12/] and is substantially lower for all other traditional varieties compared to the MVs. For all seasons, the difference in net return per unit of land is Tk 3.1 thousand per hectare, about 1.2 times higher in the cultivation of MVs than in TVs. The subsistence farmers may be interested in maximizing the net return to the family (Gross returns minus cost of purchased inputs). The new technology gives better return in this respect also. The return to family inputs is estimated at Tk 10.8 thousand per hectare for modern varieties compared to Tk 6.6 thousand for the traditional ones, an increase of about 64 per cent. The family income per day of labor is estimated at Tk 87 for modern varieties compared to Tk 75 for local varieties. The wage rate of agricultural labor prevailing in 1984/85 for the country as a whole was Tk 24.

Households who consider farming as an investment alternative would base their decisions on the rate of return on capital. The estimates of total costs show that the new technology gives scope for investment more capital on the fixed amount of land. The rate of profit, measured as a per cent of total cost is also found higher for the MVs, particularly, during the aus and boro seasons. For all three seasons, the rate of profit is estimated at 55 per cent for the new varieties compared to 43 per cent for the traditional ones.

Whether the farmers would consider the rate of profit as adequate for maintaining a reasonable level of living is a separate issue. Comparison of the rate of profit in farming with that in non-agricultural activities is not justified because accumulation of capital in farming is constrained by the amount of land owned, while in non-agriculture profits can be reinvested for further accumulation. In Bangladesh only about five per cent of the households operate farms over three hectare sizes. If a three hectare farm grows one traditional and one modern variety on the land during a year, it would have a profit of about Tk 24.7 thousand, which for a six member household gives a per capita income of Tk 4110. For 1984/85 the per capita income for the nation as a whole was estimated at Tk 3990, and the poverty level income at Tk 3096.[13/] Thus, even at this high rate of profit, farming alone does not guarantee a decent level of living for a three hectare farm family.

The impact of the changes in agricultural prices over the last decade on the cost and profitability in rice cultivation is shown in Table 4.11. Owing to the gradual withdrawal of subsidies, input prices have increased faster than output prices. The cost of cultivation in real terms increased by about one-third over the last decade and the rate of increase was faster for modern varieties since they are more fertilizer and water intensive. The rate of profit over the investment in working capital has declined from about 55 per cent in 1975/76 to 48 per cent by 1984/85; the rate of decline has been faster for modern varieties from about 77 per cent to 55 per cent over this period. The profit per unit of the scarce factor, land has also declined, particularly for the aus and boro season crops. But still the absolute level of profit in the cultivation of the MVs remains at a much higher level compared to the traditional varieties. In spite of the declining profits in individual crop varieties, the farmers have increased the level of profits per unit of land for all crops taken together, trhough reallocation of land from low to high

TABLE 4.11

THE EFFECT OF CHANGES IN PRICES ON COSTS OF PRODUCTION AND PROFITS, 1975/76 TO 1984/85

Season and Technology	Cost of Production			Profits		
	1975/76 (Tk/ha)	1984/85[a/] (Tk/ha)	Percent change	1975/76 (Tk/ha)	1984/85[a/] (Tk/ha)	Percent change
Aus Season:						
Traditional	2292	2726	19	101	-38	large negative
Modern	3463	4481	29	2181	1861	-15
Aman Season:						
Traditional broadcast	2053	2442	19	1149	1157	1
Traditional transplanted	2070	2483	20	1835	1905	-4
Modern transplanted	2826	3502	24	2769	2785	1
Boro Season:						
Traditional	3103	3960	28	1334	1026	-23
Modern	4122	5547	35	2982	2433	-18
All Seasons:						
Traditional	2198	2619	19	1079	1121	4
Modern	3517	4536	29	2710	2480	-8
Total	2384	3150	32	1309	1498	14

a/ Estimated at 1984/85 prices of inputs and output and then converted at 1975/76 constant prices by using the consumer price index for 1975/76 and 1984/85.

b/ Weighted averages, using the share of crop variety of the total cropped area under rice for the country.

profit crops. The share of the modern varieties in the total sown area under rice has doubled from about 14 per cent in 1975/76 to 28 per cent by 1984/85. The productivity growth as a result of this reallocation of land has ensured farmers about 14 per cent higher levels of profits, in spite of the adverse movement in the relative input-output prices.

The government controls the supply of fertilizer and irrigation, and the operation involves a considerable amount of subsidy. Since these inputs are consumed more in the cultivation of MVs, a pertinent question is what would happen to the difference in costs and profits if the subsidies are fully withdrawn. As mentioned earlier, through a number of consecutive price increases, the fertilizer subsidies had been withdrawn by 1985. The fertilizer price used in the calculation (US $ 167 per ton of materials) is close to the world prices. The cost of irrigation would, however, increase if subsidies are withdrawn. The Master Plan organization estimated that for 1984 the annualized capital cost plus the operation and maintenance for irrigation would come to Tk 4250 per hectare for deep tubewells, and Tk 3784 for large scale irrigation projects (at economic prices).[14/] In the cost calculation we assumed a water rate of Tk 3088 per hectare. Thus, if the subsidies are withdrawn, the irrigation charge to farmers may increase by about 37 per cent.[15/] At this price the total cost of production would be Tk 3168 per ton of paddy for MVs, compared to Tk 3738 for traditional varieties, still about 15 per cent lower. The net profit would be Tk 5061 per hectare for MVs compared to Tk 2534 for traditional varieties.

The estimates of costs and profits at farm specific prices, input use and yield rates obtained from the IFPRI/BIDS survey are shown in Table 4.12. For estimating total costs family labor was imputed at the wage rate paid by the household to hired labor. For households who did not have labor, the average wage rate for the village was used to impute cost. Costs on account of animal labor supplied by the family could not be included, as the survey did not collect information on this variable. Seeds, both household supplied and purchased, are included in cash costs. The estimates show substantially higher costs of production in the cultivation of MVs compared to local varieties, but the superiority of MVs with reard to profits and family income per unit of land is clearly demonstrated. Cultivation of modern varieties yielded Tk 3877 additional profits per hectare of land, and Tk 4531 additional return to family labor and animals. The net income per day of family labor is estimated at Tk 53 for local varieties and Tk 74 for modern varieties, while the hired labor was paid an average wage of Tk 19.5.

Table 4.13 shows the estimates of profits for different size and tenurial groups of farms. For modern varieties profits are higher on larger farms, but for traditional varieties no systematic pattern is found. The tenants pay 50 per cent of the gross produce as rent for the sharecropped land. After deduction of the rent the profit turns out to be very small on the sharecropped land, but the level is higher in modern varieties than in local varieties. The net return to tenants' family labor and draft animal was Tk 1848 per ha in local varieties and Tk 2816 in modern varieties, or, about 52 per cent higher. The net returns per day of tenants' labor is estimated at

TABLE 4.12

COSTS AND PROFITABILITY AT FARM SPECIFIC PRICES, PRODUCTION AND INPUT USE, 1982

(Figures in Tk/hectare)

Crop varieties	Gross value of output	Cash costs of production	Total costs of production	Returns to family labor	'Profits'
Aus Season:					
Traditional	3,996	1,304	2,450	2,692	1,546
Modern	13,326	3,411	4,770	9,915	8,556
Aman Season:					
Traditional broadcast	6,412	1,405	2,527	5,007	3,886
Traditional transplanted	6,760	1,833	2,762	4,927	3,998
Modern transplanted	11,990	2,947	4,389	9,043	7,601
Boro Season:					
Traditional	9,386	1,324	2,371	8,062	7,015
Modern	14,245	5,194	7,274	9,051	6,971
All Seasons:					
Traditional	6,203	1,546	2,594	4,657	3,609
Modern	13,165	3,997	5,679	9,188	7,486
Rice (All varieties)			4,187	6,687	5,145

TABLE 4.13

PROFITS AND FAMILY INCOME AT SPECITIC PRICES FOR DIFFERENT SIZE AND TENURIAL GROUPS

Group of Farmers	Profits (Tk/ha)			Return to Family Labor and Animals		
	Traditional variety	Modern variety	Percent diffe-rence	Traditional variety	Modern variety	Percent diffe-rence
Land Ownership Groups						
Small (less than 2.0 acre)	3,347	6,469	93	4,169	9,255	100
Medium (2.0 to 5.0 acres)	3,801	6,592	73	4,859	8,272	70
Large (5.0 and over)	3,577	9,102	155	4,414	10,255	132
Tenurial groups						
Owner-cultivator	3,265	7,563	132	4,439	9,095	105
Owner-cum-tenants	2,850	5,061	78	3,900	6,988	79
owned land	3,974	7,346	85	5,024	9,272	85
rented land	798	889	12	1,848	2,816	52

Source: IFPRI/BIDS Survey

Tk 21 for local varieties and Tk 23 for modern varieties, only marginally higher than the average rate of Tk 19.5 for the entire sample. Thus, the rented land benefits tenant farmers mainly through reducing the underutilization of family labor and animals.

Comparison of relative gains (compared to local varieties) from the adoption of the modern varieties across different groups show that owner farms gain more than the tenants, and large farmers gain more than the small and the medium ones. But the gains of the small farmers are also higher than the medium ones. Thus, the gains are not systematically positively related with the size of landownership of the household.

Conclusions

The modern varieties of rice have opened up an opportunity of substantially increasing production from a given amount of land. The yield of modern varieties on the farmer's field is twice that of the traditional varieties. The fluctuations in yield caused by natural factors are also lower for the modern varieties, indicating that the new technology has reduced the risk of cultivation. Farmers use about 45 per cent more labor per unit of land in the cultivation of modern varieties compared to the traditional ones. But per unit of output, use of labor is about one-third lower, and use of draft power is about 45 per cent lower for the modern varieties. The new crops, however, use substantially more fertilizer, irrigation, and pesticides per unit of output. The cash costs of production per unit of land are about 1.7 times higher, and per ton of output are about one-fifth higher for the modern varieties. The total cost of production per ton of paddy is estimated (at 1984/85 prices) at US $ 100 for modern varieties compared to US $ 124 for the traditional varieties. The profit per hectare of land is estimated at Tk 5.67 thousand for modern varieties, which is about 2.2 times compared to that for traditional varieties (Tk 2.56 thousand). The rate of profit over the cost of production is 55 per cent for the modern varieties compared to 43 per cent for the traditioal varieties. The gradual withdrawal of subsidies from fertilizer and irrigation over the last decade has reduced the profitability gap, but farmers have increased the profits from the cultivation of rice through reallocation of land from traditional to the modern varieties, since the absolute level of profit for the latter crops is still higher. Even if subsidies are fully withdrawn, the profit per unit of land would still be about twice as much in the cultivation of the new varieties compared to the traditional ones, and the unit cost of output would be about 15 per cent lower.

Chapter 4 Notes

1. For details on the implications of the nature of the change of the technology on its adoption by different socio-economic groups, see Andrew Pears, Seeds of Plenty - and Seeds of Want.

2. See Noel P. Magor, Potential in Rainfed Transplanted Rice Production in North-East Bangladesh, Bangladesh Rice Research Institute, Dhaka 1984.

3. Magor found that a substantial reduction in rainfall in 1981 over 1980 reduced the yield of modern aman varieties by 30 per cent while the reduction in yield of local varieties was 25 per cent. Ibid, p. 32.

4. A cropping system research in an Upazilla in Sylhet district found that for the aman crop 62 per cent of the yield variation in 1981 was attributable to transplanting date and water stress. The yield loss per water stress day was estimated at 75 kg/ha for MVs compared to 48 kg/ha for a local variety. Ibid. p. 2.

5. Ahmed estimated from a survey of 459 farms in three villages during 1975/76 that, compared to traditional varieties, the labor input per unit of land in the cultivation of modern varieties was 28 per cent higher during the aman season and 50 per cent higher during the boro season. Iftekhar Ahmed, "Technological Change and labor Utilization in Rice Cultivation: Bangladesh, The Bangladesh Development Studies, 6 (No. 3, 1978); 359-366.

6. For a recent survey of he literature on the labor deplacing effects of agricultural mechanization, see Michale Lipton, Modern Varieties, International Agricultural Research, and the Poor, CGIAR Study Paper No. 2, Washington, D.C. (World Bank, 1985): pp. 64-70.

7. Bangladesh Bureau of Statistics, The Statistical Yearbook of Bangladesh 1984-85, Ministry of Planning, Dhaka, 1985, p. 332.

8. Bangladesh Bureau of Statistics, The Statistical Yearbook of Bangladesh 1984-85, Ministry of Planning, Dhaka, 1985, p. 332.

9. Reported in S.R. Osmani and M.A. Quasem, Pricing and Subsidy Policies for Bangladesh Agriculture, op. cit., p. 166.

10. Bangladesh Unnayan Parishad, A Socio-Economic Evaluation of the Chandpur II Irrigation Project, a report prepared for the World Bank, Dhaka, 1982. Appendix Table A.6.1, p. 6-25.

11. Department of Agricultural Marketing, Wholesale Prices of Agricultural and Animal Products in Bangladesh, 1972-85, Government of Bangladesh, Dhaka, 1986.

12. The traditional aus is a very low yield crop, and in areas in which it is a major crop, the wage rate is also found to be very low. For the BIDS/IFPRI sample, the wage rate paid for cultivation of local aus is estimated at Tk 12.92 per day compared to Tk 23.88 in the cultivation of MV boro. If the cost of labor is evaluated at the crop specific wage rate, the net profit in the cultivation of local aus would also be positive.

13. The Bangladesh Bureau of Statistics has recently made estimates of the poverty line income for 1981/82 from the returns of the national household expenditure survey. This figure is based on this estimate, adjusted for the changes in the cost of living index. For details see chapter 8 below.

14. Cited in Mahabub Hossain, "Fertilizer Consumption, Pricing and Foodgrain Production in Bangladesh", op. cit., p. 224.

15. The actual subsidy on irrgation may in fact be higher than this proportion. A large part of irrigation subsidy is consumed by owners of irrigation machines, who charge substantially higher prices to water users than the capital and operation costs. For 1982/83 the mark-up (water charge paid by irrigators over the cost) is estimated at 62 per cent for deep tubewells, 34 percent for power pumps, and 10 per cent for shallow tubewells. See S.R. Osmani and M.A. Quasem, <u>Pricing and Subsidy Policies for Bangladesh Agriculture</u>, op. cit., p. 166.

5: PRODUCTIVITY AND EFFICIENCY OF RESOURCE USE

The effect of the new technology on the productivity of land and labor and the efficiency in their utilization is assessed in this chapter. Land is the most scarce input in Bangladesh. It could be argued that the development of irrigation, which is the most critical input in the modern technology package, could raise the effective supply of land by creating conditions of growth of an extra crop on the fallow land during the dry winter season.[1/] In order to see whether and to what extent this has happened in Bangladesh, the first section compares the pattern and the intensity of land use in the technologically developed and underdeveloped areas as well as on the irrigated and unirrigated land. This is followed by an analysis of the production function for estimating the factor shares and the marginal productivity of land and labor for the traditional and the modern technology. The final section applies a profit function model to study relative economic efficiency of the adopters of the new technology compared to the farmers still growing only traditional crops.[2/] The analysis in this and the following chapters are based on disaggregated farm and plot level data collected by BIDS/IFPRI Survey.

Intensity of Land Use and Cropping Patterns

The effect of technological change on the pattern and intensity of land use can be seen from Table 5.1 and 5.2. The tables are based on information collected at the plot level on the use of the land during the three crop seasons in 1981 in the 16 villages covered by the BIDS/IFPRI Survey. The survey enumerated 5255 plots belonging to 639 sample households (8.2 plots per household). About 68 per cent

TABLE 5.1

PATTERN AND INTENSITY OF USE OF IRRIGATED AND UNIRRIGATED LAND, 1981

Season and Crops	Irrigated Land		Unirrigated Land	
	Sown Area (ha.)	% of cultivated land	Sown Area (ha.)	% of cultivated land
Aus Season:	28.68	21.0	80.24	30.4
Local aus	5.19	3.8	60.19	22.8
MV aus	22.03	16.1	1.71	0.6
Jute	1.45	1.1	18.34	7.0
Aman Season:	92.21	67.6	166.84	63.2
Local B. aman	7.38	5.4	48.51	18.4
Local T. aman	33.91	24.9	96.06	36.4
MV aman	50.79	37.2	6.37	2.4
Sugarcane	0.14	0.1	15.89	6.0
Boro Season:	104.33	75.4	101.87	38.6
Local boro	5.97	4.4	17.98	6.8
MV boro	79.61	58.3	5.48	2.1
Wheat	3.81	2.8	8.57	3.3
Pulses	4.06	3.0	47.37	18.0
Oilseeds	8.02	5.9	8.64	3.3
Vegetables	2.17	1.6	6.15	2.3
Species	0.61	0.5	5.82	2.2
Others	-	-	1.66	0.6
Total Cropped Land	**224.22**	**165.0**	**348.76**	**132.2**
Total cultivated land	136.48	100.0	263.87	100.0

TABLE 5.2

PATTERN AND INTENSITY OF LAND USE IN TECHNOLOGICALLY DEVELOPED AND UNDERDEVELOPED VILLAGES, 1981

Seasons and Crops	Developed Villages		Underdeveloped Villages		All Villages	
	Cropped land (ha.)	Percent of cultivated land	Cropped land (ha.)	Percent of cultivated land	Cropped land (ha.)	Percent of total cultivated land
Aus Season:	40.80	21.4	68.12	32.5	108.92	27.2
Local aus	11.82	6.2	53.56	25.6	65.38	16.3
HYV aus	20.92	11.0	2.82	1.3	23.74	5.9
Jute	8.06	4.2	11.73	5.6	19.80	5.0
Aman Season:	126.64	66.4	132.41	63.2	259.06	64.7
Local B. aman	23.72	12.4	32.17	15.3	55.89	14.0
Local T. aman	44.67	23.4	85.31	40.7	129.98	32.5
HYV aman	54.64	28.7	2.52	1.2	57.12	14.3
Sugarcane	3.62	1.9	12.41	5.9	16.03	4.0
Boro Season:	118.80	62.3	87.20	41.6	206.00	51.6
Local boro	16.08	8.4	7.87	3.8	23.95	6.0
HYV boro	74.60	39.1	10.49	5.0	85.09	21.3
Wheat	3.47	1.3	8.92	4.3	12.39	3.1
Pulses	6.37	3.5	44.71	21.3	51.44	12.8
Oilseeds	10.65	5.6	6.01	2.9	16.66	4.2
Vegetables	3.85	2.0	4.47	2.1	8.32	2.1
Spices	2.79	1.5	3.64	1.7	6.43	1.6
Others	0.64	0.3	1.10	0.5	1.74	0.4
Total sown area	286.25	150.1	287.73	137.2	573.98	143.4
Total cultivated area	190.67	100.0	209.68	100.0	400.35	100.0

of the plots were owner operated, 13 per cent rented out to others mostly under sharecropping arrangements, six per cent under orchards or bamboo bushes, two per cent under ponds and the reamining 11 per cent under homesteads. Some of the land owners did not know about the use of the rented-out plots operated by the tenants, and so complete information could not be obtained for this type of land. It was also found during the survey that the practice of renting out land for only one season was widely prevalent; the plot rented out for cultivation during the boro season was resumed by some land owners for self-cultivation during the aman season. In order to avoid problems caused by these complications the information presented here is based on the data obtained for the owner operated plots only. The following main points can be noted from the information.

Irrigation has a significant impact on increasing the effective supply of land during the dry winter season (boro). Only two-fifths of the unirrigated land are croped during the boro season, but with irrigation the intensity of use increases to about three-fourths during this season (Table 5.1). Part of the increase is at the expense of the overlapping aus season crops, which are grown on 30 per cent of the unirrigated land but on 21 per cent of the irrigated land. MV boro, for example, competes with land for local aus and jute. It is harvested beginning of May when it is too late for broadcasting aus and jute seeds on the same land. Nearly one-third of the land remains fallow over these two seasons when the land is unirrigated, but the proportion is reduced to only 14 per cent with access to irrigation facilities. Irrigation, however, does not change the pattern of utilization of land during the aman season, when crops are grown basically under rainfed conditions. Two-thirds of the cultivated land are cropped during the aman season, one-third remains fallow presumably due to excessive flooding of land. Provision of irrigation facilities does not change the proportion of aman season fallow land much.

The adoption of the MVs is facilitated mostly by irrigation. Only six per cent of the unirrigated land was used to grow MVs during the three seasons. For irrigated land the proportion was about 112 per cent, which also indicates that some of the land was used to grow two HYV rice crops during the same year. Out of 86 per cent of the irrigated land cropped during the aus and boro seasons, 75 per cent was used for growing MV rice. Only during the aman season was a large proportion of the irrigated land used to grow local paddy.

Irrigation has an adverse impact on diversification of crops. Except rice and oilseeds all other crops are grown less on irrigated land compared to unirrigated land. Following the development of irrigation facilities, rice varieties replace not only the low yielding pulses but also the major cash crops, jute and sugarcane. These three crops are grown on about one-third of the unirrigated land, but on only about four per cent of the irrigated land.

Owing to the large scale replacement of the non-cereal crops by rice, the impact of irrigation on intensity of land use is much less pronounced that the impact on cereal cultivation. The sown area under cereals is about 87 per cent of the cultivated land for the unirrigated plots; with irrigation the proportion rises to about 153 per cent -- an increase of over 66 per cent. The total cropping intensity is however estimated at 165 per cent for the irrigated land compared to 132 per cent on unirrigated land -- an increase of only 33 per cent.

Table 5.2 compares the pattern of land use in sample villages classified into two equal size groups according to the scale of the diffusion of new agricultural technology (see Chapter 2). MV rice is grown on about four-fifths of the cultivated land in the developed villages compared to only on eight per cent of the land in underdeveloped villages. For the aus and boro seasons together, the proportion of cultivated land under MV rice in both groups of villages is almost similar to the proportion of area irrigated, indicating an almost unique relationship between irrigation and adoption of MV seeds. This supports the findings of strong complementarity between the two inputs reported in Chapter 3 on the basis of regression analysis of district level cross-section data. The intensity of land use is estimated at about 150 per cent for the technologically developed villages compared to 137 per cent for the underdeveloped villages. Thus a 40 per cent increase in irrigation leads to a 13 per cent increase in effective supply of land, indicating an elasticity of suply of land to irrigation of 0.33.

Productivity of Land and Labor

A technique frequently used to analyze productivity and efficiency of resource use is the Cobb-Douglas production function. The technical coefficients of production estimated from the function are used in various policy applications. The input coefficients of the function represent production elasticities of the inputs. The sum of the elasticities is used as an indicator of the degree of returns to scale in production. This section uses the farm level cross-section data for 1982 to estimate production functions for the traditional and modern varieties of rice in order to study the effect of the new technology on the productivity of land and labor.

The production function for each crop was fitted in the following form:

$$(1)\quad LnY_i = Ln\beta_0 + (\beta_1 + \beta_2)\, LnA_i + \beta_2 Ln\,(N/A)_i + \sum_{j=1}^{15} \lambda_{ij} V_{ij} + V_i D_i$$

where Y_i is the value added (Tk) for the ith farm in the cultivation of the crop, as measured by the gross value of output net of the costs on account of seeds, manure, fertilizer, pesticides and irrigation. The cost of animal labor could not be included owing to non-availability of data. A, is the amount of land sown under the crop, and N is the total number of labor days (hired plus family labor) used during the production period (from land preparation to threshing). A number of crops were affected by droughts, floods and hailstorms during the year and the effect was <u>not</u> uniform across villages and across farms within a village (owing to variations in land levels). Information was collected from every farmer about the amount of crop damage as a per cent of the harvest expected given the level of application of the inputs. This farm level variable, D_i, has been used to disassociate the effect of the natural calamities. Since the information comes from 16 widely scattered villages from different ecological zones, it is expected that the variation in climate, soil type and intensity of land use permitted by these agro-climatic factors would contribute to some variation in output, irrespective of the level of inputs used. Therefore 15 village level dummy variables, V_j, have been used to disassociate the effect of the environmental factors. The coefficient β_1 and β_2 are the output elasticity of land and labor respectively. The coefficient of LnA_i gives the sum of the elasticities which, along with its standard error of estimate, can be used to test the hypothesis about the degree of returns to scale in the specific crop production activity.

The equation (1) is a modified form of the general Cob-Douglas production function

$$(2) \quad LnQ_i = Ln\beta_0 + \sum_{j=1}^{m} \beta_i \, LnX_{ij}$$

where for ith farm Q is the gross output and X_j is the amount of the m different inputs used in its production. This particular functional form assumes that the elasticity of substitution between any two inputs is equal to one. We have used value added instead of gross output and related it only to the primary inputs, land and labor, because of the following reasons. Seed is an important material input but it has a technologically fixed relationship with land which violates the unit elasticity of substitution assumption. The variation in the amount of fertilizer used per unit of land in individual crop varieites is limited to a certain range. Changes in the use of fertilizer are realized more through choice of crop varieties. Animal power is an important input, but it is used along with human labor, which produces strong complementarity rather than substitutability assumed in the production function. Inputs like fertilizer and irrigation are also complementary rather than substitutes. Fertilizer, manure, pesticides and irrigation are not essential for production of local varieties, which is indicated by a small proportion of farmers applying these inputs (See Chapter 4 above). The log-linear production function is not appropriate if these inputs are used as explanatory variables. Thus deduction of the costs on account of the material inputs from the gross value of production appears more appropriate than using them as separate variables in the Cob-Douglas production function framework.

The assumption of unit elasticity of substitution between land and labor may be criticized as restrictive. In order to test the validity of the assumption we also fitted the more general translog (transcendental logarithmic) function of the following form.[3/]

$$(3)\quad LnY_i = Ln\beta_0 + \beta_1 LnA_i + \beta_2 LnN_i + \beta_3 LnA_i LnN_i$$

This form imposes on a priori restrictions on the elasticity of substitution between land and labor. For none of the crops was the estimated coefficient β_3 found to be statistically significant. An 'F' test using the residual sum of squares of regressions for the Cob-Douglas and translog functions also rejected the hypothesis of superiority of the translog fnctional form over the Cob-Douglas one.[4/]

Since farm level cross-section data are used to estimate the function, one expects the amount of land and labor to be highly correlated across farms. This creates the well-known problem of multicollinearity in estimating the parameters of the function. In order to avoid this problem, the labor input has been measured per unit of land, which breaks the high degree of correlation between land and labor. This produces the modified form of the function as shown in equation (1) in which the coefficient of logarithm of of the land variable becomes the sum of the elasticities of land and labor.

The estimates of the parameters of the function obtained from the use of the ordinary least square (OLS) method are reported in Table 5.3. The following major conclusions can be drawn from the findings.

Crops are significantly affected by damage due to natural factors. The coefficient of damage is statistically significnat for all crop varieties. This indicates the prevalence of a high degree of uncertainty in rice cultivation so the farmer cannot be sure about the productivity of the inputs he applies on the land. Thus, the rate of application of the inputs may depend not only on the level of prices but also on the degree of risk aversion of the farmer. The regression coefficient of crop damage is, however, found to be lower for the modern varieties compared to the traditional ones in all three seasons.

The sum of the output elasticity (factor share) of land and labor is less than one for HYV boro and greater than one for other varieties. But except for local boro, the value is not statistically significantly different from unity. This indicates the existence of constant returns to scale in rice cultivation.

The elasticity of land is, in general, higher, and that of labor, lower in the cultivation of MVs compared to the traditional ones. Only in the case of boro season is the elasticity of labor found to

TABLE 5.3

ESTIMATES OF COB-DOUGLAS PRODUCTION FUNCTIONS FOR DIFFERENT VARIETIES OF RICE, 1982

	Constant	Elasticity of		Coefficient of crop damage	$\bar{R}^2$ (SEE)	'F' Statistics
		Land 2/	Labor			
Aus Season:						
Local Variety	5.640 (0.980)	0.511 (0.055)	0.555 (0.19)	-1.41 (0.19)	0.82 (0.476)	59.0
Modern Variety	7.364 (0.852)	0.701 (0.062)	0.338 (0.19)	-0.86 (0.31)	0.89 (0.443)	98.6
Aman Season:						
Local Variety	6.110 (0.474)	0.570 (0.060)	0.490 (0.12)	-0.86 (0.12)	0.82 (0.454)	46.9
Modern Variety	7.701 (0.417)	0.636 (0.053)	0.374 (0.10)	-0.54 (0.18)	0.83 (0.424)	66.9
Boro Season:						
Local Variety 1/	7.280 (0.298)	0.787 (0.028)	0.296 (0.080)	-1.13 (0.14)	0.96 (0.202)	720.0
Modern Variety	7.196 (0.262)	0.613 (0.023)	0.371 (0.063)	-0.69 (0.08)	0.93 (0.248)	669.4

Notes: Figures within parentheses are standard errors of the estimated coefficients. The regression coefficients of village dummies have not been reported.

1/ Local boro is grown in only one ecological zone. Hence the village dummies have not been used.

2/ The standard error of estimate is for the sum of the elasticity of land and labor.

be higher compared to the local varieties. In the boro season, MV competes for land more with local aus (grown on high land) than with local boro (grown on extreme low land). Compared to local aus, the elasticity of labor is lower for MV boro.

The estimates of marginal productivity of land and labor, at the mean level of application of the inputs, are reported in Table 5.4. In estimating the marginal productivity of land, the output elasticity of land is taken as the difference of the elasticity of labor from

TABLE 5.4

ESTIMATES OF AVERAGE AND MARGINAL PRODUCTS OF LAND AND LABOR, CROP LEVEL, 1982

Crop Variety	Land (Tk/ha)		Labor (Tk/day)		Rent[b/] (Tk/ha)	Wage rate[a/] (Tk/ha)
	Average productivity	Marginal productivity	Average productivity	Marginal produtivity		
Aus Season:						
Local variety	3,216	1 ,431	23.25	12.90	2,078	12.92
Modern variety	11,394	7,543	57.66	19.49	6,411	17.64
Aman Season						
Local variety	5,856	2,987	43.91	21.52	3,502	20.09
Modern variety	10,725	6,714	60.30	22.55	5,902	21.75
Boro Season:						
Local variety	8,959	6,307	44.23	13.09	4,994	20.00
Modern variety	10,833	6,814	49.84	18.49	7,156	23.88

a/ These are average farm specific wage rate paid to hired workers in the cultivation of the crop.

b/ The value of rent is based on actual production, share rental and input shares received from the land owners in the cultivation of the rental land.

unity, since constant returns to scale prevails. The table also compares the value of the marginal productivity of land with the rent paid by sharecroppers to landowners, and that of labor with the average farm-specific wage rate paid to hired casual laborers in the cultivation of the crops during the year of survey. The following major points can be noted from the table.

Compared to local aus, the marginal product of land is about 5.3 times higher in the cultivation of MV aus and 4.8 times higher in the cultivation of MV boro. In the aman season, the increase in the marginal product in the cultivation of modern variety is less, but it is still higher by about 2.2 times compared to the local variety. In the boro season, however, the increase in productivity from the use of the modern technology is only about eight per cent, but compared to local aus, which is the main substitute crop, the productivity difference is about 4.8 times. Thus, the modern technology gives tremendous scope for increasing the net returns from the fixed endowment of land that the farmer has.

The effect of the modern technology on increasing the productivity of labor is small. Compared to local variety, the marginal product of labor is higher for the MVs by about 51 per cent for the aus season, 41 per cent for the boro season, and only 5 per cent for the aman season. The difference would not be statistically significant as indicated by the high standard error of estimate of the elasticity of labor (Table 5.3). It may also be noted that most of the increase in the marginal product of labor is passed on to workers in the form of higher wages. The workers, however, gain more through more employment under the new crops (Chapter 4).

The efficiency in the allocation of resources is determined by comparing the marginal product of the factor with its price. According to the neo-classical theory, allocation of the resources is at optimum when the marginal product of the resources is equal to their prices. In Bangladesh under sharecropping, the most common tenancy arrangement, the tenant pays 50 per cent of the gross produce as rent to the land-owner. In the cultivation of modern varieties, the landowner sometimes shares half of the cost on account of fertilizer and irrigation.[5/] The survey found that less than one per cent of the cost of material inputs was paid by the landowner. The value of rent reported in Table 5.4 is based on actual production and rental on tenanted and the input cost shared by the landowners. For aus and aman season varieties, the marginal product of land is lower than the rent for the local varieties, indicating that the tenant has to pass on a portion of the return on their labor in the form of rent, in order to get the land. For the MVs, the marginal product of land is higher than the rent, 14 per cent for the aman season, and 18 per cent for the aus season. Thus the tenants tend to gain with the diffusion of the modern technology in these seasons. For the boro season MVs however, the marginal product of land is lower than the rent.

Labor seems to be optimally allocated during the aus and aman seasons, as its marginal product is almost in line with the wage rate for the four crop varieties grown during these seasons. During the boro season, however, the marginal product is lower than the wage rate indicating over utilization of this input. This is usually the slack season of agricultural activity. Nearly one-half of the land remains fallow during the season (Table 5.2). Only about one-fourth of land is cultivated with rice, and pulses and oilseeds, which are low labor intensive, are the major crops grown during the season. It appears from the findings that farmers facing underemployment of family workers are willing to accept low returns for the labor during this season.

Relative Econoic Efficiency

In recent economic literature, a profit function model, derived by the application of duality relation between the cost and the production function, is used to mesure and compare economic efficiency and price efficiency for groups of farms.[6/] Although the model has been severely criticized,[7/] the use of the model for empirical studies remains popular. The model is appropriate for the present analysis, as one can classify farm households into two groups, adopters and non-adopters of the modern technology, and compare relative economic efficiency.

In the model, farms are assumed to have fixed endowments of land, L, and capital K, which cannot be varied in the short run, but farms can choose variable inputs, labor, N, and fertilizer, F, whose prices are W and C respectively.[8/] The amount of the variable inputs that the farm decides to use is determined by setting the marginal cost of the input i to $1/P_i$ times the marginal value product where P is considered the opportunity cost of the input supplied from the farm family. Farms are called price efficient if all the P_i are equal to unity. A farm may be more technically efficient than another if it produces larger quantity of output from the same quantities of measurable inputs. Technical efficiency may differ between two groups of farms by a multiplicative factor, δ. Differences in economic efficiency among groups of farms may be caused by differences in technical and/or price efficiency.

Under the assumption of Cob-Douglas technology, the model yields a unit output price (UCP) profit function:[9/]

(4) $Ln\pi = LnA + \delta T + \alpha_1 LnW + \alpha_2 LnC + \beta_1 LnL + \beta_2 LnK$

and input demand equations:

(5) $-WN/\pi = \alpha_{11}T + \alpha_{12}(1-T)$

(6) $-CF/\pi = \alpha_{21}T + \alpha_{22}(1-T)$

where π is the unit output price profit (Gross revenue minus total variable cost), W and C are respectively labor and fertilizer prices normalized by the output price, and T is a dummy variable taking value 1 for MV adopter farms and 0 for non-adopters.

The hypothesis of equal relative economic efficiency implies that δ is equal to zero. The hypothesis of equal relative price efficiency implies that $\alpha_{11} = \alpha_{12}$ and $\alpha_{21} = \alpha_{22}$. The hopothesis of absolute price efficiency implies that for adopter farms, $\alpha_{11} = \alpha_1$, and $\alpha_{21} = \alpha_2$, and for non-adoptor farms, $\alpha_{12} = \alpha_1$ and $\alpha_{22} = \alpha_2$.

The error terms are assumed to be additive with zero expectation and finite variance for each of the three equations. But the covariances of the error of either equation corresponding to different farms are assumed to be identically zero. Under this specification of errors, Zellner's seemingly unrelated regression equation (SURE) provides an asymptotically efficient method of estimation.[10] The efficiency of estimation can be increased by imposing known constraints on the coefficients in the equation.[11]

In estimating the model from the data, profits have been measured by deducting farm specific costs of variable inputs -- seed, fertilizer, manure, pesticides, irrigation, and labor from the gross value of output. The cost of animal labor could not be counted due to non availability of data. It has been treated as a fixed input and included in farm capital. The cost of family labor has been imputed by the wage rate paid to hired workers. It was mentioned earlier that the market for irrigation was very imperfect, and the irrigation charge varied widely depending on the source of supply of water. Since the MV crops were irrigated (Chapter 4), the cost of irrigation was also imputed by multiplying the area under MV with the average cost of irrigation per unit of land for the entire sample. The prices of variable inputs at the farm level could be computed only for labor and fertilizer, since both quantity and cost information was available only for these two inputs. For this reason, only fertilizer and labor could be used as variable inputs on the right hand side of the profit equation. A significant proportion of farmers (9.5 per cent) did not hire labor or use chemical fertilizer, so prices could not be computed for them. These cases have been dropped because of the non-availability of farm specific prices. The profits, wage rate, and fertilizer price variables have been normalized by paddy prices. The capital input has been measured in flow terms by multiplying the replacement cost of the stock of agricultural implements and draught animals with the rate of interest charged on loans from the commercial banks.

Owing to widespread crop damage from natural calamities during the reference year of survey, and the use of the wage rate as the opportunity cost of family labor, the profits turned out to be negative for a large number of cases (99 out of 475 farms in the sample). Since the UOP profit function is log linear, these cases had to be excluded. Since lower profits may also be due to inefficiency of resource use, this might introduce sample selection bias in the results. It is found from the tests of the difference of arithmetic means that farms making negative profits are one-third smaller in sizes and use 48 per cent less fertilizer, but are not significantly different with regard to the adoption of modern varieties and the use of capital services, compared to farms making profits (Table 5.5).

A major cirticsm of the model is that the invariability of the prices in the cross-section data vitiate the usefulness of the methodology.[12/] This is <u>not</u> found to be a serious problem for the data set used here. Since the sample was selected from a large number of villages scattered throughout the country, and a number of villages are located in interior areas with underdeveloped infrastructural facilities, differences in prices acrooss locations were quite significant, particularly for labor and fertilizer. The coefficient of variation of prices across villages was found at 24 per cent for labor, 14 per cent for fertilizer, and 7 per cent for paddy.[13/]

TABLE 5.5

SELECTED CHARACTERISTICS OF PROFITABLE AND LOSS MAKING SAMPLE FARMS

Variables	Units	Profitable farms (N=331)	Farms making (N=99)	Percent difference/a	Estimated T-value	Level of significance
Average Size of Land Owned	Acres	3.10	1.97	-37	-2.95	.003
Area under modern varieties	Percent of cropped land	36	37	1	0.28	.777
Fertilizer use	Kg per acre of cropped land	78	41	-48	-4.02	.000
Capital services	Tk per acre of cropped land	298	334	12	0.61	.543

a/ Values for farms making less over those for farms earning profits.

The results of the tests of various hypotheses regarding the absolute and relative price efficiency in the use of labor and fertilizer, and also of constant retuns to scale in production are presented in Table 5.6. The hypotheses that the price efficiency is the same for the adoptor and non-adoptor farms is accepted for labor but rejected for fertilizer. The chi-square value for the equality of the parameters in the fertilizer demand equation for the two groups is highly statistically significant. Both groups are absolutely price inefficient in the use of labor and fertilizer. But when the hypothesis of equal relative efficiency in the use of labor is maintained,

TABLE 5.6

TESTS OF HYPOTHESIS OF RELATIVE AND ABSOLUTE PRICE EFFICIENCY AND CONSTANT RETURNS TO SCALE

Tests	Parameter restriction	Chi-Square value	Significance level
1. Relative efficiency in the use of labor	$\alpha_{11} = \alpha_{12}$	1.19	0.275
2. Relative efficiency in the use of fertilizer	$\alpha_{21} = \alpha_{22}$	7.85	0.005
3. Absolute efficiency in the use of labor	$\alpha_{11} = \alpha_{1}$) $\alpha_{11} = \alpha_{12}$)	8.25	0.016
4. Absolute efficiency in the use of fertilizer	$\alpha_{21} = \alpha_{2}$) $\alpha_{21} = \alpha_{22}$)	7.86	0.020
5. Absolute efficiency in the use of fertilizer for adoptor farms maintaining equal relative efficiency in the use of labor	$\alpha_{21} = \alpha_{2}$) $\alpha_{11} = \alpha_{12}$)	1.19	0.549
6. Absolute efficiency in the use of fertilizer for non-adoptor farms maintaining equal relative efficiency in the use of labor	$\alpha_{22} = \alpha_{2}$) $\alpha_{11} = \alpha_{12}$)	1.31	0.518
7. Constant returns to scale	$\alpha_{11} = \alpha_{12}$) $\alpha_{21} = \alpha_{2}$) $\beta_{1} + \beta_{2}$) $= 1$)	5.09	0.166

both group appears to be absolutely price efficient in the use of fertilizer. The hypothesis of constant return to scale is also accepted.

The estimates of the parameters of the profit function and the factor share equations are presented in Table 5.7. The technology dummy is found to be highly statistically significant and the value of the parameter is positive, indicating that the adopter farms are more economically efficient. Even under the assumption of equal price efficiency for labor and constant returns to scale, the technology dummy remains statistically significant, the value indicating that the adopter farms are also more economically efficient, compared to the non-adopter farms, by about 29 per cent.

In estimating profits the cost of family labor was imputed at the wage rate paid to hired workers. This may be a very restrictive assumption, as the opportunity cost of labor could vary across farms depending on the availability of family labor. In order to see the bias created by this assumption we incorporated another explanatory variable in the Profit function, FLBR, which is measured by the proportion of labor supplied from the farm family. If the opportunity cost of labor depends on the availability of family labor, this variable should be a proxy of the price of family labor. If the variable is statistically significant, the hypothesis that the opportunity cost of family labor is equal to the wage rate can be rejected.

TABLE 5.7

JOINT ESTIMATES OF PROFIT FUNCTIONS AND INPUT DEMAND EQUATIONS, 1982

Variables (Parameters restrictions)	Parameters	Unrestricted equation	Restricted ($\alpha_{11} = \alpha_{12}$, $\alpha_{21} = \alpha_{22}$, $\beta_1 + \beta_2 = 1$)	Restricted ($\alpha_{11} = \alpha_{12}$, $\alpha_{22} = \alpha_2$, $\beta_1 + \beta_2 = 1$)
Profit function:				
Constant	LnA	-0.368 (-0.97)	-0.824 (-2.76)	-0.807 (-2.71)
Technology dummy	δ	0.258 (2.50)	0.282 (2.92)	0.288 (2.98)
Log wage rate	α_1	-0.368 (-2.52)	-0.312 (-2.21)	-0.305 (-2.15)
Log fertilizer price	α_2	-0.179 (-0.52)	-0.158 (-6.31)	-0.058 (-1.93)
Log land	β_1	0.767 (11.95)	0.882 (33.14)	0.882 (33.14)
Log capital services	β_2	0.128 (4.73)	0.118 (4.44)	0.118 (4.44)
Labor Demand				
Adoptor dummy	α_{11}	-1.058 (-5.52)	-0.953 (-.582)	-0.956 (-5.83)
Non-adoptor dummy	α_{12}	-0.653 (-2.06)	-0.953 (-5.82)	-0.956 (-5.84)
Fertilizer demand				
Adoptor dummy	α_{21}	-0.172 (-6.09)	-0.158 (-6.31)	-0.158 (-6.31)
Non-adoptor dummy	α_{22}	-0.019 (-0.40)	-0.058 (-1.89)	-0.058 (-1.93)
Chi-square for restriction			5.08	5.32
Level of significance			0.166	.150

Figures within parentheses are asymtoptic 't' values, R = 0.50 and the sample size consists of 331 profit making farms.

The unrestricted joint estimate of the profit function and the labor demand relations are as follows:

$$(7)\quad Ln\pi = \underset{(0.71)}{-0.274} + \underset{(3.26)}{0.343\ T} - \underset{(-5.33)}{0.698\ LnW} - \underset{(-0.50)}{0.195\ LnC}$$

$$+ \underset{(10.6)}{0.702\ LnL} + \underset{(3.26)}{0.122\ LnK} - \underset{(3.85)}{0.702\ FLBR}$$

$$\bar{R}^2 = 0.52 \qquad N = 331$$

$$(8)\quad WN/\pi = \underset{(-5.52)}{-1.05\ T} - \underset{(-2.05)}{0.65\ (1-T)}$$

$$(9)\quad WC/\pi = \underset{(-6.09)}{-0.171\ T} - \underset{(-0.40)}{0.019\ (1-T)}$$

The figures within parentheses are asymptotic 't' values.

The coefficient of FLBR is negative and highly statistically significant. Thus, the estimated profits decline with increased use of family labor, indicating that the opportunity cost of family labor is lower than the wage rate. Inclusion of this variable increases the value of the coefficient of the price of labor (LnW) from -0.37 in the previous estimate (Table 5.6) to -0.70. Since family labor has been incorporated as a separate variable, W can not be interpreted at the price of hired labor. The hypotheses that the value of parameter (α_1) is equal to the parameters of the labor demand relation ($\alpha_{11} = \alpha_{12}$) was also tested. The tests produced a chi-square value of 2.59 with a significance level of 0.17, which can be taken to interpret that the farmers are absolutely price efficient in the use of hired labor.

Maintaining the hypothesis that the farmers are both absolutely and relatively price efficient in the use of hired labor and that constant returns to scale prevails, produces the following estimate of the profit function.

$$(10)\ \text{Ln}\pi = \underset{(-5.73)}{-1.378} + \underset{(3.28)}{0.331}\ T - \underset{(-7.38)}{0.747}\ \text{LnW} - \underset{(-0.20)}{0.073}\ \text{LnC}$$

$$+ \underset{(34.13)}{0.895}\ \text{LnL} + \underset{(3.28)}{0.105}\ \text{LnK} - \underset{(-3.24)}{0.570}\ \text{FLBR}$$

The coefficient of FLBR suggests that a 10 per cent increase in the proportion of family labor reduces profits by 5.7 per cent. Even after incorporating the effect of the lower cost of family labor, the coefficient of the technology variable (δ) remains positive and highly statistically significant. The value of the coefficient indicates that the adoptor farms get about 33 per cent more output from a given level of input than the non-adoptor farms.

The output elasticity of various inputs for the Cob-Douglas production function can be derived indirectly from joint estimates of the parameters of profit function and input demand equations. The estimates are statistically more consistent than the ones derived from the direct estimates of Cobb-Douglas production function, which assumes all inputs to be exogenously determined, while in practice the variable inputs may be simultaneously determined depending on the prices, which is the maintained assumption in the profit function model. Since α_1 and α_2 appear in both profit function and the respective input demand equations, imposing the restriction that they are equal in both equations, the efficiency of the estimates is improved. The parameters can also be estimated imposing the condition of constant returns to scale ($\beta_1 + \beta_2 = 1$). The estimates derived from equation 7 (unrestricted) are reported in Table 5.8. The elasticity of land is 0.37 compared to 50 per cent share rental paid by share croppers to landowners in the country. The elasticity of fixed non-land capital assets is estimated at 0.06, showing the relative unimportance of this input. The elasticity for hired labor is 0.37, which yields a marginal productivity of Tk 22 per day of labor against an average wage rate of Tk 19.5 paid by the sample farms. The elasticity of fertilizer is estimated at 0.10 which gives a marginal return of Tk 2.1 per unit Taka investment on this input.

TABLE 5.8

INDIRECT ESTIMATES OF THE ELASTICITY AND MARGINAL PRODUCTIVITY OF INPUTS

Inputs	Output Elasticity	Marginal Productivity	
		Unit	Values
Fixed Inputs:			
Land	0.37	000 Tk/ha	4.9
Capital	0.06	Tk/Unit Tk investment	1.06
Variable Inputs:			
Hired labor	0.37	Tk/day	22.1
Fertilizer	0.10	Tk/Tk of investment	2.1

The estimate from the unrestricted profit function, thus shows considerable inefficiency in the allocation of fertilizer. As indicated earlier, the inefficiency is mainly due to farms which produce local varieties in which fertilizer is used in small amounts. The new crops are not only more technically efficient, they allow farmers to achieve higher levels of allocative efficiency by creating conditions to use more fertilizer per unit of land.

Conclusions

The diffusion of the modern technology increases the effective supply of land by reducing the proportion of fallow land during the dry season. The sown area under cereals is about 87 per cent of the cultivated land for the unirrigated plots -- on irrigated plots it is 150 per cent. The increase in the intensity of cereal cultivation is partly at the expense of other crops. Pulses, jute, and sugarcane are grown on about one-third of the unirrigated land, but only four per cent of the irrigated land is allocated to these crops. With the provision of irrigation facilities, the cropping intensity of the land increases by one-third.

Technological diffusion would increase marginal returns from land many times and provide scope to the landowner to earn more from this scarce resource through the gradual reallocation of land from local to modern varieties. The increase is about five times for the aus and boro season and 2.2 times for the aman season. The marginal product of labor is almost the same for the alternate varieties in the aman season, but in the aus and boro seasons the productivity is higher by about 50 per cent for the modern varieties. Labor tends to gain more from additional employment than from the increase in marginal product.

The the new technology are absolutely price efficient in the allocation of fertilizer compared to the non-adoptors, but both groups are absolutely price inefficient in the use of labor. The inefficiency in the use of labor is mainly due to low opportunity -- cost of family labor. The marginal product of hired labor is found to be close to the wages paid. The adoptor farms are more technologically efficient compared to the non-adoptor farms by about 33 per cent. The diffusion of the new technology would thus improve the efficiency of resource utilization in agriculture.

Chapter 5 Notes

1. S. Ishikawa, Economic Development in Asian Perspective, Tokyo, (Kinokuniya, 1977). For Bangladesh this hypothesis has been tested in J.K. Boyce, "Water Control and Agricultural Performance in Bangladesh", The Bangladesh Development Studies, 14 (No 2, 1986).

2. L.J. Lau and P. Youtopoulos, "Profit, Supply and Factor Demand Functions", American Journal of Agricultural Economics, 54 (No 1, 1972): 11-18; "A Test for Relative Economic Efficiency: An Application to Indian Agriculture", American Economic Review, 61 (No 1, 1971): 94-109.

3. L.R. Christensen, D.W. Jorgensen, and L.J. Lau, "Transcendental Logarithmic Production Functions, Review of Economics and Statistics, 55 (No 1, 1973): 28-45.

4. A study by Shahabuddin with data for 202 farm households survey during winter 1979 in four selected regions in Bangladesh also shows that the Cobb-Douglas restrictions are validated against both transcendental and translog functions for the majority of the crops grown by farmers. See, Quazi Shahabuddin, "Testing of Cobb-Douglas Myths: An Analysis with Disaggregated Production Functions in Bangladesh Agriculture:, The Bangladesh Development Studies, 13 (No 1, 1985): 88-97.

5. M. Raquibuzzaman, "Sharecropping and Economic Efficiency in Bangladesh", The Bangladesh Economic Review, 1 (No 2, 1973). It is found from this survey that 39 out of 72 farmers who cultivated MV boro on rented land received some input from the landowner, but the value of the landowner supplied input was only 0.8 per cent of the cost on account of seeds, fertilizer, irrigation and pesticides. The incidence of cost sharing was even less for other crops.

6. P.A. Yotopoulos and L.J. Lau, "A Test for Relative Economic Efficiency", The American Economic Review, 63 (No 1, 1973): 214-223.

7. See for example, John Quiggin and Arih Bui-Lan, "The Use of Cross-Sectional Estimates of Profit Functions for Tests of Relative Efficiency", Australian Journal of agricultural Economics, 28 (April 1984): 44-55; Remesh Chand and J.L. Kaul, "A Note on the Use of the Cobb-Douglas Profit Function", American Journal of Agricultural Economics, 68 (No 1, 1986): 162-164.

8. The profit function is estimated for the sample farm households for all crops taken together. Since over 90 per cent of the farmers used fertilizer on some crop or other, we decided to include fertilizer as a variable production input since output elasticity of fertilizer is often used as an important parameter in policy analysis (such as estimating costs and benefits of fertilizer subsidy). Also, information on farm capital was available at the household and <u>not</u> at the crop level. So this variable could be included in the profit but <u>not</u> in the crop-specific production function reported earlier.

9. For details of the derivation, see P.A. Youtopoulos and L.J. Lau "A Test for Relative Economic Efficiency", op. cit., pp 215-218.

10. Zellner A., "An Efficient Method for Estimating Seemingly Unrelated Regressions and Test for Aggregation bias", <u>Journal of the American Statistical Association</u>, 57 (No 2, 1962): 348-375.

11. P.A. Youtopoulos and L.J. Lau, op. cit., p. 219.

12. J. Quiggin and A. Bui-lan, op. cit.

13. The price variations are almost of a similar range to those reported in a study of Filipino rice growers by J. Flinn, K. Kalirajan, and L. Castillo, "Supply Responsiveness of Rice Farmers in Laguna, Philippines:, <u>Australian Journal of Agricultural Economics</u>, 26 (No 1, 1982): 39-48.

6. FARM SIZE, TENANCY AND ADOPTION OF MODERN TECHNOLOGY

A crucial factor determining equity implications of the new rice technology is the extent and intensity of its adoption among different groups of farmers. The literature is full of studies which analyze adoption behavior of farmers to test the hypothesis that the gains from the introduction of the new agricultural technology have been unequally distributed.1/ The majority of the evidence for the early period of the "green revolution" suggests that the incidence of adoption is positively related to farm size, which appears counter intutive given the evidence that the new technology is seemingly scale neutral. It is argued that the new technology may entail some fixed costs in the form of access to information and sources of supply of the new inputs, and arrangements for marketing, which tend to discourage adoption by small farmers.2/ The role of tenurial arrangements in the adoption decision is also a subject of considerable controversy. A number of recent studies, however, argue that even if small farmers and tenants initially lag behind in adopting the new technology, eventually, they catch up and ultimately, they may use it more than the large owner farmers.3/ But even if this is the case, the early adopters can accumulate more wealth and power, which they can use for further accumulation of land from the laggards, which can set in a process of unequal distribution of income with the diffusion of the new technology.

In order to assess the equity implications of the modern technology for Bangladesh, this chapter studies the adoption behavior among different size and tenurial groups of farmers and tests major hypotheses put forward in the literature in this regard. Major issues raised in the literature are outlined in the following section. The next section gives a descriptive account of the intensity of adoption among different groups of farmers. The factors affecting adoption are then analyzed using multivariate regression techniques. The final section investigates into the difference in land productivity and prices faced by different groups of farmers, since these would also have bearings on the income distribution effect of the new technology among farmers.

The Issues

The relationship between farm size and the adoption of the new technology cannot be determined *a priori* Farm size is often a surrogate for a large number of factors[4/] which may have important bearing on the adoption decision. Since the importance of these factors varies across space and over time, in empirical investigations it is possible to observe variant relationships between farm size and the rate of adoption.

An important factor is the degree of risk aversion among farmers.[5/] Apart from the objective risk of having uncertain returns from investment under conditions of weather variation and pest attacks, the new variety entails in the initial years a subjective risk of having an uncertain yield wit an unfamiliar technique, the full intricacies of which have not yet been mastered by the farmer. The more risk averse is the farmer, the less willing he will be able to adopt, and even if he adopts, he will try to minimize the risk by devoting a smaller proportion of land to the new crop. The degree of risk aversion may depend on the position of the farmer with respect to income. If the farmer operates around the poverty level income, he would want to ensure survival for self and the family by avoiding the risk of falling below the subsistence level. Since farm size and income may be highly correlated, small farmer may be more risk averse and may adopt the technology less than the large farmer. In the case of Bangladesh, a large majoity of farmers operate near the subsistence level. But the new technology is now sufficiently known to the farmers and the objective risk is found to be lower for the new crops (Chapter 4). So the risk aversion factor may not be important in explaining the adoption behavior.

The need for working capital to cultivate a given amount of land is higher for the new crop varieties (see Chapter 4). Farmers who need to invest on indivisible irrigation equipments like tubewells and power pumps, to adopt the new crops would also require a large initial fixed investment. So, unless the government bears the cost of irrigation development, access to capital in the form of accumulated savings or financial institutions may be an important determinant of the rate of adoption. In many low income countries, small farmers have limited access to financial institutions. Thus the credit constraint may induce farmers to borrow from the high cost non-institutional sources. The working capital constraints may, however, be eased considerably after a few years, if the small farmer could accumulate the incremental profits from the cultivation of the new crops.

Access to information about the sources of new inputs, the knowledge about how they could be optimally used, and the marketing of the additional output, can also be an important factor in determining the differential rate of adoption.[6/] The level of education of the farmer can be taken as a proxy of this variable. Since the opportunity cost of sending children to school rises with poverty, education status is generally found to be positively related with the farm size. The larger farmer who is better educated may have more contact with the extension agents who supply these information. So the large farmer is expected to adopt more on this account.

A number of other factors may, however, operate to encourage more adoption among the smaller farmers. The new crop use substantially more labor input per unit of land. In rice cultivation which depends more on the use of casual workers (hired on a daily basis), it makes the problem of labor management more difficult. This may prevent adoption of the new crop by relatively labor scarce large farmers. If the new crop increases the seasonal demand for labor, it would be less attractive to farmers with a limited supply of family labor.

According to the Chayanovian theory of peasant economy,[7/] the consumption unit of the family in relation to the production unit, i.e., land and worker may be an important determinant of the adoption of the new technology. The theory argues that the motive force behind the economic activity of a peasant family is the consumption need which increases with the growth of the family. The peasant responds to the increased consumption requirement by substituting labor for leisure and by acquiring more land. In land scarce countries, the scope of accumulating land is limited for the peasant. In this situation, the yield and income raising technology gives the scope for increasing consumption from the same amount of land. Hence, the new variety would be more attractive to small farmers who have more family members relative to land.

The impact of tenurial arrangement on adoption decision is a matter of considerable controversy in the theoretical literature.[8/] Bhaduri, citing the East Indian experience, argued that the landlord who derives income from rent as well as from usury is interested in keeping his tenants perpetually indebted. Under these circumstances, it is in his interest not to allow the tenant to adopt the new technology since higher incomes from cultivation of the same amount of land would reduce the tenants' indebtedness to him, and the loss in usury income would outweigh the gain in rental income accruing to the landlod. This hypothesis has, however, been criticized on the grounds that if the landlord has sufficient monopoly power to withhold adoption of the new technology, he should have power to siphon off the extra income of the tenant by increasing the rent. Newberry argues that under uncertain labor and product markets, sharecroppers would be interested in adopting the new technology. But Bardhan shows through a theoretical model that land-augmenting technical change and higher labor intensity, the characteristics of the new rice varieties, would induce a higher incidence of tenancy. The risk aversion theory implies that share tenancy may be a preferred arrangement for adoption of the new technology since the risk can be shared between the tenant and the landlord. Also, since the tenant is usually a small farmer with more surplus labor and higher subsistence pressure, he may adopt the new technology more readily than the owner cultivator.

The availability of complementary inputs can also influence the adoption behavior. In the case of the new varieties of rice, an important factor is the assured and regulated supply of water (that is irrigation) without which the new variety would be more risky and less profitable. In the Bangladesh case, with small farms and fragmented and scattered holdings, irrigation seems to be exogenously determined, since the facilities are developed by the government largely with externally funded projects. Even with private ownership on irrigation equipment by large landowners, which has proceeded somewhat since the late-seventies, the small and medium farmers have equal chance of having some of their plots located within the command area because of the random location of the fragmented holdings. Under these circumstances, the differential adoption among farmers and regions would depend on the location of irrigation projects and on access of the different groups of farmers to irrigation facilities.

Pattern of Adoption

Farm Size and Adoption of MV

Table 6.1 summarizes the observed pattern of adoption of the new crop varieties among different groups of sample farmers in the study villages. About three-fourths of the farmers cultivated the new varieties, although only about one-third of the sown area was allocated to them. The proportion of adopter farmers is not found to be significantly different among different size and tenurial

TABLE 6.1

ADOPTION OF MODERN VARIETIES OF RICE BY FARM SIZE AND TENANCY, 1982

Farmer Groups	Percent of farmers adopting MV	Area Under MV Rice as a Percent of	
		Total cropped area	Rice area
<u>Size of farm</u>:			
Small (up to 1.0 ha)	75	43.2	51.7
Medium (1.0 to 2.0 ha)	74	35.8	44.6
Large (2.01 & over)	77	32.5	42.4
<u>Tenurial Status</u>:			
Owner	77	35.7	44.1
Tenant or owner-tenants	74	38.1	48.1
All Farms	75	36.8	46.0

groups. The gains from the new technology thus appears to be widely distributed irrespective of the land holding and tenurial status of the farmer.

The intensity of adoption is, however, found to vary inversely with farm size. The farmers who own less than one hectare of land (henceforth called small farms) devoted about 43 per cent of the cropped area under modern rice varieties; among farmers who own more than two hectares (large farms), the proportion is one-third. The same pattern is observed even if the intensity of MV adoption is measured as a proportion of sown area under rice. The result appears contradictory with the general findings on this issue in the South-Asian context. The previous studies on the extent of adoption for Bangladesh, however, found a similar pattern. One of the more rigorous earlier studies (based on data for 1972) conducted by Asaduzzaman found that small farmers devoted about 28 per cent of the aman rice area to the new crops compared to only 14 per cent by large farmers.[9/] Herdt and Garcia reviewed findings of seven studies conducted between 1969 to 1981 and noted that five of these reported higher intensity of adoption among smaller farmers.[10/] The 1983-84 Agricultural Census also supports this finding. The census found about 26 per cent of the net cropped area for the small farms were under modern varieties of rice, compared to 23 per cent for medium farms and 18 per cent for large farms.

Tenancy and Adoption of MV

The adoption of MVs is not found to be significantly different between owner and tenant farmers. In Bangladesh, pure tenants, i.e., those who rent the entire holding, are rare. Most of the tenants are part tenants who own some land and rent some in order to make the holding viable. As can be noted from Table 6.1, 75 per cent of the owner-tenants cultivated some land with the modern variety compared to 77 per cent for the owner cultivators. The intensity of adoption was about 38 per cent for tenants compared to 36 per cent for owners. For rice, tenants devoted 48 per cent of the sown area under modern varieties, compared to 46 per cent for owners.

Table 6.2 shows the incidence of tenancy in the cultivation of different varieties of rice. It is found that tenants are larger

TABLE 6.2

INCIDENCE OF TENANCY BY SEASON AND TECHNOLOGY, 1982

Season	Percent of farmers renting land		Rented area as a Percent of sown area	
	Traditional variety	Modern variety	Traditional variety	Modern vareity
Aus	24.6	30.7	14.3	15.9
Aman	27.9	44.7	19.0	20.1
Boro	16.0	35.0	7.5	16.9

in proportion among farmers cultivating modern varieties in all three rice growing seasons. The proportion of area under tenancy is also found higher in the cultivation of modern varieties in all three seasons. This indicates a positive effect of the new technology on tenancy cultivation.

In Bangladesh the predominant tenancy arrangement is sharecropping under which the gross output is shared equally between the tenant and the landowner, while most of the cost of cultivation is borne by the tenant.[11/] It can be argued that under these circumstances, the tenant would be discouraged to adopt the new technology because he would have to bear the large incremental cost on account of labor, fertilizer, and irrigation while the incremental output would be shared equally between the tenant and the landowner. The empirical observation thus inconsistent with this hypothesis. Under certain circumstances, the hypothesis cannot, however, be tested by comparing the performance of the owner and tenant cultivator, particularly, when the tenant also cultivates some owned land. If markets (such as of labor and capital) are imperfect, the resource position of the cultivator may determine its opportunity cost which would vary among cultivators. The tenant may hire in land because he has some underemployed resource (human and animal labor) which he cannot sell in the market. Since the new technology is labor-using, the tenant may want to maximize his family income by devoting more land under new crops compared to the owner cultivator. The disincentive effect of share tenancy thus can only be assessed by comparing the rate of adoption on owned and share cropped portion of the holding under the same cultivator. This is done in Table 6.3. It would be noted that the tenants devoted a larger proportion of their owned land under the modern varieties compared to the owner-cultivators, which is a reflection of the negative farm size effect on MV cultivation, since most tenants are small farmers. But the tenants allocated a smaller proportion of the rented land under the new crops compared to the owned land during the aman and aus seasons, which supports the hypothesis of disincentive effect

TABLE 6.3

ADOPTION OF MODERN VARIETIES ON OWNED AND RENTED LAND FOR MIXED-TENANT FARMERS: BY SESON, 1982

Season	Owner farms	Owner-cum-Tenant Farms	
	Percent of land under HYV	Percent of owned land under MV	Percent of rented land Under MV
Aus	33.3	38.8	36.1
Aman	33.5	42.1	35.1
Boro	76.7	82.6	89.0
All Seasons	44.1	49.8	46.5

of crop sharing arrangements. Only during the boro season did the tenants grow modern varieties more on the rented land compared to owned land. This may be due to a stipulation by the landowner that the land can be rented only if it is cultivated with modern varieties. It was found during the field survey that in many cases the land is only rented seasonally, and the seasonal tenancy is more prevalent during the boro season.

Irrigation and Adoption of MV

The sample villages under study differ widely with respect to access to irrigation, types of irrigation, and the age of experience with irrigation. In three villages which belong to the Comilla dis-district, irrigation facilities were developed and modern varieties introduced in the late sixties during the experiment of the Comilla model of "cooperative capitalism". Two of the villages are under the Ganges-Kobtak project, the first large scale irrigation project developed in Bangladesh, where irrigation is provided by gravity canals. These villages got access to the irrigation canals in 1972. Two villages irrigated part of the land by fielding low lift pumps on canals developed by the food for works program in 1978. In two other villages, irrigation was introduced only two years before this survey by a few large landowners who invested in shallow tubewells. At the time of the survey, five villages did not have any access to irrigation facilities, three of them located in the coastal district of Khulna where intrusion of saline water during the dry season makes irrigation development difficult. The diversity in the sample allows us to investigate the role of irrigation in adoption among different groups of farmers in the early and late adopter villages.

The importance of irrigation in the adoption of the modern varieties has been shown earlier (Table 5.1) from the analysis of the pattern of land use for the irrigated and unirrigated plots. Further analysis of the use of the owner operated plots show the crucial importance of the level of land and the access to irrigation in the intensity of adoption of modern varieties (Table 6.4). Only six per cent of the unirrigated plots were used for growing MVs compared to 77 per cent of the irrigated plots. MVs were grown much more on the plots located on the medium level land compared to the extremely high and extremely low lying plots, because the physical characteristics of the latter do not generally allow regulation of water supply. About a half of the plots located on the medium high land were reported to be irrigated, compared to only one-sixth of the plots located on the extreme high and low lying land. One-third of the irrigated plots were used for growing MVs twice during the year, and it appears that the land level is the most important factor determining the intnsity of use. Almost one-fourth of the plots located on the medium high land were used to grow MVs twice during the year compared to less than four per cent for the other categories of land. The second MV crop is grown during the monsoon season, and so the low lying plots which remains deeply flooded cannot be used to raise the dwarf modern varieties. Since the importance of the different types of plots in the portfolio of landholding may vary across villages and farmers, the above findings points to the importance of dissociating the effect

TABLE 6.4

ADOPTION OF MODERN VARIETIES BY LEVEL OF LAND AND ACCESS OF LAND TO IRRIGATION FACILITIES, 1981

Type of Land	No. of plots in the sample	Percent of the Plots			
		Irri-gated	Not grow-ing MV	Growing MV once	Growing MV twice
Land Level:					
Extreme High	1063	14.6	89.6	7.7	2.7
Medium High	1383	52.3	52.4	24.2	23.4
Medium Low	941	44.3	62.3	33.0	4.7
Extreme Low	181	16.0	83.4	13.3	3.3
Access to Irrigation:					
Unirrigated	2242	Nil	94.0	5.5	0.5
Irrigated	1326	100.0	23.1	47.4	29.6
All Plots	3568	37.2	67.7	21.1	11.3

of the physical characteristics of the land in analyzing the impact of the socio-economic factors on the adoption behavior of the farmer.

Table 6.5 compares the pattern of adoption among different farm size groups between irrigated and unirrigated villages. About one-fifth of the farmers in the unirrigated villages allocated some land to modern varieties compared to about 90 per cent in the irrigated villages, where the proportion of adopter farms is invariant across farm size. Thus once irrigation facilities are developed in a village, the gains are widely distributed across the farm size scalr. Even in the late adopter villages where only about one-fourth of the cropped

TABLE 6.5

ADOPTION OF MODERN VARIETIES IN IRRIGATED AND UNIRRIGATED VILLAGES BY FARM SIZE, 1982

Size of farm	Percent of adopter farmers		Percent of cropped area under modern variety	
	Unirrigated villages	Irrigated villages	Unirrigated villages	Irrigated villates
Small	20	87	3.7	59.6
Medium	20	93	2.7	51.4
Large	15	93	0.7	49.5
All Groups	19	90	2.2	53.5

land is cultivated with modern varieties, more than 80 per cent of the farmers are adopters (Table 6.6). In the late adopter villages, the proportion of adopters is smaller among small farmers, while in the early adopter villages, almost all farmers grew MVs even among the small size groups. This supports the contention that, with experience, small farmers catch up with the large ones.

The intensity of adoption is observed to be inversely related with farm size even in the irrigated villages. About 54 per cent of the cropped land in these villages is allocated to MV rice; 60 per cent for the small farms compared to 50 per cent among the large ones (Table 6.5). The inverse size effect prevails even in the early adopter villages (Table 6.6) indicating that the large farmers remained laggards even with the passage of time. Presumably, facing shortage of family labor, the large farmers may have adopted MVs partly through tenants.

TABLE 6.6

ADOPTION OF MODERN VARIETIES BY TYPE OF IRRIGATION AND THE AGE OF EXPERIENCE ,1982

Village groups	Percent of Adopter farmers			Percent of cropped area under modern variety		
	Small farm	Medium farm	Large farm	Small farm	Medium farm	Large farm
Type of Irrigation:						
Low Lift Pumps	84	95	87	32.6	33.6	23.2
Canals	91	100	100	58.0	49.8	58.9
Tubewells	87	89	92	68.9	60.7	61.3
Age of Experience:						
Early Adopter	98	100	100	74.8	69.3	71.3
Late Adopter	79	88	85	29.6	26.5	24.9

One can argue that the type of irrigation itself may contribute to differential rate of adoption among farmers. If the irrigation equipment is privately owned, as often is the case with tubewell irrigation in Bangladesh, one can expect a large farmer monopoly in the supply of water, since the size of the command area and the high initial cost of investment would prohibit tubewell ownership by smaller farmers.[12/] In this case, one can expect a direct relationship between farm size and adoption of the MV rice. On the other hand, the communal development of irrigation, as in the case of the Water Development Board's large-scale canal irrigation project, may lead to a more egalitarian system of distribution of water supply, and other things remaining constant, the intensity of adoption would be invariant with farm size. In order to test this hypothesis, we also estimated the rate of adoption along the farm size scale for different types of irrigation (Table 6.6). In the case of villages receiving water from canals, no systematic pattern of adoption is found, but in the case of both tubewell and low lift pump irrigation, the small farmers adopted more, which is contrary to the above hypothesis.

Adoption of Fertilizer

Nearly nine-tenths of the sample farmers used fertilizers during 1982 although only about a half of the plots were treated with fertilizers. The non-users were mostly among those who grew only traditional varieties of rice. All farmers growing MV boro and aus rice, and 98 per cent of those growing MV aman used fertilizers. The proportion of user farmers was 74 per cent for local transplanted aman, 73 per cent for local aus, 19 per cent for local broadcast aman, and only 6 per cent for local boro. The fertilizer adoption is thus very much variety specific and depends on the type of land and environment.

The pattern of adoption of fertilizers among different groups of farmers can be reviewed from Table 6.7. The adopter farmers are proportionately more among the larger size groups. But the intensity of use per hectare of land is inversely related with farm size. This apparent inconsistency can be explained by the fact that the number of plots under cultivation is higher for the larger farmer and, hence, the probability for one of he plots failing under the command area of irrigation and, therefore, being suitable for growing MV and application of fertilizer, is higher the larger the size of farm. The amount of use per unit of land is thus a more appropriate indicator of adoption behavior than the proportion of user farms. Table 6.7

TABLE 6.7

USE OF CHEMICAL FERTILIZERS BY FARM SIZE AND TENANCY, 1982

Farmer Groups	All crops		Amount used in major crops (Kg/ha)				
	Farmers using fertilizers (percent)	Amount used (Kg of nutrients per ha of sown area	MV boro	MV aus	MV aman	Local aus	Local aman
Farm Size:							
Small	85.5	60.3	169	117	93	22	20
Medium	92.3	54.2	158	117	97	16	20
Large	95.0	44.8	127	114	73	31	14
Tenurial Status:							
Owner	87.8	54.7	156	117	89	25	26
Tenant	90.8	53.3	161	114	93	17	9
All Farms	89.2	54.1	157	116	91	22	19

shows that compared to large farmers, the small farmers use about 35 per cent more fertilizer per unit of cropped land, and the medium farmers about 20 per cent more. The extent of use is found similar for the owner and tenant farmers. Similar findings on differential adoption of fertilizer was noted by the IFDC from its countrywide survey.13/

A major factor behind the inverse farm size effect on fertilizer use is that the small farmers grow a larger proportion of land under MV (Table 6.1) which are much more fertilizer intensive compared to the traditional varieties of rice. For dissociating the cropping pattern effect, we have also reviewed the pattern of adoption in specific crop varieties, which are reported in Table 6.7. The inverse size effect prevails in the case of MV for all three seasons, and it is highly pronounced in the case of MV boro. For local varieties in which fertilizers are used in small amounts, no systematic pattern of use across the farm size scale is found. The owner farmers tend to use more fertilizers than the tenants in local varieties, but for MVs, no systematic pattern is found

Adoption Behavior: An Econometric Analysis

The size and tenurial status of a farm is often a surrogate for other factors which affect the adoption behavior of farmers. In order to explain the observed pattern of adoption reported in the previous sections, it is thus necessary to carry out a multi-variate analysis of the factors determining the adoption behavior and the importance of these factors for different groups of farmers. This is attempted here through the use of the multivariate regression technique. First, a <u>probit</u> model is used to identify the factors which affect the decision to adopt MV rice, and then a <u>tobit</u> model is used to explain the extent of adoption.

The following model was estimated using the <u>profit</u> method in order to identify factors which affect the farmers' decision of whether to adopt MVs or not:

ADPT = f (OWNL, TNC, IRGP, CRDTI, CRDTN, LBR, LNDPC, NAGRI, INFR)

where, ADPT = The dichotomous adoption variable which takes value 1 for adoptor farms and zero for non-adoptor farms,

OWNL = The amount of land owned by the household (in acres),

TNC = The proportion of rented in land,

IRGP = The proportion of land irrigated,

CRDTI = The amount of loan received from institutional sources (hundred Tk per acre)

LBR = The amount of land cultivated per worker (acre)

LNDPC = The amount of land owned per member in the household (acre)

NAGRI = The income from trade and industry per acre of cropped land (hundred Tk/acre)

INFR = An index of underdevelopment of infrastructure at the village level.[14/]

LBR and LNDPC are measures of labor scarcity and subsistence pressure in the household and are expected to negatively influence the decision to adoption MVs. CRDTI, CRDTN and NAGRI are expected to ease the capital constraint and hence should have positive influence on adoption decision.

The results of the exercise are presented in Table 6.8. Estiated equation 1 incorporated only the farm size and tenancy variables and they are found statistically insignificant with an extremely low $\bar{R}^2$ for the regression equation (obtained in the OLS estimate of the parameters). The labor scarcity and the subsistence pressure variables have right signs of the estimated parameters but they are also statistically insignificant. An alternative labor scarcity variable was

TABLE 6.8

FACTORS INFLUENCING THE DECISION TO ADOPT MVs, PROBIT ESTIMATE

Variables	Equation 1	Equation 2	Equation 3
Constant	0.452 (4.89)	-0.105 (-0.46)	-0.038 (-0.16)
OWNL	-0.016 (-0.98)	0.015 (0.56)	0.012 (0.47)
TNC	0.802 (0.42)	0.914** (3.70)	0.871** (3.54)
IRGP		4.171** (10.57)	4.164** (10.62)
LBR		-0.040 (-0.90)	
LNDPC		-0.206 (-0.83)	-0.302 (-1.51)
CRDTI		-0.371 (-0.25)	-0.056 (-0.04)
CRDTN		0.324 (0.75)	0.316 (0.73)
NAGRI		-0.098 (-0.64)	-0.087 (-0.56)
INFR		-0.047* (-2.08)	-0.047* -(2.08)
LBRH			-0.239 (-0.82)
$\bar{R}^2$	0.01	0.33	0.33

The sample consists of 470 farm households. Figures within parentheses are asymptotic 't' values. The statistical significance of 't' values are ** $p < .01$ and * $p < 0.05$. Value of $\bar{R}^2$ are for OLS estimates.

measured by the proportion of hired labor (LBRH), but the negative value of the coefficient is also statistically insignificant (equation 3). Institutional credit and non-farm income variables in fact have opposite signs but not statistically significant. Only irrigation and development of infrastructure are significantly positively associated with the adoption of MVs. When the effects of the other variables are controlled, the proportion of area under tenancy is significantly positively correlated with the adoption variable.

A large number of variables and their measurements were experimented with for selecting the variables that best explain the extent of adoption of modern varieties. After a careful scrutiny of the results of alternative estimates, the following model is found to best explain the variation of MV adoption in the sample.

MVP = f(IRGP, LBR, FSZ, CRDTI, CRDTNI, NAGRI, EDNH, OWNL, TNC).

where

MVP: The proportion of cultivated area under modern varieties,

FSZ: the number of members in the family, which is a measure of the consumption pressure in the household.

EDNH: Level of education of the head of the household (completed years of formal schooling),

Other variables are as explained before.

The equation was estimated separately for two seasons. For the overlapping aus and boro seasons, irrigation is a prerequisite for adoption of the modern varieties because the rainfall is scanty and paddling of soil for transplantation of seedlings cannot be done without irrigation. This is also a relatively slack season of agricultural activities since a significant proportion of land remains fallow. So factors like labor shortage may not be a binding constraint for adoption during this season. During the aman season, rainfall is plenty and so modern varieties can be grown under rainfed conditions, but a physical control is imposed by the level of land, since the low levels of land remains deeply flooded throughout the season which makes the land unsuitable for growing MVs. Since most of the land is cropped during this season, occasional labor shortages may appear. Owing to thse differences, the analysis at the seasonal level was thought to be more appropriate. The proportion of medium high land was used as another explanatory variables but the coefficient was not found to be statistically significant and in fact had negative sign in the equation for aus and boro seasons. Since irrigation was highly correlated with this variable, the land level variable was dropped in the final estimated equation in order to avoid the problem of high multicollinearity.

One has to be careful about the method of estimation of the parameters of the specified model since the observed value of the dependent variable has a limited range. This is the case of a limited dependent variable model and the application of the least square method to the observed data may lead to seriously biased estimates. Since the dependent variable is observed in the range of zero to one, i.e., it is censored in both tails, the "two limit probit" (Tobit) model appears to be the most appropriate technique for its estimation. The software LIMDEP developed by Greene[15/] for estimation of the tobit model was applied to the data set to get the values of the parameters of the model.

The estimated parameters are reported in Table 6.9. As expected, irrigation is found to be the most significant variable determining the adoption rate. The asymptotic "t" value for the estimated coefficient is the highest for irrigation compared to all other variables included in the model. The dropping of this variable from the equation reduces the value of the adjusted coefficient of determination ($\bar{R}^2$) from 0.47 to 0.08. The comparison of the "t" value for this coefficient for the two seasons indicates that for adoption of MV, irrigation is more important for the boro and aus season than for the aman season. The value of the coefficient (in the equation for all seasons) indicates that a 10 per cent increase in the area under irrigation may increase the proportion of land under modern varieties of rice by about 11 per cent.

The coefficient of the family worker variable is positive for the aman season indicating that given the amount of land to be cultivated, the higher the availability of the family labor, the more is the tendency to cultivate the modern varieties. The value of the coefficient, however, is <u>not</u> found to be statistically significant. For the aus and boro season, the coefficient of this variable has an opposite sign, but it is not statistically significant. As indicated earlier, this is the slack season of agricultural activities and so households with less endowment of labor relative to land may

TABLE 6.9

DETERMINANTS OF ADOPTION OF MODERN VARIETIES OF RICE, 1982

Variables	Boro and Aus season		Aman Season		All Seasons	
	OLS Estimate	Tobit Estimate	OLS Estimate	Tobit Estimate	OLS Estimate	Tobit Estimate
OWNL	-0.291 (-0.65)	-0.484 -0.99)	0.036 (0.08)	0.002 (0.004)	-0.255 (-0.41)	-0.429 (-0.47)
TNC	0.130*** (2.74)	0.137*** (2.99)	0.183*** (4.00)	0.190*** (3.73)	0.314*** (4.70)	0.283*** (4.64)
IRGP	0.609*** (14.09)	0.651*** (11.10)	0.527*** (12.57)	0.547*** (10.02)	1.137*** (18.69)	1.084*** (12.56)
LBR	-1.305 (-0.95)	-1.639 (-0.88)	0.733 (0.55)	0.581 (0.45)	-0.572 (-0.30)	-0.550 (0.25)
FSZ	0.539 (0.92)	0.743 1.07)	0.311 (0.55)	0.264 (.43)	0.850 (1.04)	0.337 (0.38)
EDNH	-0.403 (-1.02)	-0.396 (-0.80)	-0.248 (-0.65)	-0.269 (-0.65)	-0.650 (-1.169)	-0.416 (-0.66)
CRDTI	0.351* (1.71)	0.518** (2.36)	0.442** (2.21)	0.459** (2.48)	0.793*** (2.74)	0.743*** (2.74)
CRDTN	0.423*** (4.64)	0.625*** (5.07)	-0.108 (-1.23)	-0.113 (-0.87)	0.315*** (2.46)	0.695*** (3.82)
NAGRI	0.137 (-1.44)	-0.165 (1.46)	-0.126 -(1.368)	-0.134 -(1.10)	-0.264** (-1.97)	-0.290** (-1.99)
(Constant)	0.14*** (3.36)	0.14*** (2.38)	-0.004 (-0.10)	-0.004 (0.06)	0.14** (2.33)	0.17** (2.34)
(Sigma)		33.141*** (24.58)		30.19*** (25.88)		40.0*** (19.67)
$\bar{R}^2$	0.36		0.28		0.48	
Log-L		-2037		-2136		-1768

Notes: Figures within parentheses are asymptotic "t" values.
Significance of "t" value, * P<0.10, ** P<0.05, *** P<0.01.
The sample consists of 470 farm households.

not be constrained in growing more labor-intensive crops, as they can count on easy availability of hired labor.

The coefficient of family size is positive for both seasons supporting the Chayanovian hypothesis that the hiher the subsistence pressure, the greater is the tendency to adopt the new technology. The relationship, however, is weak. The value of the coefficient is not statistically significant.

In the context of a small farmer peasant economy as in Bangladesh, the shortage of working capital is often emphasized as a major constraint to adoption of the new technology. In this exercise, the amount of loans received per unit of land has been taken as a proxy of the availability of liquid funds, which may ease the capital constraint. The variable, however, could not be measured season-specific and so, it is difficult to interpret the value of the coefficient of this variable in the equations for different seasons. The value of the coefficient of institutional credit is positive for both seasons, which suggests that the availability of institutional credit facilitates adoption. The coefficient is found to be statistically significant in all the equations at less than five per cent probability error. This results may, however, appear surprising in view of the fact that the access of the small farmers to the agricultural credit institutions is still limited although there has been rapid expansion of short-term institutional loans in the country over the last decade.[16/] The credit is concentrated in the hand of the medium and and large farmers. In the present sample only 13 per cent of the farm households received institutional loans during 1982, and the amount of institutional loans was about a quarter of the total loans received by them. Households receiving institutional loans were 10 per cent among small farmers compared to 24 per cent for the large ones.

The incidence of borrowing from the non-institutional sources was found to be quite widespread. Nearly two-thirds of the farmers borrowed from friends and relatives, most often without any interest, and also from local moneylenders who charge very high rates of interest. Nearly 40 per cent of the loans from non-institutional sources were free of interest. The coefficient of the non-institutional credit variable is found to be positive and statistically significant at less than five per cent probability error for the aus and boro season. For the aman season, however, the coefficient has an opposite sign, but it is not statistically significant. Because of the need for irrigation and more-intensive use of fertilizer, the working capital requirement for the cultivation of MV crop is significantly higher for the boro and aus season compared to the aman season (Chapter 4). The proportion of holding allocated to MVs is also less for the aman season. Thus, farmers who do not have access to formal credit institutions may tap non-institutional loans for cultivating the modern variety during the dry season, while their own resources may be sufficient for growing the small amount of land that they currently allocate to MV during the aman season.

Farmers who earn some income from non-agricultural sources may have less liquidity constraint than those who depend mostly on agriculture. So access to non-agricultural income may ease the capital constraint to adoption of MV. The amount of income earned from trade and industry per unit of cultivated land was related to the intensity of adoption in order to test this hypothesis. The value of the coefficient is found to be negative irrespective of the season, which is contrary to the hypothesis. The negative value is statistically significant for all seasons. In fact, it is found in further tests that if the service incomes are added, the "t" value for the negative coefficient increases. This indicates that farmers who cannot adopt the modern varieties due to technical constraints (non-availability of irrigation, etc) try to augment household incomes through alternative ways, e.g., by self-employing themselves in various non-agricultural activities and taking up temporary low income jobs (public works program, etc)/(see Chapter 7 for further details).

Another variable for which the result is found to be contrary to a priori hypothesis is the level of education. The value of the coefficient is found to be consistently negative in all equations indicating that the less educated adopt modern varieties more intensively. The finding tends to support the contention that the type of education provided in schools is not agriculture oriented. Education provides better opportunities for non-agricultural employment which may be higher paying and less arduous than agricultural employment. Thus, although education gives better access to information about the new technology, it may not necessarily facilitate its adoption.

When the effect of other socio-economic variables are controlled, the size of landownership does not seem to affect the intensity of adoption. The coefficient of the landownership variable is positive for the aman and negative for the boro season, but the values are not statistically significant. The estimated "t" values is less than one for all cases. The tenancy variable, however, still remains highly statistically significant. The positive value of the coefficient indicates that the extent of adoption of MVs is higher on the rented land than on owned land. Since the MVs are labor-intensive, and tenants rent in land for minimizing the under-utilization of family workers, the large landowners may gain more by getting MVs cultivated by sharecroppers than self-cultivating them with wage laborers. Since there is so much excess demand for land, the tenancy market may be governmed more by the interests of the landowners than by those of the tenants, who would be discouraged to cultivate MVs on rented land under the crop-sharing arrangements.

The higher intensity of adoption on smaller farms, as reported in the previous section, mainly comes through availability of irrigation, and the incidence of tenancy. Irrigation in Bangladesh is mostly exogenously determined. It is developed by the government, often with foreign assistance. Irrigation has spread mostly in areas where the average farm size is generally low (eastern and south-eastern parts of the country). In the coastal and flood prone districts where there are physical constraints to development of irrigation, concentration of land in the hand of the large farmers is generally higher. So the proportion of land irrigated is found higher on smaller farms (Tabale 6.10). The same pattern is noted for the country as a whole by the latest agricultural census of 1983-84. Tenancy cultivation is also more prevalent among the smaller farmers. It was found in the present survey that about one-sixth of the cropped land was tenant

TABLE 6.10

INCIDENCE OF IRRIGATION AND TENANCY FOR DIFFERENT GROUPS OF FARMERS

Groups of Farmers	Percent of land irrigated		Percent of cropped area under tenancy
	Sample farmers 1982 1/	Bangladesh agricultural census, 1983/84 2/	Sample farmers 1982
Farm size:			
Small	32.3	22.8	37.9
Medium	32.9	19.0	9.9
Large	28.3	18.3	4.0
Tenurial Groups:			
Owner	33.6	n.a.	nil
Tenant	29.6	n.a.	35.4
All Farms	31.7	19.9	15.9

1/ As a precent of owned land

2/ As a per cent of cultivated holding. Medium farms are those with 2.5-7.50 acres of operated area.

Source: Bangladesh Bureau of Statistics.

cultivated, the proportion was 38 per cent for the small farms, compared to only four per cent for the large ones (Table 6.10).

Size, Land Productivity, and Prices

The observation that the adoption of the new technology is inversely related with farm size does not necessarily imply that in Bangladesh the income distribution effect associated with the diffusion of the new technology would be favorable to smaller farmers. It would also depend on the variation in productivity and prices among different groups of farmers.

For Bangladesh, a large number of studies show an inverse relationship between farm size and productivity of land.17/ Most of the findings are however, for areas which did not experience significant diffusion of the new technology and refer to time periods (mostly late sixties and early seventies) when the technology was at its early stages of adoption. Some of the studies for India,18/ where the size-productivity relationship is also found to be inverse in the case of traditional crops,19/ argue that this relationship may not hold for the new technology, as it gives considerable scope for using capital. Since the larger farmers have more accumulated savings and also have better access to financial markets, they are in a better position to apply purchased inputs like fertilizers and water more intensively than the smaller farmers. Thus, one may even expect a positive size effect on the yield rates for MVs, depending on the importance of the new inputs in the cultivation of the variety.

The differences in land productivity among size groups of farms observed from the survey can be reviewed from Table 6.11. Since the productivity may also vary depending on the stage of development of the new technology, the sample villages have been classified into two equal groups according to the proportion of area under the modern varieties. The developed villages have about 60 per cent higher rice yields compared to the underdeveloped villages. In the cultivation of modern varieties the yield is about 14 per cent lower in the developed villages, which may be due to the diffusion of the varieties to marginal farmers and marginal land, as well as raising of two rice crops per year on some land, which reduces the yield of each crop.

TABLE 6.11

FARM SIZE AND PRODUCTIVITY OF LAND BY TECHNOLOGY, 1982

(Tons per Hectare)

Farm size Groups	Technologically developed Villages			Technologically Under-developed Villages		
	Local Varieties	Modern Varieties	All Rice Varieties	Local Varieties	Modern Varieties	All Rice Varieties
Small	1.79 (0.08)	3.21 (0.13)	2.72 (0.11)	1.56 (0.09)	3.77 (0.38)	1.80 (0.10)
Medium	1.76 (0.09)	2.80 (0.13)	2.32 (0.08)	1.30 (0.07)	3.39 (0.41)	1.43 (0.09)
Large	1.52 (0.14)	2.70 (0.24)	2.13 (0.20)	1.25 (0.12)	2.63 (0.77)	1.32 (0.13)
All Farms	1.75 (0.06)	3.03 (0.09)	2.55 (0.08)	1.44 (0.06)	3.52 (0.26)	1.59 (0.07)

Figures within parentheses are standard errors of estimate

In the cultivation of local varieties the yield is about one-fifth higher for the developed villages.

The yield is found to be inversely related with farm size in both groups of villages, and for both the traditional and modern varieties of rice. The difference in yield between the small and large farmer is, however, less pronounced for the technologically developed villages compared to the underdeveloped ones, suggesting that with the diffusion of the technology, the productivity gap narrows down to some extent. Still, in the developed villages, the productivity for the small farmers is about one-fifth higher compared to the large ones and the difference is statistically significant.

The income from cultivation may also differ across farms due to variation in prices. The new technology has increased the dependence of the farmers on the market for acquisition of the new inputs and also for labor. The prices of the inputs may vary across farms especially under conditions of underdeveloped infrastructure facilities and monopoly control on the supply of the new inputs. The prices paid by different groups of farmers for the major agricultural inputs can be reviewed from Table 6.12. The fertilizer prices are reported separately for the dry and monsoon seasons, because the prices which are government controlled were raised on 1st of July, 1982, and so farmers growing aman crops faced higher prices than those growing boro and aus crops, and the effect of this factor needs

TABLE 6.12

PRICES OF MAJOR AGRICULTURAL INPUTS - BY FARM SIZE AND TENANCY

Farmer Groups	Fertilizer Price (Tk/kg)		Irrigation charge per acre	Wage Rate (Tk/day)
	Boro and Aus season	Aman season	Boro season	
Size of Farm:				
Small	3.20	3.64	672	20.22
Medium	3.23	3.55	583	19.43
Large	3.18	3.51	544	17.73
Tenurial Status:				
Owner	3.20	3.58	589	18.91
Tenant	3.22	3.62	698	22.88
Total	3.21	3.60	627	159

Source: BIDS/IFPRI Household Survey, 1982 to be dissociated. The fertilizer prices seem to be invariant with the size and the tenurial status of the farm. But the water charge and the wage rate varies considerably across farms. The small farmer paid about one-fourth higher prices for water compared to the medium ones. Tenant farmers paid about 19 per cent higher water charge compared to owner farms. This is expected because the ownership and management of irrigation equipment is controlled more by the larger landowners.[20/] The small farmers and tenants also pay substantially higher wage rates compared to the large landowners. Since the tenants and small farmers come to the labor market during busy periods, when the wage rates are higher, the weighted average wage rate is expected to be higher for them, although for a particular day, all farmers may face the same wage rate. The cost of working capital may also be higher for the small farmers because they have to borrow more from the high-cost non-institutional sources. It is found from this survey that nearly three-fourths of the small farmers took loans from the non-institutional sources, compared to two-fifths among the large farmers. The institutional credit accounted for 20 per cent of the total loans taken by small farmers, compared to 44 per cent for the large farmers.

Conclusions

In Bangladesh, small farmers and tenants have adopted the modern technology at least as much as large farmers and owner cultivators. The scale neutrality of adoption may have been the result of the government investment for development of irrigation, which is the main vehicle for the diffusion of the modern technology. Even under private investment on tubewells and power pumps, small farmers have as much access to irrigation facilities as the large ones because of the randomness with which the extremely fragmented and scattered farm holdings are distributed.

The small farmers, however, pay higher prices for inputs, particularly for water, labor and working capital loans. The ownership of privately owned machines and the management of the irrigation cooperatives is controlled by large farmers, who take a sizeable mark-up from the irrigation market. The small farmers paid about 25 per cent higher water charge compared to the large farmers and 40 per cent higher wage rate, presumably because they have to go to the labor market during busier periods of agricultural operations. Since the small farmers have to borrow more from the high-cost informal markets than do the large farmers, the average cost of working capital may also be higher for the former group. The variation in the prices of agricultural inputs would thus put a negative pressure on income distribution, which may outweigh the positive effect of the inverse relationship between farm size and adoption rates.

Chapter 6 Notes

1. This is in fact an over-researched issue. There are also a large number of surveys of the literature. See among others, Michael Lipton, Modern Varieties, International Agricultural Research and the Poor,. CGIAR Study Paper No. 2, World Bank, Washington D.C., 1985; "Inter-Farm, Inter-Regional and Farm-Non-farm Income Distribution: The Impact of the New Cereal Varieties", World Development 6, (No. 3, 1978): 319-337; G. Feder, R. Just and D. Silberman, "Adoption of Agricultural Innovations in Developing countries: A Survey", Economic Development and Cultural Change, 33 (No. 2, 1985): 255-298; Mr. Prahladachar, "Income Distribution Effects of the Green Revolution in India: A Review of Empirical Evidence", World Development, 11 (No. 11, 1983): 927-944; Richard Perrin and Don Winkelmann, "Impediments to Technical Progress on Small Versus Large Farms", American Journal of Agricultural Economic, 58 (December 1976)' 888-894.

2. Andrew Pears, op. cit., p. 120.

3. V.W. Rutton, "The Green Revolution: Seven Generalizations", International Development Review, 19 (No. 4, 1977): 16-23.

4. A. Berry and W. Cline, Agrarian Structure and Productivity in Developing Countries, Johns Hopkins Press, Baltimore, 1979.

5. G. Feder et. al., op. cit., pp. 262-265.

6. Andrew Pears, op. cit.

7. A.V. Chayanov, The Theory of Peasant Economy, (ed. D. Thorner), Irwin, Homewood, 1966.

8. Amit Bhaduri, "A Study in Agricultural Backwardness under Semi-feudalism", Economic Journal, 83 (March, 1973): 120-137; David Newberry, "Tenurial Obstacles to Innovations" Journal of Development Studies, 11 (July, 1975): A.K. Ghose and Ashwani Saith, "Indebtedness, Tenancy and the Adoption of New Technology in Semi-Feudal Agriculture", World Development, 4 (April, 1976): 305-320; P.K. Bardhan, "Agricultural Development and Land Tenancy in a Peasant Economy: A Theoretical and Empirical Analysis", Amirican Journal of Agricultural Economics, 61 (No. 1, 1979): 48-56; P.K. Bardhan and T.N. Srinivasan, "Crop Sharing Tenancy in Agriculture: A Theoretical and Empirical Analysis", American Economic Review, 61 (No. 1, 1971): 48-64.

9. M. Asaduzzaman, "Adoption of HYV Rice in Bangladesh", The Bangladesh Development Studies, 7 (No. 3, 1979): 23-49.

10. R.W. Herdt and L. Gracia, op. cit.

11. Mahabub Hossain, "Nature of Tenancy Markets in Bangladesh Agriculture", Journal of Social Stu ies (Dhaka), 3 (No. 1, 1979): F.T. Jannuzi and J.T. Peach, Agrarian Strucure of Bangladesh: An Impediment to Development, West View Press, 1980.

12. Andrew Pears, op. cit., 107.

13. For a summary of the findings of previous studies in this regard, see R.W. Herdt and L. Gracia, op. cit., and Mahabub Hossain, "Fertilizer Consumption, Pricing and Foodgrain Production in Bangladesh", op. cit., pp. 197-206.

14. This a compositive index of infrastructure underdevelopment construced by R. Ahmed and M. Hossain from the village specific information on access to a number of elements such as roads, markets and financial and educational institutions, for a separate study of the effect of infrastructure on rural development. The infrastructure variable significantly affects a number of endogenous variables investigated in the present study, but the results have not been reported here in order not to preempt the findings of the other study. The conclusions of this study remain valid even after inclusion of the infrastructure variable. See, Raisuddin Ahmed and Mahabub Hossain, "Infrastructure and Development of a Rural Economy", IFPRI (Draft), 1987.

15. William, H. Green, LIMDEP: User's Manual, May, 1986; "On the Asymptotic Bias of the Ordinary Least Square Estimator of the tobit Model", Econometrica, 49 (No. 2, 1981): 505-513; G.S. Maddala, Limited Dependent and Qualitative variables in Econometrics, Cambridge, Cambridge University press, 1984.

16. The supply of agricultural credit from institutional sources increased about eight times (at real value) over the 1975-84 period. During 1983/84, the amount disbursed was about seven per cent of the value added in agriculture, and 2.3 times the cost of fertilizers consumed in the country. See Mahabub Hossain, "Institutional Credit for Rural Development: An Overview of the Bangladesh Case", The Bangladesh Journal of Agricultural Economics, 8 (No. 1, 1985): 1-16.

17. See, among others, Mahabub Hossain, "Farm Size, Tenancy, and Land Productivity: An Analysis of Farm Level Data in Bangladesh Agriculture", The Bangladesh Development Studies, 5 (No. 3, 1977): 285-348; Mandal, M.A.S., "Farm Size, Tenancy and Productivity in an Area of Bangladesh", The B angladesh Journal of Agricultural Economics, 3 (December 1980): 21-42.

18. P. Roy, "Transition in Agriculture: Empirical Studies and Results", Journal of Peasant Studis, 8 (No. 2, 1981): G.S. Bhalla and G.K. Chadha, Green Revolution and the Small Peasant, Concept, New Delhi, 1983.

19. Krishna Bharadwaj, Production Conditions in Indian Agriculture, Department of Applied Economics, Occasional Paper No. 33, Cambridge University Press, 1974, Biplob Dasgupta, The New Agrarian Technology and India, Macmillan, New Delhi, 1972; P.K. Bardhan, "Size, Productivity, and Returns to Scale: an Analysis of Farm Level Data in Indian Agriculture" Journal of Political Economy, 81 (No. 6, 1973).

20. The government started selling deep tubewells and low-lift pumps to individuals and cooperatives from 1979/80. By the end of 1983, some 43 per cent of the the operating deep tubewells and 56 per cent of the low-lift pumps came to be owned by the private sector. Nearly two-thirds of such machines were owned by households with more than five acres of land. See M.A. Quasem, "Impact of the New System of Distribution of Irrigation Machines in Bangladesh", The Bangladesh Development Studies, 13 (September-December, 1985): 127-140.

7: LABOR MARKET AND EMPLOYMENT EFFECTS OF THE MODERN TECHNOLOGY

In Bangladesh, nearly a third of the rural households do not own any cultivable land and about a half own less than 0.5 acres; for them farming is only a marginal source of income.[1/] Having no access to land, most of these households are at the bottom of the rural income scale. Their income depends on the conditions in the labor market i.e., the duration of employment and the wage rate. The new technology would affect the agricultural labor market by changing the labor-intensity of cultivation, the productivity of labor which in turn would influence the wage rate, and the income of the farmer which would affect his labor-leisure choice. It can also indirectly affect the non-agricultural labor market, since the expenditure of the increased agricultural income would generate additional demand for non-agricultural goods and services, some of which may produced within the locality.[2/] The objective of this chapter is to trace these employment effects of the new technology. Although the main focus is on employment generation for the landless and the marginal farmers, employment for the land-owning groups has also been studied, since their behavior with respect to self-employment would affect the labor market.

Employment in rural Bangladesh consists mainly of self-employment and most of the agricultural workers are hired on a daily basis. Workers change jobs from one day to another, from self-employment to wage employment and from agriculture to other forms of employment. Under these circumstances, accurate information on employment can be obtained only through a large number of regular surveys covering a short period, so that the respondent can recall what he did during this period. To collect accurate information for the whole year, it would be better to conduct 52 weekly surveys but that would have been extremely expensive and taxing on the respondents. Considering the trade-offs, this survey collected information for all members of the sample households who participated in productive work for each day of the week preceding the day of interview, for eight weeks scattered throughout the year 1982. The periods were selected on the basis of the *a priori* knowledge of the cropping pattern of the area so as to represent the normal, busy, and slack periods of employment. The supply of labor for the whole year and the composition of employment has been estimated by extrapolating the data for the eight weeks. The demand for agricultural labor has been estimated from labor use in crops reported by farmers, which was collected through three rounds of interviews conducted at the end of each of the crop seasons during the year.

Participation in Economic Activities

A worker has been defined as a person who was available for work in an income earning or expenditure saving activities (henceforth called economic activities) during any of the eight weeks of the survey. These activities included supervision of farm labor, crop cultivation, post harvest processing and marketing, livestock and poultry raising, commercial and subsistence fishing, vegetable growing in kitchen gardens, cottage industry, house construction and repair, earthwork, collection of fuel, and trade transport and other services. Domestic labor for women should also be regarded as expenditure saving for the household but it was not considered in this definition. The average number of workers, thus defined, is 1.88 persons per household out of a household size of 6.34 persons for the entire sample. The labor force participation rate (workers divided by members) thus comes out at 29.7 per cent of the rural population, which is very close to 29.4 per cent activity rate reported in the National labor Force Survey of 1983/84.[3/] The low rate of participation in economic activities is partly because of the large proportion of the young population (up to age 15) but is mainly due to the virtual absence of women from the country's labor force. About one-third of the population in the sample was below age 10, and only eight per cent of the female population participated in economic activities. The rate of participation of women in income earning activities is estimated at 5.1 per cent by the 1981 population census and 7.9 per cent by the 1983/84 labor force survey.

The labor force participation rates for different landholding groups can be reviewed from Table 7.1. The impact of the new technology is assessed by comparing the information for two groups of villages equally divided according to the scale of the rate of adoption of the new technology (see Chapter 2). The average number of persons in the household was about five per cent higher in the developed villages and the difference is found statistically significant. This difference is however mainly due to the landless category. The difference for other groups is not significant. Presumably better economic conditions in developed villages reduces mortality rates and increases family size.

TABLE 7.1

LABOR FORCE PARTICIPATION IN DEVELOPED AND UNDERDEVELOPED AREAS BY LANDHOLDING, 1982

Landownership Group (acres)	Average No. of persons in the family	Average No. of workers (age 15 and over)	Participation rate (percent)	Number of male workers as per cent of family members	Number of female workers as per cent of total workers
Underdeveloped Villages:	6.19	1.84	29.7	27.3	7.9
Landless	4.82	1.55	32.2	28.8	10.4
Small	5.98	1.82	30.4	27.7	8.9
Medium	7.04	2.09	29.7	28.4	4.2
Large	8.87	2.21	24.9	22.9	8.0
Developed Villages:	6.52	1.93	29.6	25.8	12.8
Landless	5.45	1.88	34.5	27.3	21.0
Small	5.93	1.70	28.7	24.6	13.9
Medium	7.38	2.08	28.2	26.0	8.1
Large	9.08	2.52	27.8	26.6	3.9

The participation rate is found to be almost similar in the two groups of villages. The participation of women is, however, found to be marginally higher in the technologically developed villages and is significantly higher for the landless and the small farmer groups. The proportion of female workers in the landless household is about 21 per cent in the developed villages compared to 10 per cent in the underdeveloped villages. This may be due to more employment opportunities generated for women in non-agricultural activities in the developed villages. The number of male workers as a proportion of total population is about 25.8 per cent in the developed villages compared to 27.3 per cent in the underdeveloped villages, i.e., about six per cent lower for the former group.

The size of landholding has a strong influence on the participation rate. In the underdeveloped villages, the participation rate is about 32 per cent for the landless and marginal landowners compared to 25 per cent for the large landowners. Similar differences are also found in the developed villages. The female participation rate is also higher among the landless and the marginal landowners, significantly so in the developed areas. With technological advancement the participation of male members in the labor force appears to decline.

The participation rate can be taken as a proxy indicator of the supply of labor in the stock sense. The findings that technological advancement and the size of landownership has a negative influence on the participation rate indicate that leisure is substituted for labor at higher levels of income. It appears that the very poor households supply as many workers as possible to the labor force in order to earn a subsistence income for the family subject to job availability and limitations imposed by socio-religious factors.[4/] As income increases with technological progress and/or with larger amount of land, the household may withdraw the women and the children from the labor force in order to have higher social status and better education for the children.

The above point is further demonstrated by Table 7.2 which shows occupations of family members aged 10 to 25, the age group which participate in the labor force, attended educational institutions or take up domestic duties as housewives. It can be noted that the labor force participation rate in this age group is about 27 per cent in the developed villages compared to 37 per cent in the underdeveloped villages. Although a larger proportion of the female population in that age group are married and take up domestic work, the main reason behind the lower participation rate in the developed villages is larger participation in educational institutions. The proportion of students in the age group is 36 per cent in the developed villages compared to 23 per cent in the underdeveloped villages. A larger proportion of male members attend schools than the female. With technological progress, the student population increases for both sexes, but the increase is more pronounced for the male members; about 50 per cent in the developed villages compared to 30 per cent in the underdeveloped villages. The size of landownership also significantly influences the school attendance. In underdeveloped villages students are less than one-fifth for households owning up to two acres, but about a half for households with more than five acres of land. Even after controlling for the effect of landownership group, the school attendance is found higher in developed villages.

Education increases the quality of labor and provides opportunity for taking up higher-paid non-agricultural employment. Even self-employment in trade, services, and processing activities requires functional literacy and numeracy. Considering the above, the downward

TABLE 7.2

OCCUPATION OF FAMILY MEMBERS AGED 10 TO 25, BY LANDOWNERSHIP AND SEX

(Figures in percent of members in the group)

Groups	Underdeveloped villages				Developed villages			
	Student	House wife	Inac-tive	Worker	Student	House wife	Inac-tive	Worker
Landownership:								
Marginal	16.4	39.7	9.3	34.6	23.0	37.2	7.5	32.2
Small	18.9	37.8	3.0	40.2	32.1	34.0	3.3	30.6
Medium	27.2	34.7	1.9	36.2	46.2	32.1	2.7	19.0
Large	50.0	24.0	6.0	20.0	57.5	21.3	4.3	17.0
Sex:								
Male	29.9	-	3.6	66.5	49.6	-	7.1	43.3
Female	16.3	71.5	6.4	5.8	22.1	65.6	3.1	9.2
Total	23.1	36.4	4.9	35.7	36.0	32.9	4.7	26.5

pressure of the technological advancement on labor force participation should be taken as a positive development. With improved economic conditions, the lower income groups can afford to send more children to school and have better education, which may promote occupational mobility and increase lifetime earnings.

Extent and Composition of Employment

Since the number of hours of work put in during a day may vary across villages, and a worker may be engaged in a number of activities during a day, the information on duration of employment was collected in the survey in hours by activity for each of the workers belonging to the sample households. The information was collected on a daily basis for seven days preceding the date of interview and as such may contain some margin of error due to the problem of memory recall. The estimate of total employment at the household and worker level has been built up from the data and is measured in average weekly employment hours for the eight weeks of survey. The information can be converted to standard eight-hour days of employment for the year 1982. It may be mentioned here that the figures only measure the supply of labor by the sample households both on own and other's account, which may not necessarily be equal to total employment generated in the study areas. The estimation of the later would have required data an in- and out-migration of labor in flow terms, which were not collected by the survey.

The average duration of employment estimated from the survey is about 39 hours per week or about 253 standard eight-hour days during the year of survey. About 62 per cent of the employment was generated in agricultural activities. Self-employment accounted for about 68 per cent of the total employment. The respondent workers reported that they were available for work for 345 days a year. On this basis the rate of underemployment is estimated at about 27 per cent.[5/] However, if six days of work a week is taken as a full employment norm, then the rate of underemployment on the time criterion is estimated at only 19 per cent.

The duration of employment for different landownership groups in the technologically developed and underdeveloped areas can be reviewed from Table 7.3. It appears from the data that the supply of labor declines with technological advancement. Compared to underdeveloped villages, the supply of labor in developed villages is about 13 per cent lower at the worker level and 9 per cent lower at the household level. The duration of employment is also inversely related to size of landownership, reflecting that at higher levels of income, people substitute leisure for labor. The workers belonging to landless households worked, on average, for about 42.4 hours a week compared to 38.2 hours for workers belonging to households owing more than five acres of land, a difference of about 11 per cent. With technological advancement, the difference becomes more pronounced - the landless putting in about 24 per cent more labor than the large landowners. The reduction in duration of employment is less for the landless compared to the land owning groups. In fact, at the household level, the landless in developed villages supply about 14 per cent more labor than their counterparts in underdeveloped villages. Thus, by raising incomes, the technical progress puts a downward pressure on the supply of labor. As the higher income groups demand more leisure, the increase in labor lied demand generated by the new technology would be met by increased supply from the lower income groups, some of it may even be supply migrant workers from villages where the technology has not yet developed. In that sense, the comparison of the duration of employment between developed and underdeveloped areas would underestimate the positive employment effect of the new technology on the lower income groups.

TABLE 7.3

DURATION OF EMPLOYMENT IN TECHNOLOGICALLY DEVELOPED AND UNDERDEVELOPED AREAS BY LANDOWNERSHIP GROUPS

(Labour hours per week)

Landownership Group	Employment per household			Employment per worker		
	Under-developed villages	Developed villages	Percent difference	Under-Developed villages	Developed villages	Percent Difference
Landless	65.37	74.39	13.8	42.40	40.09	-5.5
Small	75.47	63.87	-15.4	42.36	37.26	-12.0
Medium	87.79	66.67	-24.1	41.34	32.53	-21.3
Large	83.87	80.83	-3.7	38.24	32.33	-15.5
Total	76.38	69.62	-8.8	41.59	36.12	-13.2

The substitution of leisure for labor at higher income levels is more pronounced for agricultural activities where the work is arduous. This is shown by Table 7.4. Labor supplied in agriculture is positively related to the size of landownership because of greater opportunities for self-employment on larger farms. But with technological advancement the workers belonging to farm households put in less labor in agriculture compared to their counterparts in underdeveloped villages. In contrast the workers in the landless group supply about 80 per cent more labor in the developed villages. The total supply of labor in agriculture is found to be about seven per cent more in the developed villages.

TABLE 7.4

DURATION OF EMPLOYMENT IN AGRICULTURE AND NON-AGRICULTURAL ACTIVITIES, BY TECHNOLOGY AND LANDOWNERSHIP GROUPS

(Weekly labor hours per household)

Landownership Group	Agriculture			Non-agriculture		
	Underdeveloped villages	Developed villages	Percent difference	Underdeveloped villages	Developed villages	Percent difference
Landless	23.61	42.43	79.7	41.76	31.96	-23.5
Small	42.16	41.03	-2.7	33.31	22.84	-31.4
Medium	60.66	53.24	-12.1	27.13	13.43	-50.5
Large	65.42	60.53	-7.5	18.45	20.30	10.0
Total	43.54	46.67	7.2	32.84	22.95	-31.1

The poor cannot afford to remain unemployed. Since the landless do not get enough employment on the land, they tend to engage more in non-farm rural activities. In underdeveloped villages, about 64 per cent of the employment for the landless households was generated in non-agricultural activities compared to only 22 per cent for the large landownership group (Table 7.3 and 7.4). As agricultural income increases with technological advancement, more demand is generated for non-farm goods services, some of which may be produced in rural areas (see chapter 8 below). This may increase demand for labor in non-agricultural activities. It appears from the data that the additional employment is taken up by the households in underdeveloped villages and by large landowning groups in developed villages. The supply of labor in non-agricultural activities is about one-third lower in the developed villages, the rate of decline increases with the size of landownership but only up to the middle farmer group. The supply of labor to non-agriculture from the large landowning group is in fact greater in the developed villages.

Employment in some of the non-farm activities whose market is expanded by increased rural incomes may require investment in working capital and some basic skills like functional literacy and numeracy which can be acquired in schools. The poor may be constrained in taking up non-agricultural employment opportunities by widespread illiteracy and the lack of access to financial institutions. Thus they may be engaged more in farming and those non-farm activities which require more manual labor than capital, physical or human. These may often be distress employment, i.e., very low productivity jobs taken up by a worker when he has nothing else to do. As technological progress generates opportunities for additional employment in farming and increases the productivity of agricultural labor, employment in non-farm activities is substituted by employment in agriculture.

Table 7.5 gives a detail activity-wise breakdown of employment for all workers in the sample. One is struck by a complete lack of specialization in rural employment. Even farming does not generate enough employment for a household to keep one worker busy throughout the year. Rice farming has the additional problem of the seasonal pattern of demand for labor, so even in large landowning households, family workers may remain unemployed during slack seasons of the year. A household may be engaged simultaneously in a number of agricultural and non-agricultural activities, and a worker may be engaged in a number of activities during the same week. It will be noted from

TABLE 7.5

LABOR SUPPLY IN DIFFERENT ACTIVITIES IN DEVELOPED AND UNDERDEVELOPED AREAS, ALL RURAL HOUSEHOLDS, 1982

Activity	Percent of households participating		Average Weekly Employment Hours			
			For participating households		All households	
	Underdeveloped villages	Developed villages	Underdeveloped villages	Developed villages	Underdeveloped villages	Developed villages
Agriculture:	93.7	95.9	46.46	49.15	43.53	47.13
Cultivating family farms	81.1	80.3	34.34	34.64	27.85	27.82
Wage labor	45.3	40.1	23.54	22.98	10.66	9.21
Livestock & poultry raising	41.2	53.2	8.25	9.73	3.40	5.18
Fishing	18.6	26.4	8.76	18.60	1.63	4.91
Non-agriculture:	92.5	90.5	35.52	25.62	32.86	23.19
Industry	12.3	7.3	27.14	8.83	3.34	0.65
Trade and shopkeeping	31.1	26.1	24.74	21.31	7.70	5.56
Construction and Transport	41.2	38.2	20.09	15.80	8.28	6.04
Services	21.7	38.9	26.40	19.20	5.73	7.46
Earthwork	27.4	14.0	14.48	13.61	3.97	1.91
Others	56.0	43.6	6.87	3.56	3.85	1.55

table that although 95 per cent of the households participate in agricultural work, more than 96 per cent also have some non-agricultural occupations. Nearly a half of the households in the underdeveloped villages report engagement in miscellaneous non-agricultural activities (these include collection of fuel, fencing, etc.) which generate less than six hours of employment on average in a week, even for the participating households.

The activities for which the duration of employment declines with technological advancement are agricultural wage labor, cottage industry, trade and shopkeeping, earthwork, and miscellaneous activities. Agricultural labor and earthwork are arduous and are also considered socially degrading if the work is performed on others' account. So with increases in incomes, some households can afford to avoid them. Miscellaneous activities may be performed when there is nothing else to do. So with increased employment opportunities, these are replaced by other work. The decline in labor supply to industry and trade, however, appears to be surprising. Presumably with increases in income, people tend to replace some low quality cottage industry products, the so-called dying industries, with competing products of formal industries, located mostly in urban areas. Also, the labor productivity in many cottage industries and petty trade is very low, even lower than the agricultural wage rate.[6/] So when people do not find any work, they engage in these activities as self-employed workers. As the demand for and the productivity of agricultural labor increases with technological progress, these activities may be relocated to the underdeveloped villages where these may increase employment opportunities for the lower-income groups. Further investigation is necessary to test this hypothesis.

Labor Market

General Conditions

The size of the labor market is found to be quite small. Only about 32 per cent of the labor hours were supplied against wages - 22 per cent in the agricultural and 49 per cent in the non-agriculture (Table 7.6). This is not surprising since the typical holding in agriculture is too small to provide full employment for family workers, and many agricultural workers generate non-farm employment on their own account in response to the lack of employment in the crop production sector.

TABLE 7.6

THE SIZE OF THE LABOR MARKET FROM THE SUPPLY SIDE, BY SECTORS

Sectors	Percent of households supplying labor in the market			Wage labor as a percent of total labor		
	Under-developed villages	Developed villages	Both groups	Under developed villages	Developed villages	Both groups
Agriculture	49.9	40.1	43.0	25.0	19.9	22.3
Non-agriculture	56.3	50.0	53.2	48.2	49.1	48.6
Total	67.9	63.4	65.7	35.0	29.5	32.3

Although the labor market is small, most of the cultivators hire labor at some time or other during the year (Table 7.7). The labor hiring households are a large majority even among small farmers cultivating less than one hectare. This may be the result of seasonality in the demand for agricultural labor. At busy periods labor must be hired to supplement family labor, while during slack periods, members of the same household will seek jobs in the labor market.

TABLE 7.7

THE NATURE AND THE SIZE OF AGRICULTURAL LABOR MARKET FROM THE DEMAND SIDE, BY LANDOWNERSHIP GROUP

Landownership group of farmers	Percent of farmers hiring attached workers		Percent of farmers hiring casual labor		Hired labor as a percent of total labor	
	Under-developed villages	Developed villages	Under-developed villages	Developed villages	Under-developed villages	Developed villages
Small	4.6	2.0	76.2	87.1	30.3	34.4
Medium	17.5	14.3	90.2	96.0	36.0	47.1
Large	54.8	33.3	100.0	100.0	55.9	60.2
All	15.4	9.5	84.5	91.1	40.6	46.7

Because of the seasonal variation in the demand and supply, the rural labor market is, in general, informal in nature and most workers are hired casually, on a daily basis, according to the need. During the year of survey, only one-eighth of all farmers and one half of the large farmers hired workers for a season or for the year. Two-fifths of those hired on a regular basis were children looking after livestock mostly employed for wage in kind of free board, meals, and clothin. Such employment is often determined by the level of absolute poverty in the village concerned rather than by the demand for regular workers by the employer.

The Impact of Technology

The technoogical progress increases the demand for labor in the agricultural sector. In the crop production activity, labor hired in casual basis account for about 47 per cent of the total labor used in the technologically developed villages compared to about 41 per cent in the underdeveloped villages (Table 7.7). The proportion of hired labor increases even for the small farmer group. So there is a downward pressure on the supply of hired labor from the farming households. This is one of the reasons why the proportion of labor supplied in the agricultural market is found to be lower in the technologically developed villages (20%) compared to the underdeveloped villages (25%) while the labor supplied in the non-agricultural market remains unchanged (Table 7.6).

It will be noted from Table 7.8 that most of the agricultural labor in the market is supplied by the landless and the marginal landholding groups. In the underdeveloped villages, two-thirds of the landless participate in the labor market and three-fourths of their employment is generated on others' account. The proportion are 13 and 3 per cent respectively for the large landownership group. In the developed villages labor supplied against wage is lower than in underdeveloped villages for all landholding groups and the difference

TABLE 7.8

PARTICIPATION IN LABOR MARKET FOR DIFFERENT LANDOWNERSHIP GROUPS

Landownership Groups	Agriculture				Non-agriculture			
	Percent of households supplying wage labor		Percent of labor supplied against wage		Percent of households supplying wage labor		Pecent of labor supplied against wage	
	Under-developed villages	Developed villages	Under-developed villages	Developed villages	Under-developed villages	Developed villages	Under-developed villages	Developed villages
Landless and marginal owner	67.7	73.7	74.0	52.5	74.0	69.5	51.8	58.3
Small	50.9	39.4	29.0	15.0	66.4	51.9	54.2	47.3
Medium	27.2	17.3	7.8	2.9	37.9	32.1	41.7	40.8
Large	12.9	2.9	2.9	0.3	16.1	32.4	10.0	27.1

is more pronounced for larger landowners. In the non-agricultural sector also, the participation rate in the market is inversely related with the size of landownership. But unlike in agriculture, the supply of labor in the market does not change much with technological advancement. In fact, the supply of wage labor in non-agricultural market is higher in developed villages for the landless and the large landowner groups. Thus, the tendency to avoid agricultural wage employment at higher levels of income and to shift to non-agriculture in response to higher employment opportunities puts a downward pressure on the supply of agricultural labor when the technology progresses. These forces operate to provide more employment and income to the lower income groups.

The wages received for hired-out labor (excluding payment in kind) in the two groups of villages are shown in Table 7.9. The wage rate was higher for non-agricultural labor than for agriculture and for male workers than for female. The agricultural wage rate for women was 44 per cent than for men in the underdeveloped villages. The comparison suggests that technological progress has a positive impact on the wage rate. For male workers, the agricultural wage rate in developed villages was 19 per cent higher than in underdeveloped villages, and the non-agricultural wage rate was 47 per cent higher.

TABLE 7.9

WAGE RATE RECEIVED FOR HIRED LABOR: BY THECHNOLOGY, LANDHOLDING AND SEX OF WORKERS

(Tk per labor hour)

Technology and landholding of family (acres)	Male workers		Female workers	
	Agriculture	Non-agriculture	Agriculture	Non-agriculture
Underdeveloped villages	1.53	1.95	0.68	1.16
Less than 0.5	1.46	1.74	0.53	1.21
0.50 - 2.0	1.61	2.15	1.34	1.25
2.00 & above	1.68	2.25	*	0.72
Developed villages	1.82	2.86	1.22	1.52
Less than 0.5	1.86	2.47	1.21	1.13
0.50 - 2.0	1.79	3.03	*	1.75
2.0 & above	1.63	3.29	*	1.91

Note: The wage exclude payments in kind of meals. The estimates for female workers for different landholding groups would be unstable, as it is based on a very small number of cases since female participation in the labor market is negligible.

*denotes that there was no case in the cell.

The wage rate paid by sample farmers for agricultural labor was about 25 per cent higher in technologically developed villages that in underdeveloped ones (Table 7.10). The difference in wage rate was higher for the small landowners (30 per cent) than the large ones (16 per cent). Thus, while the landless gain from the higher wages following technological progress, this factor would increase inequality in agricultural incomes acrooss the farm size scale.

TABLE 7.10

WAGE RATE PAID BY SAMPLE FARMERS FOR AGRICULTURAL LABOR IN TECHNOLOGICALLY DEVELOPED AND UNDERDEVELOPED VILLAGES, 1982

Size of Landownership	Underdeveloped villages		Developed villages		Percent difference in wage rate (developed over (underdeveloped)
	No. of cases hiring labor	Wage rate (Tk/day)	No. of cases hiring labor	Wage rate (Tk/day)	
Small	86	17.19	128	22.26	30
Medium	74	17.63	72	21.28	21
Large	27	16.34	32	18.90	16

Note: The wage include imputed value of payments in kind. The mean wage rate for the entire sample was Tk. 19.95 and the standard error of estimate Tk 0.26. The difference in wage rate between developed and underdeveloped villages was statistically significant for all group. The Bangladesh Bureau of Statistics estimated the wage rate for the contry as a whole at Tk. 17.05 for 1982/83.

Operation of the Labor Market - A Multi-Variate Analysis

An important limitation of the analysis presented above is that it is based on a partial approach since only two factors, the size of landownership and technology are taken into account. The labor market would be affected by a host of other factors including the wage rates, whose effects also need to be controlled for in assessing the impact of the new agricultural technology. This section attempts to broaden the analysis by applying the multi-variate regression technique.

Determinants of Labor Supply

Following Yotopoulos and Lau, and Bardhan,[7] the supply of labor by a rural household is assumed to be governed by the following function:

SLBR = f(OWNL, TECH, CPTL, FSZ, WRKR, FEM, EDCN, LVNG, VWAGE)

where, SLBR = The average weekly hours of labor put in by the household

OWNL = The amount of land owned by the household (in acres)

TECH = The amount of land cropped with modern varieties (in acres)

CPTL = The amount of non-land fixed assets owned by the household (in thousand Taka)

FSZ = The number of members in the household (persons)

WRKR = The number of family workers in the household

FEM = The number of female workers in the household

EDCN = The educational level of the head of the household (completed years of schooling)

LVNG = The standard of living in the village as measured by (the per capita consumption expenditure

VWAGE = The wage rate prevailing in the village (Tk per day)

In the utility function of an individual, leisure is considered as one of the consumer goods. Its cost is the wage income which has to be sacrificed if leisure is consumed. This would reduce the purchasing power of other consumer goods. So the choice between leisure and consumer goods will be determined by their relative prices, i.e., the wage rate and the prices of consumer goods. An increase in income from non-wage sources will shift the indifference curve upwards and hence the individual can have more of leisure and consumer goods at the same level of relative prices. Thus labor, which is the residual of the time available for work after the consumption of leisure, would be determined mainly by the wage rate, the prices of consumer goods, and the income from non-wage sources. It would be positively related with the wage rate and negatively related with the prices of consumer good. Owing to the difficulty of measuring the index of the prices of a large number of consumer goods, we have not been able to incorporate this variable in the labor supply function. Since the labor market is more fragmented, owing to the difficulty of mobility of workers, one expects a much larger variation in the wage rate among the cross-section of households than in the prices of consumer goods. The omission of this variable thus may not affect the results seriously.

The main determinants of the non-wage income are the assets owned by the household. The variables OWNL, TECH, CPTL, and EDCN have been incorporated to take care of the effect of this factor. Non-labor agricultural income would be higher the larger the amount of land owned by the household and the larger is the proportion of the land devoted to cultivation of modern varieties. The non-land fixed assets would provide scope for generating self-employment in non-agricultural activities, while education may open up opportunities for shifting to relatively higher paid employment in service activities, and hence for earning higher income from the same amount of labor. Thus, while capital and education may have a positive effect on non-agricultural employment, the higher income effect would put a negative pressure on the supply of labor. The net impact would depend on the magnitude of these two opposite effects.

The decision regarding the consumption of goods and services and the supply of labor is determined at the household level. So the composition of the household and of the working members may also affect he supply of labor. The higher the number of consumers (FSZ) relative to workers, the lower would be the per capita income from labor in the household and hence the higher would be the supply of labor. The larger the proportion of female workers, the lower would be the supply of labor since women also have to supply domestic labor and hence they would have less time available for productive work. So other things remaining constant, labor supply would be positively associated with family size and negatively associated with the number of female workers.

In estimating labor supply functions, questions are raised about appropriate measurement of the wage rate as an independnet variable.[8/] The wage rate derived from the information on wage earnings and labor hours worked outside the household, if incorporated in the function where the latter is used as the dependent variable, would pose well-known measurement error problems. For households who do not sell labor, the variable cannot be observed. The problem of simultaneity is also involved because at the household level, both the amount of labor supplied and the wage rate may be jointly determined by other variables. In order to avoid these problems, we have used the wage rate for agricultural labor prevailing in the village for all households. As Bardhan points out, the village level wage rate may be more exogenous to the individual household than the wage actually received, which may be determined by the amount of labor supplied, the level of income of the household, etc.

The labor supply functions estimated from the data for all households in the sample, for agriculture and non-agriculture, and for self- and wage employment, are reported in Table 7.11. The total supply of labor seems to be significantly related to all the variables included in the function. The model explains about two-thirds of the variation in the supply of labor among the sample households. A worker supplies on the margin about 30 hours per week, about three-fifths of which are on own account of the household (self-employment) and in the agricultural sector. A large number of dependents seems to necessitate more work by the earner. This additional work is, however, generated mainly in agriculture and on own account of the household. The coefficient of the family size variable is statistically insignificant and has opposite sign in the equation for non-agriculture and wage employment, indicating that such employment may be demand-determined i.e., even if the household is willing to supply additional labor to satisfy the consumption needs of a larger number of dependents, the employment may not be available in the market. A female worker puts in about 11 hours less labor than an average worker if she is employed in agriculture, but in non-agriculture the difference is insignificant.

The larger the size of land owned by the household, the less is the supply of labor, which supports the a prior expectation about labor-leisure substitution. Ownership of land, however, gives scope of generating more employment in agriculture, particularly, on own account. The value of the coefficient of land in the equation of self-employment shows that an additional acre of land ownership generates 1.36 hours of additional self-employment a week (about nine days per year). But the positive income effect of land ownership reduces the supply of labor in the market by about 2.45 hours a week. (16 days a year). Thus, on balance, the total supply of labor is reduced.[9/] The results also indicate that the larger the size of land, the less is the necessity for working in non-agricultural activities. Education gives additional scope for working in the non-agricultural sector, but the higher income effect of education, and the higher social status of the educated worker operate to reduce his supply of labor in agricultur . On balance, the better educated supply less labor in agriculture and on others' account. Among the income variables, only capital seems to increase the supply of labor. It reduces supply for the market, but the negative effect is more than compensated by the positive effect on creation of employment on own account, both in agriculture and in non-agricultural activities.

The supply of labor responds positively to the wage rate but mostly for non-agricultural labor. For agricultural labor, the coefficient of the wage variable is statistically insignificant. This is found to be the case for all land ownership groups from separate estimates of the supply functions for agricultural labor. The estimated coefficient of the wage rate, valued at the arithmetic mean of the

TABLE 7.11

ESTIMATES OF LABOR SUPPLY FUNCTIONS, ALL RURAL HOUSEHOLDS

Variables	All activities	Agriculture	Non-agriculture	Self-employment	Hired-employment
VWAGE	1.10*** (4.71)	0.07 (0.29)	1.03*** (3.73)	0.58** (2.12)	0.52* (1.93)
LVNG	-1.47*** (-6.51)	-0.97*** (-4.00)	-0.50* (-1.88)	-0.33 (-1.22)	-1.15*** (-4.44)
OWNL	-1.09*** (-2.80)	0.77* (1.83)	-1.86*** (-4.04)	1.36* (2.97)	-2.45*** (-5.49)
TECH	-2.18*** (-2.95)	1.86*** (2.34)	-4.04*** (-4.65)	0.04 (0.46)	-2.57*** (-3.05)
CPTL	0.34*** (3.89)	0.16* (1.74)	0.18* (1.72)	0.58*** (5.58)	-0.23** (-2.31)
FSZ	1.28*** (3.34)	1.55*** (3.78)	-0.27 (-0.61)	1.99*** (4.42)	-0.71 (-1.63)
WRKR	31.06*** (27.73)	18.34*** (15.23)	12.72*** (9.47)	18.03*** (13.68)	13.03*** (10.18)
FEM	-11.27*** (-4.76)	-11.13*** (-4.38)	-0.14 (-0.05)	-2.39 (-0.86)	-8.88*** (-3.29)
EDCN	-0.66** (-2.42)	-1.44*** (-4.91)	0.78** (2.43)	-0.23 (-0.71)	-0.43 (-1.39)
Constant	32.60*** (4.38)	28.34*** (3.54)	4.26 (0.88)	-4.77 (-0.54)	37.36*** (4.39)
$\bar{R}^2$	0.67	0.47	0.21	0.47	0.27
N	624	624	624	624	624
F	140.6	62.2	19.8	62.4	26.4

Figures within parentheses are estimated "t" values. The sample size consists of 624 households, with valid observations for all variables.

The level of significance of the "t" value * p<.01, ** p<.05, and * p<0.10.

variable, gives an elasticity of supply of non-agricultural labor at 0.71.

Another variable which is found to significantly affect the supply of labor is the standard of living in the village. This variable is measured by the per capita consumption expenditure at the village level. The value of the coefficient is negative and highly statistically significant, indicating that the higher the standard of living in the villages, the less is the supply of labor by its households. This variable affects mostly the supply of labor for the market - the negative coefficient in the equation for wage employment is statistically highly significant. The coefficient for self-employment is also negative but not statistically significant. This result suggests that improvement in economic conditions in a village, from whatever sources it may be, would reduce the supply of labor for the market which would give scope for more employment for workers from neighboring low-income villages and/or put an upward pressure on the wage rate.

For the present purpose, we are interested in the coefficient of the technology variable. After controlling for the effects of other variables, the coefficient of the technology variable is negative indicating that the diffusion of modern technology would depress the supply of labor. The value of the coefficient suggests that an increase in area under modern varieties by one acre would reduce the supply of labor on the margin by 2.2 hours per week (14 days per year). The technological progress creates opportunities for more employment in agriculture. The value of the coefficient in the equation for agriculture is found to be positive and statistically significant. But by raising incomes, it reduces the necessity for working in the non-agricultural activities. The negative effect on non-agricultural labor is more pronounced than the positive effect on agricultural labor. The difference is presumably due to the income effect of the technological progress. Technological progress also reduces the supply of labor for the market. The value of the technology coeficient in the equation for wage employment indicate that an increase in area under the new technology by one acre would reduce the supply of wage labor by 2.6 hours per week (17 days per year).

Table 7.12 reports the estimated labor supply functions for the landless and marginal landowning households. A close scrutiny of the results shows a behavioral pattern similar to that for all households in the sample, with a few exceptions. The coefficient of the size of landownership is not significant in either of the equations, which is understandable as this group owns only up to 0.5 acres of land. A worker in this group supplies about 30 hours, only 2.2 per cent less than for other groups, but unlike the landowning groups two-thirds of the labor is supplied to the market, mostly in agricultural activities. The total supply of labor is positively related to the wage rate, but the response is mostly for labor on own account. It appears that when the wage rates goes up, this group reduces hiring-in of outside labor, replaces it by more self-exploitation of family labor.

The technological progress generates additional agricultural employment for the landless compared to the landowning groups. This is achieved by substituting for non-agricultural labor. The positive effect on agricultural labor is more pronounced than the negative effect on the non-agricultural labor. On balance, the technology has a positive effect on labor supply for this group, although it is not

TABLE 7.12

ESTIMATES OF LABOR SUPPLY FUNCTIONS, LANDLESS HOUSEHOLDS

Variables	All activities	Agriculture	Non-agriculture	Self-employment	Hired employment
VWAGE	1.40***	0.57	0.89**	1.55***	-0.15
	(3.25)	(1.41)	(1.67)	(2.74)	(-0.27)
LVNG	-1.41***	-1.55***	0.14	0.02	-1.42***
	(-3.92)	(-3.71)	(0.31)	(0.03)	(-3.00)
OWNL	-5.00	-2.21	-2.80	0.24	-5.25
	(0.68)	(0.26)	(-0.30)	(0.03)	(-0.54)
TECH	1.14	8.24**	-7.10***	4.76	-3.61
	(0.36)	(2.21)	(-1.68)	(1.13)	(-0.85)
FSZ	3.52***	3.12***	0.40	3.96***	-0.44
	(3.74)	(2.85)	(0.32)	(3.20)	(-0.36)
WRKR	30.38***	19.93***	10.45***	10.43***	19.95***
	(12.52)	(7.07)	(3.28)	(3.27)	(6.23)
FEM	-2.41	-13.75***	11.34**	14.85***	-17.26***
	(-0.58)	(-2.89)	(2.08)	(2.71)	(-3.14)
EDCN	-0.15	-1.31*	1.15	0.88	-1.03
	(-0.23)	(-1.76)	(1.38)	(1.05)	(-1.23)
Constant	12.51	15.09	-2.58	-44.88***	57.39***
	(0.99)	(1.02)	(-0.16)	(-2.67)	(3.42)
$\bar{R}^2$	0.68	0.41	0.17	0.31	0.26
N	191	191	191	191	191
F	52.28	17.02	5.81	11.49	9.35

Figures in parentheses are estimated "t" values.

Level of significance of "t" value, *** p<.01, ** p<.05, * p<.10.

statistically significant. It is also interesting to note that like the landowning groups, the landless also reduces the supply of labor to the market in response to technological progress.

Determinants of Demand for Agricultural Labor

The survey collected information on the demand for labor only for crop production activity. The information was collected from the farming households at the crop level for three agricultural seasons. Table 7.13 presents the information for different groups of farm households. The total demand for labor in the crop production activity in the developed villages was about 27 per cent higher than in underdeveloped villages. Most of the increase, however, is on account of hired labor. compared to underdeveloped villages, an average household in the developed villages used 42 additional days of labor, 34 days being met by employment of hired workers. The additional self-employment for family labor is mostly on account of small farm households. The demand for hired labor was about 56 per cent higher in developed villages and the additional employment was generated more on the smaller farms (131 per cent) than in the large ones (19 per cent). It appears that large farmers kept the upward pressure on the wage rate low (Table 7.10) by hiring in labor relatively less than small and medium farmers.

TABLE 7.13

USE OF LABOR IN CROP PRODUCTION IN DEVELOPED AND UNDER-DEVELOPED VILLAGES, BY THE SIZE OF LAND OWNED BY FARMERS

(Number of days per household)

Landownership Group	Family Labor			Hired Labor			Total Labor		
	Under-developed villages	Deve-loped vill-ages	% dif-ference	Under-developed villages	Deve-loped vill-ages	% dif-ference	Under developed villages	Deve-loped vill-ages	% dif-ference
Small	52.7	72.0	36.6	19.8	45.8	131.1	72.5	117.8	62.5
Medium	118.4	106.3	-10.2	66.5	94.8	42.6	184.9	201.1	8.8
Large	155.1	155.5	0.3	196.6	234.4	19.3	351.7	389.9	10.9
Farm Households	90.9	98.5	8.4	61.3	95.3	55.5	152.2	193.8	27.3

Note: The table excludes the functionally landless households. A few of them were engaged in farming and used farm labor, which is not accounted for.

The following demand function for hired labor was estimated from the data.

$$\text{DLBR} = \underset{(4.23)}{68.29} + \underset{(10.74)}{8.72}\ \text{LAND} + \underset{(13.11)}{27.76}\ \text{TECH} - \underset{(-0.58)}{1.64}\ \text{WRKR}$$

$$- \underset{(-2.99)}{2.27}\ \text{VWAGE} - \underset{(-4.00)}{0.48}\ \text{TNC}$$

$$\bar{R}^2 = 0.49 \qquad F = 95.9 \qquad N = 461$$

where DLBR is the number of labor days hired in from outside the household in the crop production activity; LAND is the total cropped area in acres; TECH is the area devoted to cultivation of modern varieties;WRKR is the number of family workes in the household; TNC is the number of cropped area under tenancy; and VWAGE is the wage rate in Taka per day estimated at the village level. The figures within parentheses are the estimated 't' values of the coefficient. As expected the demand for labor is positively associated with cropped land but negatively associated with the proportion of area under tenancy. The wage rate, measured at the village level, affects the demand for labor. The coefficient of the variable is statistically significant at less than one per cent probability error. The value of the coefficient evaluated at the mean level of the variable gives a wage elasticity of demand for labor at -0.58. The coefficient of the technology variable suggests that technological progress would increase the demand for labor significantly. The estimated "t" value of the regression extremely high. The value of the coefficient indicates that an increase in area under the new technology by one acre would increase the demand for hired labor in crop production by about 28 days.

The labor demand function has also been estimated with the alternative specification of the wage rate at the household level. The results are the following:

$$\underset{}{DLBR} = \underset{(4.80)}{73.19} = \underset{(10.78)}{8.70}\ LAND - \underset{(-0.56)}{1.59}\ WRKR + \underset{(13.48)}{28.06}\ TECH$$

$$- \underset{(-4.08)}{0.48}\ TNC - \underset{(-3.55)}{2.53}\ HWAGE$$

$$\bar{R}^2 = 0.51 \qquad F = 97.4 \qquad N = 408$$

where, HWAGE is the wage rate in the Tk per day paid by the household and other variables, as defined earlier. The results are similar except that the value of the coefficient for the wage rate increases and its statistical significance improves. The wage elasticity of demand for labor at this value is estimated at -0.65.

The Impact of Technology on the Wage Rate

As mentioned earlier, the survey did not collect information on in-migration of labor from outside the sample and on demand for labor in non-farm activities. So it is not possible to balance the supply and demand for labor in order to estimate a simultaneous equation system for determination of the wage rate.

The single equation estimation of the supply and demand for agricultural labor, however, indicate that technological progress may significantly affect the wage rate. It generates opportunities for additional self-employment in agriculture which reduces the supply of labor in the market by the landowning households. On the other hand, it increases the demand for farm labor in the market and thus a gap develops between the demand for and supply of labor by the landowning households in the technologically developed villages. The gap may be filled in by supply of more labor from the landless group within the villages and/or by out-migration of labor from labor-surplus household in villages where the technology has not yet progressed far. In this way, the forces in the labor market may operate to redistribute income from higher to lower income groups within the developed villages, and from developed to relatively underdeveloped villages. The results also show that as technology progresses even the landless in the developed villages supply less labor to the market. This indicates the possibility of considerable in-migration of labor from underdeveloped villages, in the absence of which there would be an upward pressure in the wage rate for clearing the labor market.

In order to see the impact of the technology on the wage rate, we estimated a wage equation incorporating all variables which significantly affect the supply and demand for agricultural labor. After elimination of the statistically insignificant variables, the following wage equation has been obtained:

$$\underset{}{VWAGE} = \underset{(46.95)}{19.32} - \underset{(-4.19)}{0.26}\ LAND + \underset{(10.59)}{1.25}\ TECH + \underset{(2.38)}{0.44}\ TNC$$

$$- \underset{(-4.10)}{0.72}\ WRKR + \underset{(1.71)}{0.10}\ EDCH$$

$$\bar{R}^2 = 0.22 \qquad F = 26.1 \qquad N = 408$$

Figures within parentheses are estimated "t" value. If wages are exogenously determined, we would have expected all variables to be statistically insignificant. But nearly a fifth of the variation in wage rate across the villages is explained by the above variable. Technology seems to be the most important variable affecting the wage rate. This is also found to be the case when wage rate is measured at the household level, as shown by the following equation:

$$HWAGE = \underset{(51.12)}{19.50} - \underset{(-3.56)}{0.23}\ LAND + \underset{(9.84)}{1.24}\ TECH - \underset{(-3.72)}{0.68}\ WRKR$$

$$+ \underset{(2.01)}{0.39}\ TNC$$

$$\bar{R}^2\ 0.18 \qquad F = 26.5 \qquad N = 408$$

VII. Conclusions

The modern technology affects the labor market mainly through the income variable. At higher levels of income, households substitute leisure for labor and supply less labor in the market. This redistributes employment from higher to lower income groups. Even the poor supplies less labor in the market as income increases with technological progress. But the demand for agricultural labor goes up because of the higher labor intensity of modern varieties, which puts an upward pressure on the wage rate and increases wage earnings from the same amount of labor. These forces in the labor market may also operate to redistribute some employment and income from technologically developed to underdeveloped villages, by promoting rural-rural migration. Unfortunately, the present survey did not collect any information on migration and so a direct testing of hypothesis is not possible.

Chapter 7 Notes

1. According to the land occupancy survey of 1978, the first attempt in the country to get information on landownership, 15 per cent of rural households did not own any land, and 29 per cent owned only homestead land. But households who claimed no more than one-half acre of land other than the homestead, who are considered in Bangladesh as "functionally landless", constituted 50 per cent of rural households in that year. According to the latest agricultural census, in 1983/84 nine per cent of the households did not own any land, and 46 per cent own less than one-half acre. About 40 per cent of the household reported agricultural wage labor as the main occupation, two-thirds of them belonged to households who owned less than 0.5 acres. See, F.T. Jannuzi and J.T. Peach, The Agrarian Structure of Bangladesh op. cit. p. 110, and the Bangladesh Bureau of Statistics National Report on 1983-84 Census of Agriculture and Livestock Holdings in Bangladesh, Table 1.1 and Table 2.6A.

2. John mellor, The New Economics of Growth: A Strategy for India and the Developing World, Ithaca, Cornell University Press, 1976. For detailed empirical investigations, see among others, P.B.R. Hazell, and Alisa Roell, Rural Growth Linkages: Household Expenditure Pattern in Malaysia and Nigeria, Research Report 41, Washington DC, International Food Policy Research Institute, 1983: Mahabub Hossain, "Agricultural Growth Linkages: The Bangladesh Case", The Bangladesh Development Studies 15 (No 1, 1987).

3. The crude activity rate is estimated at 30.0 percent for the country as a whole, 34.2 per cent for urban areas, and 29.4 per cent for rural areas. The Bangladesh Bureau of Statistics Preliminary Report of Labor Force Survey 1983-84, October 1984, Table 4, p.24.

4. In Bangladesh there is a social stigma against women working in the field or performing manual labor on others' account. The women from very poor families, however, try to earn or save expenditures by organiziang production around the homestead under pressure of poverty. About 70 per cent of the people who take loans from the Grameen Bank, an institution created for providing credit to landless households, are women. They take loans mostly for livestock and poultry raising, cottage industry, and shop-keeping activities. A large survey in 1979 found that nearly two-fifths of the workers employed in cottage industries were women and 84 per cent of them were unpaid family laborers. As agricultural incomes increase, the demand for these activities in which the poor women can find employment may also go up. See, Hossain, Mahabub, "Credit for Alleviation of rural Poverty: The experience of Grameen Bank in Bangladesh", (mimeo), IFPRI, September 1986; "Employment and Labor in Bangladesh Rural Industires", The Bangladesh Development Studies, 12 (March-June 1984); 1-24.

5. In rural Bangladesh open unemployment is rare because family members share the household work but underemployment is considerable. Estimates of the rate of underemployment for the country as a whole are not available. The estimate from different micro-studies for the recent period varies from 28 to 43 percent. A part of the difference is, of course, due to regional variations as most of the studies cover only a few villages and in different areas of the country, but a large part of the variation can also be attributed to differences in concepts and definitions particularly regarding the full employment norm. See, Atiq Rahman and R. Islam, Labor Use in Rural Bangladesh: A Study with Micro-Level Data, Asian Regional Team for Employment Promotion, ILO, Bangkok, 1985 (mimeographed): Iqbal Ahmed, "Unemployment and Underemployment in Bangladesh Agriculture", World Development 6 (December 1978): 1281-1296: Mahmud Khan, "Labor Absorption and Unemployment in Rural Bangladesh", The Bangladesh Development Studies, 13 (September-December 1985); 67-88.

6. On estimates of productivity of labor in cottage industries and petty trade see, Mahabub Hossain, "Productivity and Profitability of Bangladesh Rural Industries", The Bangladesh Development Studies, 12 (March-June 1984): 127-161 and Credit for the Rural Poor: The Grameen Bank in Bangladesh, (Chapter 4), Research Monograph No. 4, The Bangladesh Institute of Development Studies, Dhaka, 1984. The former study has found that if the cost family labor is imputed by the agricultural wage rate, the profit becomes negative for a large number of cottage industries, such as net and rope making, cane and bamboo works, mat making, and rice processing by indigenous methods, which account for about one-third of the cottage industry employment. These activities are undertaken to raise household income through employment of female labor and of male labor during off-peak agricultural seasons, which have very little opportunity cost.

7. Yotopoulos and Lau derives a labor supply function of the household from an indirect utility fnction, while Bardhan employs a pragmatic approach to explain the labor market participation behavior of peasant households. See, Pan, A. Yotopoulos and L.J. Lau, "On Modeling the Agricultural Sector in Developing Economics", Journal of Development Economics, 1 (1974) 105-127: Bardhan, P.K., "Labor Supply Functions in a Poor Agrarian Economy", American Economic Review, 69 (March 1979): 73-83. Other major works which cover this issue are, L. J. Lau et al, "The Linear Logarithmic Expenditure System: An Application to Consumption-Leisure Choice", Econometrics 46 (July 1978): 843-868; M.R. Rosenweiz, "Rural Wages, Labor Supply and Reform: A Theortical and Empirical Analysis", The American Economic Review, 68 (December 1978): 847-861.

8. P.K. Bardhan, "Labor Supply in a Poor Agrarian Economy", op cit.

9. Values of regression coefficients reported in the table are those obtained by the OLS method. Since some of the cases have zero values for the dependent variable (the number was large for the category of hired employment) the censored regression method is more appropriate for estimation of the supply functions for different categories of employment. We estimated the equations using the Tobit method and found the parameter values somewhat different but the general conclusions remained valid. We chose to present the OLS estimates because the sum of the parameters of the specific variables in functions for different categories of labor add up to the parameter for that variable in the supply function for total labor.

8: LINKAGE EFFECTS OF AGRICULTURAL GROWTH

Introduction

It was shown in Chapter 4 that the diffusion of the new technology would substantially increase the income from crop production. The crop sector accounts for about 77 per cent of the agricultural income in the country. The technological progress is thus expected to have a significant effect on the growth of agricultural incomes.

Agricultural growth involves linkages to non-farm sectors and the poor may gain indirectly through the generation of employment in these activities.[1/] The linkages may be generated from the supply side through the investment of the new surpluses by the land-owners, and/or from the demand side through income induced expenditure on non-farm goods and services. The growth of agricultural incomes may also increase the opportunity for investment and employment in non-farm rural activities through its effects on (i) the demand for irrigation equipment and other modern agricultural inputs produced in non-agricultural sector; (ii) the demand for services for processing and marketing of the additional surplus produce; (iii) the demand for trade and transport services arising out of the additional purchase of non-farm products and so on.

Empirical studies for a number of developing countries show that the linkage effects of agricultural growth can be substantial.[2/] Bell, Hazell, and Slade concluded from a study of Muda irrigation project in Malaysia that for each dollar of agricultural income project in Malaysia that for each dollar of agricultural income created directly by the project, an additional 80 cents of value added was created indirectly in the local non-farm sector. In a study of interrelationships between agricultural and industrial growth performance in India, Rangarajan found that a one per cent addition to the agricultural growth induced a 0.5 per cent incremental growth of industrial output and 0.7 per cent additional growth of national income. Recognizing the importance of such expenditure induced growth linkages, Mellor argued that contrary to the conventional wisdom, agriculture can play the role of the leading sector in the process of development.[3/]

This chapter attempts to assess the nature and extent of such linkage effects by analysizing the expenditure pattern of the sample households in the technologically developed and underdeveloped villages. The data on expenditures were collected from two types of interviews. Information on daily necessities was collected on a weekly basis asking households about consumption and purchases of these items for the week preceding the date of interview. This survey was conducted eight times during 1982 representing busy, normal, and slack seasons of economic activities in the sample villages. The expenditure on these items for the whole year was then estimated on the basis of the eight weeks' data. The information on expenditures on major items, such as clothing, household effects, education, recreation, and health and acquisition and repair of fixed assets was collected four times during the year retrospectively on a quarterly basis.

Expansion of Market: An Analysis of Consumption Pattern

Methodology

The commodities and services consumed have been classified into the following groups for studying the consumption induced linkages:

Crops	: Rice, wheat, other grains, roots, vegetables, pulses, fruits, spices, betel nut and betel leaves, rice husk, jute stick.
Forestry	: Firewood, leaves
Livestock	: Meat, milk, eggs, cow dung
Fishery	: Raw and dried fish
Rural Processing	: Raw sugar (gur), bidi, tobacco, mustard oil, sweets, handloom clothes, tailoring
Urban Processing	: Sugar, tea, citarette, soyabean oil, coconut oil kerosine oil, electricity, matches, soap, soda, toiletry, mill made clothing, ready made garments, imported new and old clothes, shoes
Services	: Education, health, transport, personal services, social services, religious services.

The impact of the growth of income on the demand for the various goods and services has been studied by estimating an Engel function of the following type on the cross section data.[4]

$$(1)\ E_i = \alpha_i + \beta_i E + \gamma_i E \log E + M_i \log F + \lambda_i E \log F$$

where, E is the per capita expenditure of the household, E_i is the amount of expenditure incurred on the consumption of goods in the ith group, and F is the number of persons in the households. This a non-linear function which allows for variation in the marginal budget share for the ith group, MBS_i, at different levels of income, which can be derived as follows:

$$(2)\ MBS_i = \beta_i + \gamma_i (1 + \log E) + \lambda_i \log F$$

The size of the family would have an important bearing on the economic position of the household at a given level of income and hence it has been included in the equation as an important socio-economic variable influencing consumption behavior of the household.

In order to avoi the problem of heteroscedasticity, that the variability in the E_i increases with the explanatory variable E, the function has been fitted in the following expenditure share from which is derived from (1).

$$(3)\ S_i = \beta_i + \alpha_i/E + \gamma_i \log E + M_i \log F/E + \lambda_i \log F$$

where $S_i = E_i/E$ is the share of the expenditure. The disadvantage of estimating the share equation is that the Value of $\bar{R}^2$ is typically small,[5/] but it ensures the desirable property that the sum of the marginal budget share is equal to unity.[6/]

Since per capita income is a better measure of the economic standing of the household, as compared to the household income, the expenditure variable has been measured in per capita terms. But the household size has been included so that the model permits this variable to influence both the intercept and the slope of the individual Engel functions.

Discussion of Results

The estimated parameters for the Engel function are reported in Table 8.1. As the function is estimated in the expenditure share from, the value of $\bar{R}^2$ is in general low. For forestry, livestock, fishery, and rural processing, the value of $\bar{R}^2$ is less than 0.10 indicating the share of these commodities in total expenditure does not vary much with the level of income, which suggests that the expenditure elasticity of demand is close to unity. But the value $\bar{R}^2$ is relatively high for crop sector outputs and services, which indicates that the expenditure elasticity of demand for them deviate significantly from unity. The value of the coefficient, Y, shows what happens to the marginal budget share as the level of income changes. The estimated value of this variable is significantly negative for crop sector output showing that the incremental expenditure on these commodities declines with increases in income. The value is significantly positive for livestock, manufacturing goods and services.

The estimates of marginal budget share and the expenditure elasticity of demand derived from the parameters of the Engel's function are reported in Table 8.2. About two-thirds of the expenditure is allocated to commodities produced in the crop and forestry sector, where the share of land in value added is very high. But the marginal budget share for these commdoties is 53 per cent, which suggests that with increases in income, people spent proportionately much less on these items. The expenditure elasticity of demand is estimated at 0.77 for crops and 0.79 for the forestry products.[7/] Among agricultural commodities, livestock and fishery products have elastic demand,

TABLE 8.1

ESTIMATES OF ENGEL FUNCTION, RURAL HOUSEHOLDS, 1982

Commodity Groups	Estimated Values of the Parameter					$\bar{R}^2$	SEE
	α	β	γ	μ	λ		
Crop	-230 (4.73)	2.779 (18.15)	-0.2575 (-14.86)	-2.251 (-0.64)	-0.0017 (-0.99)	0.44	0.073
Forestry	23.7 (1.43)	0.031 (0.60)	-0.0012 (0.20)	-0.65 (0.54)	-0.0021 (-3.53)	0.08	0.025
Livestock	-0.38 (-0.02)	-0.116 (-2.39)	0.0195 (3.54)	1.286 (1.157)	0.0004 (0.76)	0.08	0.023
Fishery	-40.9 (-3.53)	0.061 (1.68)	-0.0007 (-0.02)	2.66 (3.18)	-0.0016 (-3.93)	0.09	0.017
Rural processing	92.8 (3.79)	-0.342 (-4.44)	0.0502 (5.76)	-3.01 (-1.71)	0.0020 (2.25)	0.06	0.037
Urban processing	39.9 (1.41)	-0.409 (-4.61)	0.0596 (5.92)	1.53 (0.75)	-0.0005 (-0.49)	0.12	0.043
Services	114.7 (3.29)	-0.990 (-9.03)	0.1255 (10.10)	0.38 (0.15)	0.0033 (2.64)	0.28	0.052

Figures within parentheses are estimated "t" values.

Note: The function was estimated in the following form:

$$S_i = \beta_i + \alpha_i / E + \gamma_i \log E + \mu_i F/E + \lambda_i F$$

where S_i is the share of the commodity group in total consumption expenditure, E is the per capita consumption expenditure and F is the number of persons in the household.

TABLE 8.2

ESTIMATES OF MARGINAL BUDGET SHARES AND EXPENDITURE ELASTICITY OF DEMAND

Commodity Groups	Average Budget Share (percent)	Marginal Budget Share (percent)	Expenditure Elasticity of Demand
Crops	64.94	50.26	0.77
Foresting	3.59	2.82	0.79
Livestock	4.22	5.80	1.38
Fishery	3.95	5.01	1.27
Rural Processing	9.51	11.22	1.18
Urban Processing	7.51	11.21	1.49
Services	6.21	13.46	2.17

the marginal share of these products is 11 percent while the average share is eight percent. Manufacturing goods have a share of 17 percent of the total budget, nearly 56 percent of which are produced in rural areas. These commodities also have elastic demand, the share of them in the incremental expenditure is nearly 23 percent. The expenditure is, however, more elastic for goods produced in urban areas.[8/] With increase in income, the marginal share of manufacturing goods of rural origin increase less than proportionately.

But the highest elasticity of demand is for rural service sector activities, in which the labor's share of income is very high. Nearly 13 percent of the enlarged market for goods and services go to the service activities. The expenditure elasticity is estimated at 2.2, indicating that with a 10 percent in total expenditure, the demand for the service sector activities would increase by about 22 percent. All non-farm goods and services together share about 47 percent of the incremental expenditure and has elasticity of 1.5.

For assessing the impact of technological progress on the demand for various types of commodities, Engel's function has been estimated separately for the technologically developed and underdeveloped villages. The estimates of demand derived from the parameters for the two groups of villages are reported in Table 8.3. It will be noted from the results that for both groups of villages, the pattern of expenditure is almost similar to that obtained earlier for the entire sample. Crops and forestry products have inelastic demand while services and urban manufacturing products have the most elastic demand. With technological progress, the difference becomes even more pronounced due to the increase in the level of income. The per capita income in developed villages was 22 percent higher than in underdeveloped one (see Chapter 9 below). In the underdeveloped villages, 42 percent of the incremental expenditure was spent on cereals, but in the developed village, the share was 31 percent. The expenditure elasticity of demand for cereal is 0.64 in the developed villages compared to 0.79 in underdeveloped villages. Roots and vegetables have inelastic demand, the marginal budget share and the value of elasticity is lower in the developed villages. Pulses have highly elastic demand but its average and marginal consumption are lower in developed villages presumably because of reallocation of land from pulses to MV rice. Among food items meat, egg and milk have expenditure elasticity

TABLE 8.3

EXPENDITURE PATTERN OF HOUSEHOLDS IN DEVELOPED AND UNDERDEVELOPED VILLAGES, 1982

Commodity Groups	Under Developed Villages			Developed Villages		
	Average share	Marginal share	Expenditure elasticity	Average share	Marginal share	Expenditure elasticity
Crops:	67.0	56.5	0.84	62.9	45.0	0.71
Cereal	53.0	42.1	0.79	49.1	31.2	0.64
Pulses	1.1	1.3	1.24	0.8	1.2	1.56
Roots and Vegetables	5.4	4.7	0.87	4.8	3.1	0.65
Fruits	2.1	3.4	1.62	1.9	3.0	1.57
Spices	3.4	2.9	0.84	3.7	3.3	0.91
Betel nut and Betel leaves	0.9	1.4	1.55	1.3	1.3	1.00
Rice husk and Jute sticks	1.0	0.7	0.70	1.3	1.7	1.30
Forestry:	4.1	3.2	0.78	3.1	2.7	0.88
Firewood	2.0	2.6	1.29	1.5	2.1	1.38
Leaves	2.1	0.6	0.30	1.6	0.7	0.43
Livestock:	4.4	5.7	1.29	4.0	6.4	1.59
Meat and egg	1.6	3.2	2.0	2.1	4.4	2.10
Milk	0.9	1.8	1.93	1.3	2.4	1.92
Cow dung	1.9	0.6	0.33	0.7	-0.4	-0.58
Fishery:	3.6	4.2	1.19	4.4	5.3	1.22
Manufacturing:	16.7	22.9	1.37	17.5	22.7	1.29
Rural origin	9.5	12.4	1.30	9.5	10.3	1.09
Urban origin	7.2	10.5	1.46	7.8	12.4	1.56
Services:	4.2	7.5	1.79	8.2	17.9	2.18

Note: Figures are derived from commodity specific Egel functions estimated from household level data. The figures may not add up due to rounding errors.

of 2.0 and their share of the marginal budget 6.8 per cent in developed villages compared to 5.0 per cent in underdeveloped villages. The most significant difference in the marginal budget share is found for service sector activities. In the underdeveloped villages only nine per cent of the incremental expenditure was spent on these items, in the developed villages, the share was about 18 per cent. Only for rural manufacturing the value of the expenditure elasticity is lower in the developed village but the absolute value is still greater than unity. It is indicated by the above findings that the market for livestock and fishery products, manufacturing and services expands more than proportionately as technological progress increases rural incomes. The most significant effect is on service activities, where labor's share of income is high compared to other commodity groups.

Reinvestment of Surplus

Investment defined as additions to the value of fixed assets and working capital is classified here into two broad groups -- <u>dirctly productive investment</u> and <u>other investment</u>. Investment in agricultural and non-agricultural enterprises are regarded as directly productive investment. Agricultural investment includes expenditure on land development (such as land levelling, fencing, clearing of water hyacinth, raising small embankments in fields for improved water control, digging field channels for irrigation, etc.); purchase of agricultural machinery and tools, equipment and draught animals, purchase of cattle and poultry for rearing, and expenditure on digging of ponds and planting trees. Non-agricultural investment includes purchases of industrial mchinery and tools, transport equipment, purchases of shares and debentures, and additions to the fixed and working capital for trade and business. Changes in the stock of output and raw materials for agriculture and industry could not be taken into account due to lack of information. Non-monetary investment in the form of the use of family labor has been imputed by the prevailing market wage rate.

Households also incur expenses on construction and improvement of housing and cattle sheds, education of children, digging of wells and tubewells for drinking purposes, and on construction of latrines. These may be termed as social investment for formation of human capital which may increase the productivity of labor in the long run. Expenditures on household durables such as furniture and fixtures, electrical goods, metal and earthen utensils, etc. have also been treated as investment.

A significant number of households have been engaged in transactions which may be termed as <u>transfers</u>. These include purchases and sales of land, receipts and repayments of loans and interests, expenses on account of litigation, theft of property, etc. At the aggregate level, the net transfers should be zero. For the sample under study, however, the net transfer was found to be significantly positive, indicating the possibility of an underreporting of negative transfers, which people tend to suppress. Because of the conceptual problems involved, these items have not been included in investment.

The pattern of investment in the technologically developed and underdeveloped villages can be reviewed from Table 8.4. total investment per households was almost the same for the two groups, but because

TABLE 8.4

THE PATTERN OF INVESTMENT IN TECHNOLOGICALLY DEVELOPED AND UNDERDEVELOPED VILLAGES, 1982

Types of Investment	Amount per household		As a percent of gross investment		As a percent of total expenditure	
	Under-developed villages	Deve-loped vill-ages	Under-developed villages	Deve-loped vill-ages	Under-developed villages	Deve-loped vill-ages
Directly Productive Investment:						
Agriculture:	1039	881	32.9	28.2	5.6	3.9
Land development	106	135	3.4	4.3	0.6	0.6
Agricultural tools and equipment	408	75	12.9	2.4	2.2	0.3
Draft animals and livestock	494	645	15.6	20.6	2.6	2.9
Other agriculture	31	26	1.0	0.8	0.2	0.1
Non-agriculture:	1132	769	35.9	24.6	6.1	3.4
Industry	225	29	7.1	0.9	1.2	0.1
Business	874	711	27.7	22.7	4.7	3.4
Transport	33	29	1.1	1.0	0.2	0.1
Other Investment	986	1477	31.2	47.2	5.3	6.5
Housing	727	1186	23.0	37.9	3.9	5.3
Sanitation	27	29	0.9	0.9	0.1	0.1
Consumer durables	232	262	7.3	8.4	1.3	1.2
Total Investment	3157	3127	100.0	100.0	16.9	13.9
Total Expenditure (Consumption plus ivestment)	18640	22600	—	—	100.0	100.0

of higher levels of expenditure, the rate of investment was lower in the developed villages (14%) compared to the underdeveloped villages (17%). The difference is mainly on account of the directly productive investments, which accounted for 11.7 per cent of the total expenditure in underdeveloped villages compared to 7.3 per cent in the developed villages. Two items on which households in developed villages spent proportionately more are construction of housing and acquisition of livestock animals. But the rate of investment on agricultural equipment and tools, cottage industry and business was significantly higher in the underdeveloped villages.

Table 8.5 shows the pattern of investment for different landownership groups. As expected, the rate of investment is positively associated with the size of landownership. For the landless and small landowning households, the rate of investment was almost similar in the technologically developed and underdeveloped villages. But the medium and large landowners in the developed village accumulated proportionately much less than their counterparts in the underdeveloped villages. It is interesting to note that the large landowners invested relatively less for capital formation in agriculture compared to the small and medium landowners. A similar finding was reported by Rahman from a survey of two areas in 1975.[9/]

Capital formation in non-agricultural activities was significantly higher in the technologically underdeveloped villages. Since the scope of accumulation of land is limited in these villages, rural households try to increase income trhough accumulation in non-agriculture, as the market for non-farm goods and services expands with the

TABLE 8.5

THE PATTERN OF INVESTMENT FOR DIFFERENT LANDOWNERSHIP GROUPS, 1982

Area and Land Ownership Groups	Directly Productive		Other Investment		Total
	Agriculture	Non-agriculture	Housing & Sanitation	Consumer Durables	
Underdeveloped Villages:					
Marginal landowner	2.3	3.8	1.7	0.7	8.5
Small	5.4	2.1	3.5	2.0	13.0
Medium	7.1	5.3	5.2	1.0	18.6
Large	5.8	14.3	4.9	2.0	26.3
Developed Villages:					
Marginal landowner	1.2	2.2	4.0	1.1	8.4
Small	6.2	1.6	3.6	1.1	12.6
Medium	3.6	6.0	4.2	1.1	14.9
Large	3.5	2.7	10.4	1.4	18.0

technological progress. But the opportunity is taken up more by the upper income households. In the underdeveloped villages the non-agricultural investments as a proportion of total expenditure is about 14 per cent for the large landowning households compared to two to five per cent for the other landholding groups.

The information presented in this section thus leads to the following main conclusions. First technological progress does not necessarily lead to higher capital formation in agriculture. This may be a reflection of the fact that investment in irrigation, which is the main vehicle of technological progress is done by the government. Second, the expansion of market for non-farm goods and services seems to stimulate more non-agricultural investment in the villages where the technology has progressed less. This may be explained by the fact that the new technology provides an opportunity for increasing income from the land for households in the developed villages. Since such an opportunity is lacking in the underdeveloped villages, the households look for opportunities in the farm sector to increase their incomes. Third, the income from the investment induced linkages tends to be unequally distributed. Because of the higher levels of income, accumulated savings and better access to financial institutions, the large landowners can respond more to opportunities of investment in the non-farm sector than the landless and small landowners, although the latter may gain from creation of additional employment in these activities.

Impact on the Land Market

A factor on which much emphasis has been given in the literature[10/] to explain the negative income distribution effects of the modern technology is the impact of agricultural surplus on the rural land market. By increasing the profitability of cultivation, the new technology inflates the surplus of the large landowners and increases the value of land. On the other hand, it would make cultivation difficult on the part of the marginal landowners, since the working capital requirement for cultivation of the new varieties is substantially higher, and the poor have little access to credit from financial institutions. It is argued that with technological progress these forces will operate to increase the transaction in the rural land market and the large landowners would buy out the marginal farms, leading to further accumulation of land in the hands of the rich and a higher concentration of income.

The survey collected information on the source of acquisition of each plot of land owned by the sample households. This information can be used to empirically test the above hypothesis. If technological

TABLE 8.6

SOURCES OF ACQUISITION OF LAND IN TECHNOLOGICALLY DEVELOPED AND UNDERDEVELOPED VILLAGES

Source of Acquisition of Ownedland	Underdeveloped Villages		Developed Villages	
	Land owned per household (decimals)	Percent of total land	Land owned per household (decimals)	Percent of total land
Inheritance from parents	162	72.0	142	62.8
Inheritance from in-laws	3	1.3	7	3.1
Purchased	57	25.3	72	31.9
Others	3	1.3	5	2.2
Total	225	100.0	226	100.0

diffusion is associated with high transactions in the land market, the proportion of land obtaied through the market would be higher for households in the technologically developed villages, compared to those in the underdeveloped villages. The findings reported in Table 8.6 tend to support the hypothesis. In developed the time of the survey was inherited from parents, compared to 72 per cent for households in the underdeveloped villages, which suggests that the former group of households had been engaged in land transactions after inheritance much more than the latter. The proportion of land acquired through purchase was reported at 32 per cent for the developed villages compared to 25 per cent for the underdeveloped villages.

A more direct test of the hypothesis could be made with information on land purchases and sales during the year of the survey. An important limitation on this information is that investment of land is a large indivisible expenditure and the household may have to accumulate for a number of years in order to buy a piece of land. So it is difficult to get a representative picture of the behavior of an individual household from information for one year. A representative picture may be obtained by looking at mean values for a large number of households in homogenous group. The group would incur such expenditures every year.

The proportion of households who participated in the land market in 1982 and the extent of transactions involved can be reviewed from Table 8.7. The following major points can be noted from the Table.

The land maket is very thin. Less than 10 per cent of the households participated in the market during the year of survey and the maximum amount of transactions (sold or purchased) was less than two per cent of the amount of land. The net transaction was positive in the developed villages and negative in the underdeveloped villages. The accumulation of land in the developed village is partly at the expense of the small landowners within the villages. For the small

TABLE 8.7

TRANSACTIONS IN THE LAND MARKET IN TECHNOLOGICALLY DEVELOPED AND UNDERDEVELOPED VILLAGES, 1982

Area and Land Ownership groups	Amount Transacted as a Percent				
	Percent of Households		of Ownedland		Net accumulation as a per cent of owned land
	Purchased Land	Sold Land	Purchased Land	Sold Land	
Underdeveloped Villages:	8.8	8.2	1.11	1.79	-0.68
Marginal and small landowner	4.9	8.8	2.05	4.98	-2.93
Medium landowner	13.6	4.9	0.92	0.70	0.22
Large landowner	22.6	2.9	0.85	1.31	-0.46
Developed Villages:	9.8	8.8	1.73	1.30	0.43
Marginal and small landowner	5.0	7.0	1.32	2.18	-0.86
Medium landowner	16.3	13.8	1.47	2.09	-0.62
Large landowner	21.6	8.1	2.03	0.30	1.73

farmer group, the proportion of land sold was much less in the developed compared to the underdeveloped ones which suggests that by increasing income per unit of land, the technological progress reduces the necessity to sell land. The highest accumulation, however, was by the large landowning groups in the developed villages. They increased the size of landownership by 1.7 percent during the year of survey.

The result seem to support the hypothesis of the negative effect of technological progress on income distribution through accumulation of land. The impact, however, is very small. During 1982, the households in the developed villages accumulated only 0.4 percent of the holdings. At the rate of accumulation even the large landowners would take 13 years to increase the size of large holding by only a quarter. On the other hand, without technological progress the small and marginal landholdings would get smaller at a faster rate.

Conclusions

The increase in agricultural incomes significantly expands the market for non-farm goods services, many of which are located in rural areas. The share of these commodities of the incremental budget is 52 percent for the technologically developed villages compared to 40 percent in the underdeveloped villages. The market of cottage industry products and services which are located mostly in rural areas also expands more proportionately than the increases in comes. Thus, rural households may indirectly gain from employment generated in these activities. But the income growth does not promote capital accumulation in agriculture, presumably because the investment on irrigation, which is the main vehicle for technological progress, is done by the government. The opportunity for additional investment in non-agriculture is taken mainly by the higher income groups in the technologically underdeveloped villages. The technological progress seems to follow more investment on the formation of human capital and also more accumulation of land by large landowners in the developed villages. This suggests that unless the higher income groups are induced to invest in production activities, or their surplus is siphoned off for acceleration of public investment, the diffusion of the new technology may led to further inequality in the distribution of landholding and agricultural incomes both regionally and across income scales.

Chapter 8 Notes

1. J.W. Mellor, The New Economics of Growth, op.cit.

2. Peter Hazell and Alisa Roel Rural Growth Linkages, op.cit; C. Rangarajan, Agricultural Growth and Industrial Performance in India, Research Report No. 33, Washington DC, IFPRI, 1982.

3. J.W. Mellor, The New Economics of Growth, op.cit.

4. For details of this form of the Engel Function and its characteristives see, P. Hazell and Alisa Roel, op.cit.

5. The value of R^2 for this equation measures the extent to which the variation of the average budget share of the commodity across the sample is explained by the variation in income. If the marginal budget share is equal to the average share, i.e., the expenditure elasticity of demand is unity, the average budget share would be the same across the income level and the value of R^2 would be zero.

6. S.J. Press and H.S. Honthaker, The Analysis of Family Budgets, Cambridge University Press, Cambridge, 1971.

7. Not all commodities in this group have expenditure elasticity less than unity. Pulses and fruits have highly elastic demand, but their share of the budget was less than four percent. See supplementary table.

8. The manufactured goods which have elastic demand are bidi, tobacco, kerosin oil, washing soda, and old readymade garments which are imported from aborad for the poor. As incomes increase, bidi and tobacco are substituted by cigarettes, washing soda is substituted by soaps, and the kerosin oil which is used as fuel is a basic necessity and is also substituted by electricity in areas of developed infrasturcture. The other substitute commodities are gur and sugar, the former is produced in villages. While the expenditure elasticity of gur is lower than that of sugar, it is still higher than unity. See supplementary table.

9. Atiq Rahman, "Surplus Utilization and Capital Formation in Bangladesh Agriculture", The Bangladesh Development Studies, 8 (No.4, 1980).

10. See for example, Andrew Pears, Seeds of Plenty and Seeds of Want, op. cit.

9. EFFECT ON INCOME DISTRIBUTION AND POVERTY

The impact of the differential rate of adoption of the new technology among farmers, the prices of products and inputs faced by them and the effect of the technology on production, employment, and expansion of the market for non-farm goods and services would ultimately be felt on the changes in the level and distribution of rural incomes. This chapter attempts to assess the impact from direct information on household incomes.

Since rural households do not keep records of their activities, it is difficult to estimate income accurately, particularly for activities conducted on a self-employed basis. Most rural households are also involved in many expenditure saving activities such as production of fruits and vegetables in kitchen gardens, rearing of poultry, fishing from nearby creeks and canals, processing of food and manufacturing of personal and household effects, basically for consumption of the family. There is a tendency to under-report these activities, since the respondents do not generally consider these activities as sources of income.

In this survey we have been careful to collect information as comprehensive as possible for estimating income. A detailed questionnaire on inputs and outputs for crop production activities was administered three times during the year at the end of each cropping season in order to reduce errors attributable to faulty memory. Input-output information on processing, manufacturing, and trading activities was collected through quarterly surveys. The wage income and the irregular expenditure saving activities were recorded in the weekly consumption, expenditure, and employment survey which was administered eight times during the year. The annual incomes from these sources have been estimated by extrapolating from the estimates for the eight weeks.

The Level and Structure of Income

The estimates of income obtained from the survey for households in technologically developed and underdeveloped villages can be reviewed from Table 9.1. For the entire sample, the average household income is estimated for 1982 at Tk 21,000 and per capita income, Tk 3304. The latest national level household expenditure survey conducted by the Bangladesh Bureau of Statistics estimates the per capita rural income for 1983/84 at Tk 3883, which yields Tk 3347 at 1982 prices which is very close to our estimate.[1]

The total household inocme was 29 percent higher in the technologically developed villages compared to the underdeveloped villages, indicating a positive effect of the technology on the level of income. The number of persons per household is also higher in the developed area[2], so that the difference in per capita income is less, about 22 percent.

As expected, the new technology has a more pronounced effect on agricultural incomes than on non-agricultural incomes. Nearly 61 percent of the household income originates from the agricultural sector, 52 percent from crop and vegetable production and 9 percent from livestock and fishing. In developed villages, the crop sector income (including agricultural wages) was 48 percent higher and total

TABLE 9.1

STRUCTURE OF HOUSEHOLD INCOMES IN TECHNOLOGICALLY DEVELOPED AND UNDERDEVELOPED VILLAGES, 1982

Sources of Income	Underdeveloped Villages		Developed Villages		Increases in Income in developed villages as % of that in underdeveloped villages
	Income per household (Tk/annum)	Percent share of the source	Income per household (Tk/annum)	Percent share of the source	
Agriculture:	11178	61.0	15644	66.2	40.0
Crop cultivation	6258	34.1	9265	39.2	48.1
Kitchen gardening	2465	13.5	2730	11.5	10.8
Livestock and poultry rasing	1272	6.9	1511	6.4	18.8
Fishing	287	1.6	1099	4.6	283.0
Agricultural Wages	896	4.9	1039	4.4	16.0
Non-agriculture:	7151	39.0	7994	33.8	11.8
Cottage Industry	726	4.0	268	1.1	-63.1
Trade	886	4.8	1889	8.0	113.2
Services	3268	17.8	4417	18.7	35.2
Non-agricultural Wages	2271	12.4	1420	6.0	-37.5
Total household income	18329	100.0	23638	100.0	29.0
Family Size	6 19		6.52		5.3
Per Capita Income	2961		3626		22.4

agricultural income, 40 percent higher compared to underdeveloped villages. The increase in agricultural income was 54 per cent for crop cultivation, and 16 percent for agricultural wages. The absolute level of non-agricultural income was also higher in the developed villages, but the difference is substantially less than for agricultural income. The income from trade and other services was about 52 percent higher in the developed villages, but the income from cottage industry and non-agricultural wage was lower by about 44 percent, which pushed down the income difference from non-agricultural sources between these two groups of households. Many cottage industries are low productivity activities and part of the non-agricultural wages are earned from domestic service and earthwork, the jobs which are not preferred at higher levels of income. As argued in the chapter on employment, the stimulus from agricultural growth for these activities appears to be taken by households in underdeveloped villages and by lower income groups.

Table 9.2 measures the income effect for different landownership groups by comparing the estimates for the developed and underdeveloped villages. It is found that among the farming households, the positive income difference for developed villages is higher for the larger landowning groups; 34 percent for the large landowner compared to 22 percent for the small and 28 percent for the medium owner, which suggests a trend towards inequality in the distribution of income among farm households. But the group which have gained the most is the functionally landless, the bottom one-third of the rural households

TABLE 9.2

IMPACT OF TECHNOLOGY ON INCOME FOR DIFFERENT LANDHOLDING GROUPS

Landownership Group	Underdeveloped Villages (Tk/household)	Developed Villages (Tk/household)	Difference in developed villages as percent of underdeveloped Villages
Agricultural Income:			
Landless and marginal owner	3,708 (3,549)	8,000 (6,151)	116 (73)
Small	9,201	11,234	22
Medium	16,190	20,685	28
Large	29,437	39,435	34
Non-agricultural Income:			
Landless and marginal owner	6,036	6,264	4
Small	6,819	7,071	4
Medium	8,119	7,618	-6
Large	9,372	16,721	78
Total Income:			
Landless and marginal owner	9,743 (9,585)	14,264 (12,415)	46 (30)
Small	16,020	18,305	14
Medium	24,309	28,303	16
Large	38,809	56,156	45

Note: Figures within brackets are household incomes for the group excluding the income from fishing. One of the villages under study has a high concentration of commercial fishermen most of whom belong to the landless and marginal landower group. The village is included in the developed area and so the high income of the landless from fishing in the developed villages may show a spuriously high positive impact of the new technology on the income for this group.

on the landownership scale. For this group, the income from agricultural sources is more than double in the developed villages compared to the underdeveloped villages. Further disaggregation of results for this group shows that a major source of the difference in income is due to fishing (Supplementary Table). Commercial fishing in Bangladesh is highly localized and in our sample, it was concentrated in one village, where land per person is extremely low but a large proportion of land was irrigated and cultivated with high yielding varieties. The poor in this village earn a large proportion of their income from fishing, which cannot be attributed to the new technology. But even if fishing is excluded, agricultural income for the landless was 73 per cent higher for the developed villages compared to underdeveloped villages, still higher than the income difference for the large landowning groups. The difference is mostly on account of income from cultivation (204 per cent) and agricultural wage (79 per cent). The transfer of irrigated land to marginal landowners through the tenancy market for cultivation of the modern varieties of rice was an important mechanism for increasing the income of the poor from cultivation. In the undeveloped villages a large proportion of marginal land owners rented out their tiny holdings and were dependent on the agricultural labor market and non-farm activities for their livelihood. Only 32 per cent of the sample households who own less than 0.5 acres of land received income from crop cultivation in underdeveloped villages, compared to 58 per cent in developed villages. For the farm households in this group, the average income from crop cultivation was 65 per cent higher in developed villages than in underdeveloped ones.

The figures in Table 9.2 show that the income gains from the non-agricultural sources have remained confined mostly to the large landowning group. Compared to underdeveloped villages, the income from non-agricultural sources in developed villages is about 78 per cent higher for the large landowner, but six per cent lower for the middle landowning group. Because of this unequal distribution of the incremental income from the non-agricultural sources, the difference in gains for the landless and the large landowning groups narrows down. For these groups the household income in the developed villages was about 45 per cent higher, about three times the gains for the small and medium landowning groups.

The transfer of incomes to various landholding groups through the operation of the labor market can be assessed from wage earnings from agricultural and non-agricultural labor. The survey estimates of the income from this source for the two groups of villages are reported in Table 9.3. The findings are similar to those reported in Chapter 7 about employment effects of the new technology. The agricultural wage income is inversely related with the size of landholding and large landowners earn very little from this source. The agricultural wage income is about 16 per cent higher in developed villages, but this is exclusively due to the functionally landless group, whose income from this source was about 79 per cent higher in the developed villages. With increases in income the landowning group participate less in the agricultural labor market; their income from this source was substantially lower in the developed villages compared to the underdeveloped ones. Only for the large landholding group was the wage income from non-agricultural labor higher in

TABLE 9.3

INCOMES EARNED THROUGH THE LABOR MARKET: BY TECHNOLOGY AND LANDHOLDING GROUPS

Land-ownership Groups	Agricultural Wage Income (Tk per Household)			Non-agricultural Wage and Salary Incomes (Tk per Household)		
	Under-developed villages	Deve-loped villages	Percent diffe-rence	Under-developed villages	Deve-loped villages	Percent diffe-rence
Landless and marginal landowner	1,326	2,370	79	2,546	2,163	-15
Small	1,147	753	-34	2,850	1,364	-52
Medium	366	184	-50	1,835	761	-58
Large	31	94	n.e.	349	1,000	187
All Groups	897	1,039	16	2,271	1,420	-37

n.e. - not estimated due to very small income from wage earning for this group.

developed villages. The smaller landholding groups had lower non-agricultural wage earnings in developed villages, indicating that with increases in agricultural incomes they withdraw some of the labor from the non-agricultural labor market. The income loss from this source was more pronounced for the small and medium landowners than for the landless.

Impact Effect of Technology: A Regression Estimate

The previous section assessed the income effect of the modern technology by comparing the estimates of income for households in technologically developed and underdeveloped area. A limitation of the approach is that besides technology, a host of other factors determine income, whose effects cannot be dissociated when comparing mean values of the variables for the two groups. A more appropriate method of assessing the income effect of the new technology would be to fit a regression model, relating income to its determinants and incorporating technology as an additional explanatory variable.

The following regression model was fitted to explain household income:

INCM = f(OWNL, TNC, CPTL, WRKR, EDCN, DPND, TECH, OWNL[2/])

where, INCM = Annual income of the household (Tk)

OWNL = Land owned by the household (acres)

TNC = Land rented in by the household (acres)

CPTL = The value of non-land fixed assets (Tk)

WRKR = The number of family workers (persons)

EDCN = Educational level of the head of the household (completed years of schooling)

DPND = Dependency ratio as measured by the number of consumers per worker in the household.

The adoption of the technology at the household level, TECH, has been measured by three alternative specification of the variable, the amount of land irrigated, LIRGN, the amount of land sown under the modern varieties of rice, LMV, and the expenditure on chemical fertilizers (in Tk), FERT. Owing to the strong correlation among these three variables, each variable has been entered alternatively in the model to explain agricultural incomes.

The dependency ratio has been included to test the Chayanovian hypothesis that in a peasant economy, the motive force behind the economic activity is the consumer-worker balance in the family.[3/] It has already been found to be a significant variable affecting the labor supply of the household.

The square of owned land has been added to allow the marginal return from land to vary with the size of landownership. It has already been observed that crop yield varies inversely with farm size and that larger landonwers prefer more leisure, which indicate that the marginal return from land will decline with the increase in the size of landownership.

The estimated values of the parameters of the income equation for total household income, as well as for agricultural and non-agricultural incomes are reported in Table 9.4. The model explains about 55 percent of the variation in agricultural income and 52 percent of the variation in total income within the sample households. Land, both owned and rented, number of workers and the use of the new technology is found to be significant determinants of agricultural income. The value of non-land fixed assets does not significantly contribute to agricultural incomes. The coefficient of this variable is not statistically significant in either of the agricultural income equations. The value of the regression coefficient for agricultural income (Equation 1) indicate that an acre of owned land contributes at the margin Tk. 3,200 while one family worker at the margin earns about Tk. 1300 per annum. The marginal contribution of rented land is less than one-third of that of owned land. This is understandable in view of the stringent conditions of the sharecropping arrangement that the tenant bears all costs of non-land inputs and pays a half of the gross produce to the landowner.

The coefficient of all three technology variables in alternative equations for agricultural income is statistically significant at less than one percent probability error. As discussed in Chapter 3 and 6, irrigation, MV seeds and fertilizers are highly complementary and so the separate effect of each of the variables is difficult to measure. The value of the regression coefficient of each of the three technology variables thus measures the composite effect of all of them.

The marginal return from an acre of irrigated land is estimated at Tk. 5712 (3244 + 2468).[4/] Thus irrigated land and the associated increase in MV area and fertilizer use increases agricultural income at the margin by about 76 percent over that of non-irrigated land. The value of the coefficients of land variables in the estimated equation (2) for agricultural income indicate that an acre of land under modern varieties increases agricultural income on the margin by about Tk. 5116; about 51 percent higher than the income earned at the margin from land devoted to traditional crop varieties (tk 3387). One taka of expenditure on fertilizer seems to increase agricultural income on the margin by Tk. 2.17.[5/]

TABLE 9.4

DETERMINANTS OF RURAL HOUSEHOLD INCOMES: REGRESSION ESTIMATES, 1982

Variables	Agricultural Income			Non-agricultural Income	Total Income
	Equation (1)	Equation (2)	Equation (3)		
OWNL		3244***	3387***	3486***	2003459***
	(14.24)	(14.87)	(14.63)	(1.08)	(11.26)
$(OWNL)^2$	-63***	-43***	-41***	-2.5	-43***
	(7.54)	(5.28)	(-4.82)	(-0.36)	(-3.93)
TNC	1067***	627*	708**	-183	351
	(3.27)	(1.90)	(2.08)	(-0.66)	(0.78)
CPTL 1/	0.021	-0.005	0.015	0.205***	0.101***
	(0.54)	(-0.13)	(0.35)	(6.04)	(2.66)
WRKR	1313***	975***	1075***	2095***	3125***
	(3.64)	(2.65)	(2.82)	(6.68)	(6.22)
EDCN		-123	-113	-129	249***
172	(-1.50)	(-1.37)	(-1.51)	(3.50)	(1.52)
DPND	636	799*	848*	827**	1649***
	(1.41)	(1.75)	(1.79)	(2.13)	(2.65)
LIRGN	2468***				
	(7.87)				
LMV		1729***		375*	1973***
		(7.22)		(1.89)	(6.13)
FERT				2.17***	
			(3.57)		
CONSTANT	1757	1978	1980	256	2045
	(1.43)	(1.56)	(1.53)	(0.24)	(1.20)
R^2	0.55	0.55	0.53	0.19	0.52

1/ Capital is measured as agricultural capital for the agricultural increase income equation, non-agricultural capital - non-agricultural income, etc. The sample size consists of 629 households with valid observations for all variables in the equation.

Figures within parentheses are "t" values. The significance of "t" values *P<0.10, ** P<0.05, *** P<0.01

The main determinants of non-agricultural incomes are the number of workers in the family, accumulation of non-agricultural assets, education, and the consumption pressure of the family. The regression coefficients of these variables are statistically significant at less than five percent probability error. The explanatory power of the model in however weak as indicated by the low value of R^2. This suggests that there may be other variables which determines non-agricultural incomes and/or the estimate of non-agricultural income at the household level involves a large margin of error. Education increases household income mainly through involvement of the worker in the non-agricultural sector. The estimated value of the coefficient suggests that an additional year of schooling increases non-agricultural income on the margin by Tk 250 per annum, but it is achieved partly at the expense of agricultural income, so its effect on total household income is less. The rate of return on accumulation of non-agricultural capital appears to be 21 per cent. The households who cultivate more land with modern varieties have higher levels of non-agricultural income. This may be the effect of reallocation of family labor from agricultural to non-agricultural activities, which has been explained in Chapter 7. The value of this coefficient is statistically significant at less than 10 per cent probability error.

In the estimated equation for total household income, the coefficient of the technology variable is found to be highly statistically significant. The values of the coefficient of the land variable (OWNL and LMV) show that a shift of land from traditional to modern varieties would increase the marginal return from land by about 57 per cent. The coefficient of the square term of land is negative and highly statistically significant. It indicates that the marginal income from land declines with increases in the size of landownership. This may be the result of the negative income effect on the supply of labor, as reported in Chapter 7, which operates particularly in the agricultural sector. This finding also supports the hypothesis that when income increases, the forces in the labor market may operate to redistribute some income from the upper to the lower income groups.

Distribution of Income

The sample households have been ranked on the basis of the per capita income and the incomes shares of successive decline groups have been estimated in order to see the pattern of distribution of income in the sample. The impact of the technological progress on income distribution has been assessed by comparing the income share of various groups in the technologically developed and underdeveloped villages. The results can be reviewed from Table 9.5 and also from Figure 1 which shows Lorenz curve depicting the pattern of income distribution across the landownership scale.

The income distribution is fairly unequal. The bottom 40 per cent of the household in the per capita income scale get about 21 per cent of the total income, while about 24 per cent of the income accrue to the top 10 per cent of the household. The pattern of distribution of income in developed villages was found almost similar to that estimated for rural Bangladesh by the national level household expenditure survey of 1981-82. The income, however, appears to be more unequally distributed in the technologically developed villages. The income share of the top 10 per cent of the household is about

TABLE 9.5

DISTRIBUTION OF HOUSEHOLD INCOME IN THE TECHNOLOGICALLY DEVELOPED AND UNDERDEVELOPED VILLAGES

Ranking of households according to per capita income	Share of Income of the Group (Percent)		
	Sample Households, 1982		
	Underdeveloped villages	Developed villages	Rural Bangladesh 1981/82/a
Bottom 20%	7.7	8.0	7.1
Second 20%	13.4	13.2	11.7
Third 20%	18.4	17.0	16.2
Fourth 20%	24.0	21.9	22.6
Top 20%	36.5	39.9	42.4
Top 10%	21.4	25.8	26.7
Top 5%	10.7	15.6	16.8

a/ The households have been ranked by total household income.

Source: The figures for rural Bangladesh are from the Bangladesh Bureau of Statistics, Report of the Bangladesh Household Expenditure Survey, 1981-82, Dhaka, March 1986.

Figure 1: Lorenz curve showing the pattern of distribution of income in developed and undeer-developed villages along per capita income scale

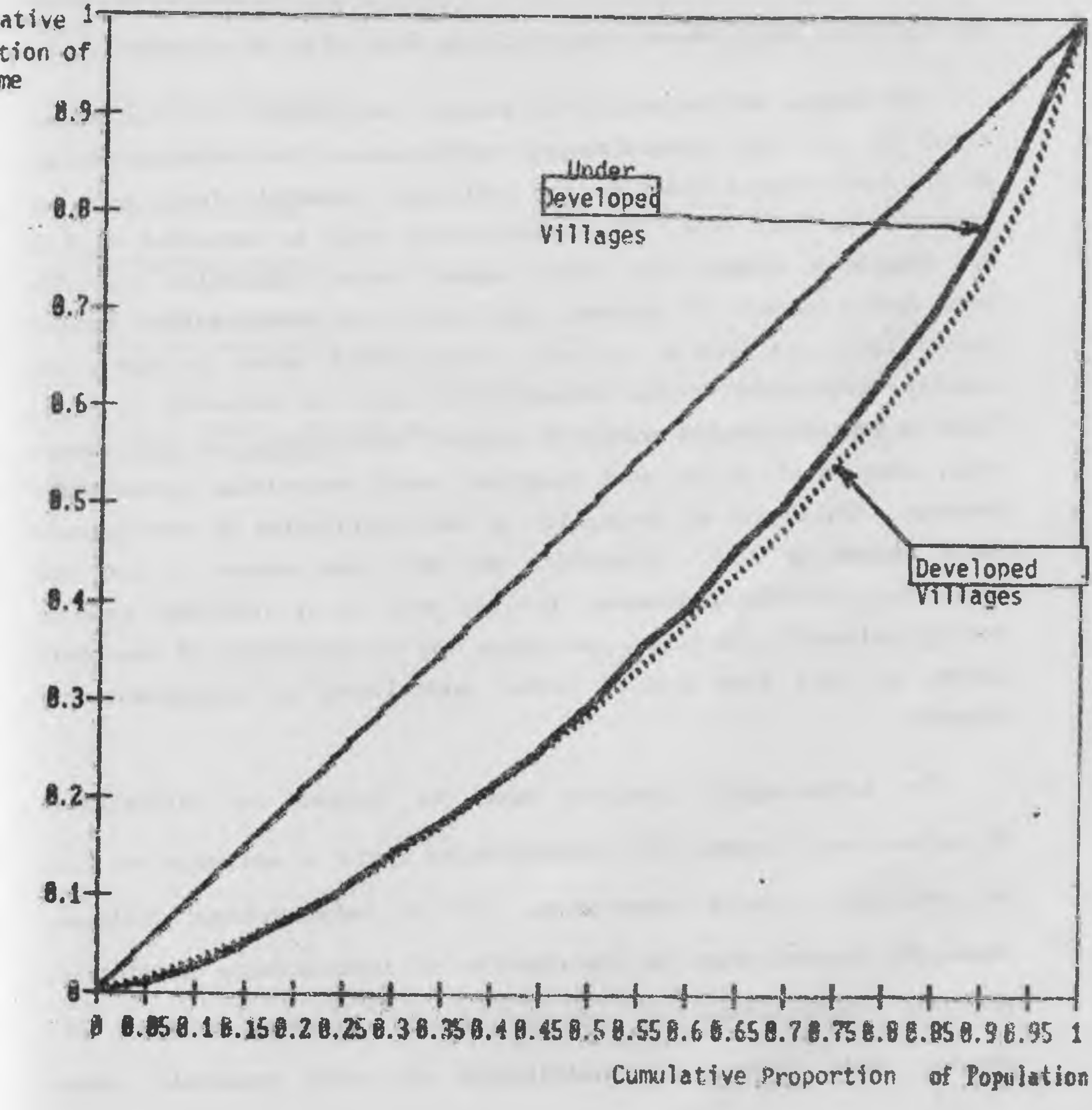


TABLE 9.5

DISTRIBUTION OF HOUSEHOLD INCOME IN THE TECHNOLOGICALLY DEVELOPED AND UNDERDEVELOPED VILLAGES

Ranking of households according to per capita income	Share of Income of the Group (Percent)		
	Sample Households, 1982		
	Underdeveloped villages	Developed villages	Rural Bangladesh 1981/82/a
Bottom 20%	7.7	8.0	7.1
Second 20%	13.4	13.2	11.7
Third 20%	18.4	17.0	16.2
Fourth 20%	24.0	21.9	22.6
Top 20%	36.5	39.9	42.4
Top 10%	21.4	25.8	26.7
Top 5%	10.7	15.6	16.8

a/ The households have been ranked by total household income.

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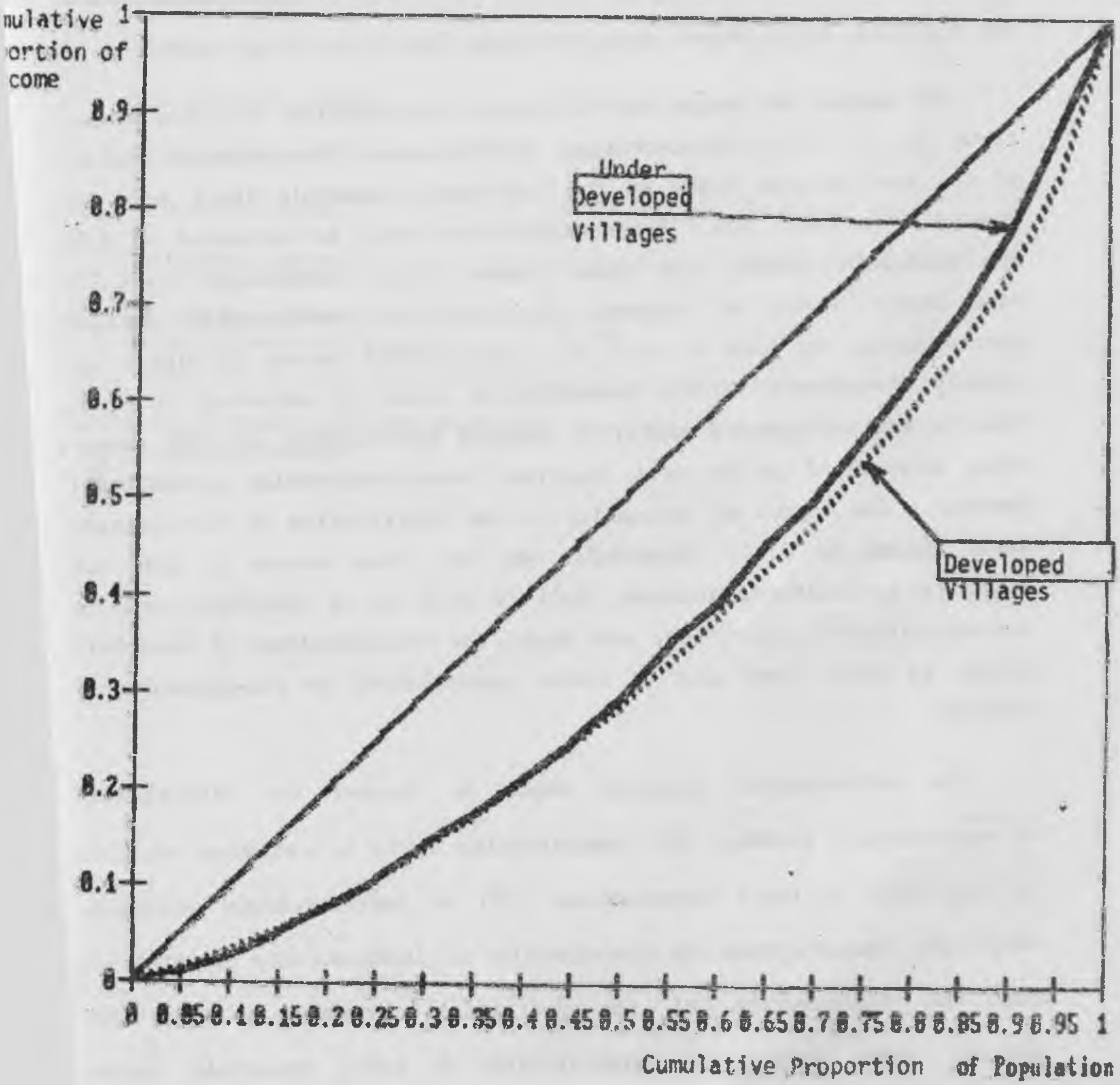

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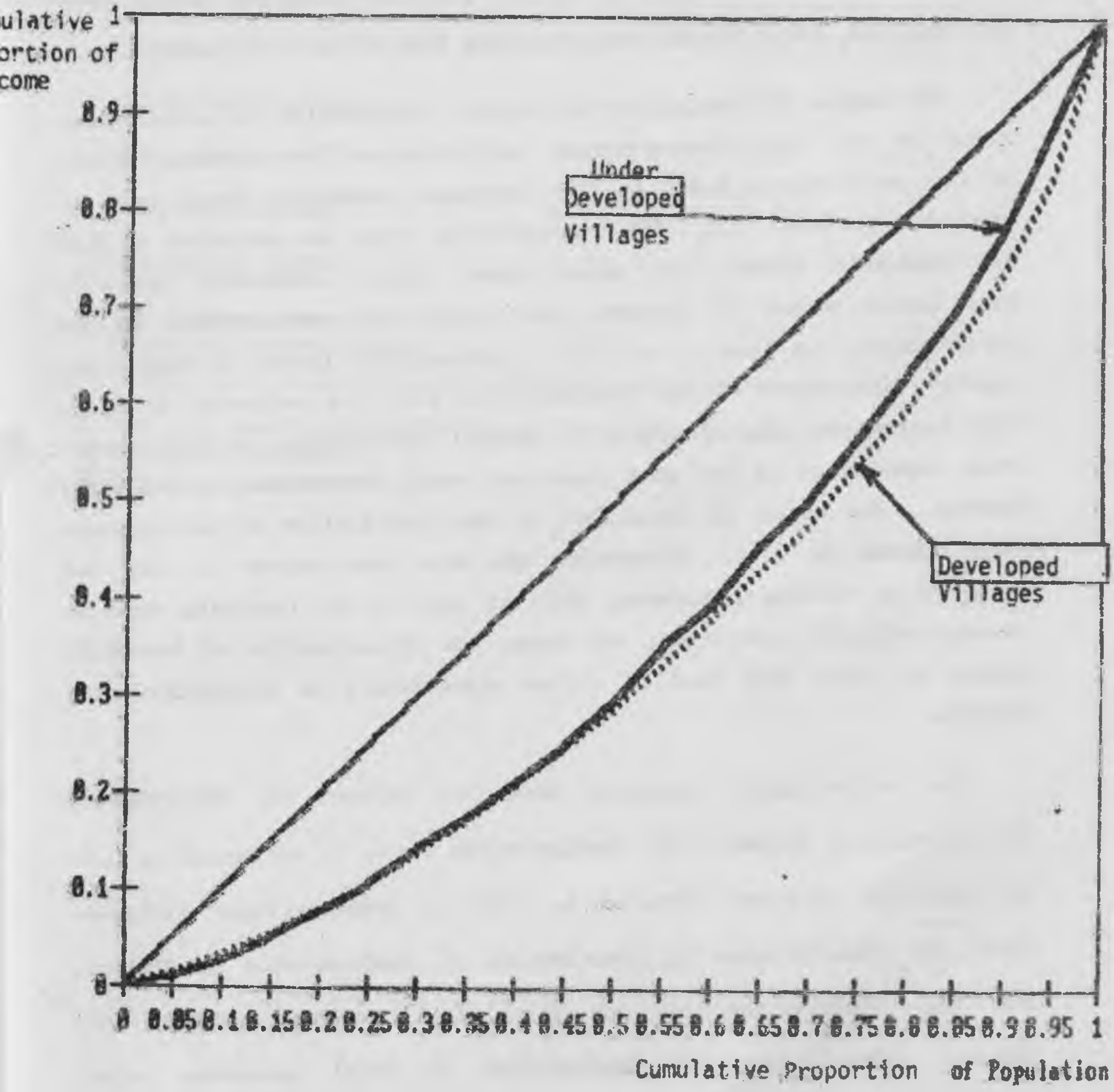

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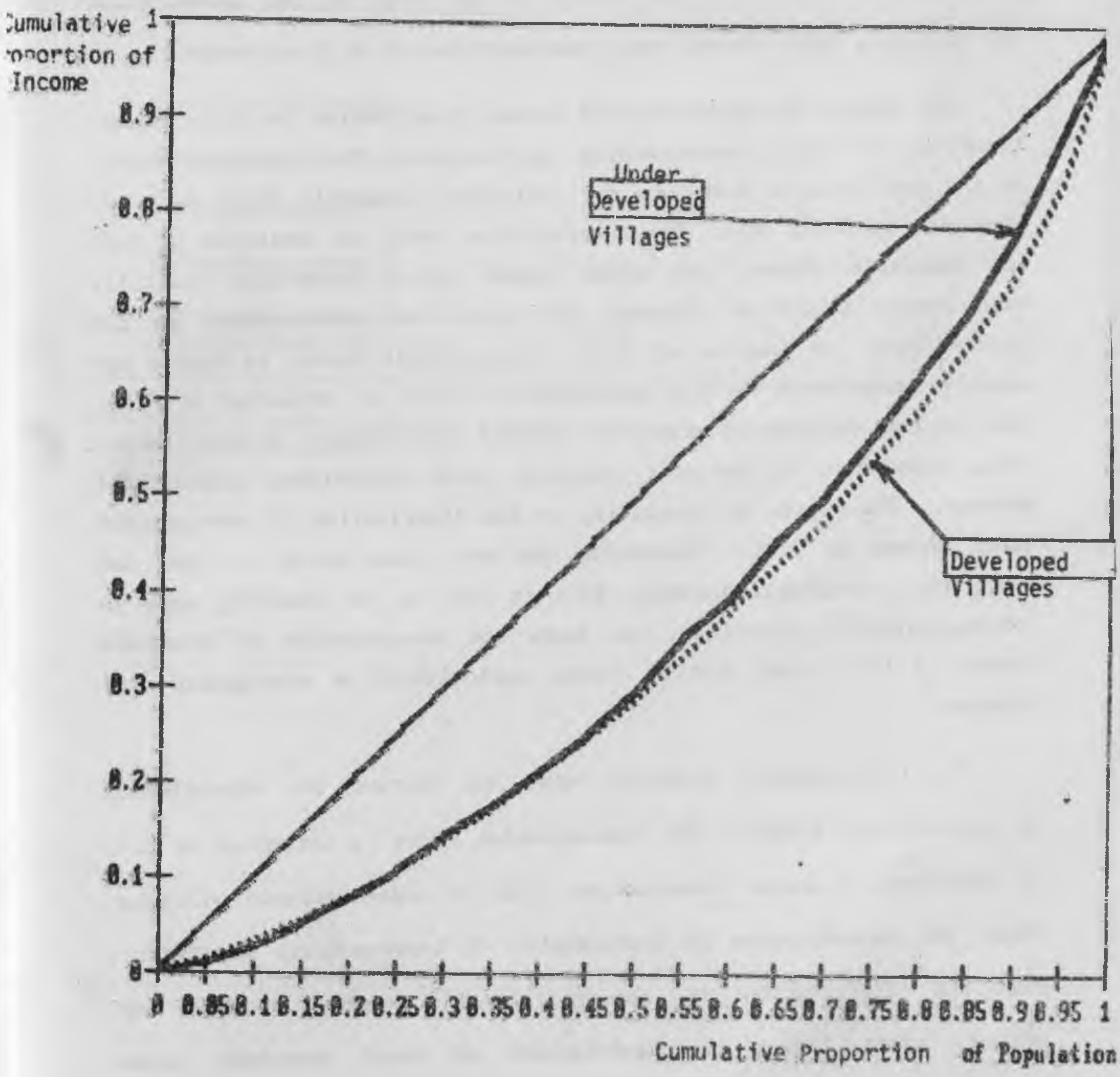

26 per cent in the developed villages, compared to 21 per cent in the underdeveloped villages. But the position of the bottom 40 per cent of the households does not change. Their share of income is 21 per cent in the developed villages compared to 22 per cent in the underdeveloped villages. So the middle 40 per cent in the income scale are squeezed, their income share declines from 42 to 39 per cent.

The degree of inequality in income distribution is often summarized by the Gini concentration coefficient. The estimated values of the coefficients based on the individual household level data are presented in Table 9.6. The concentration ratio is estimated at 0.39 for household income, but since higher income households typically have larger number of persons, the degree of concentration in per capita income is less -- at 0.35. Agricultural income is highly unequally distributed -- the concentration ratio is estimated at 0.62. This is however related mostly to unequal distribution of land ownership, since land is the most important asset determining agricultural incomes. The degree of inequality in the distribution of non-agricultural income is 0.44. Households who have less access to land and hence to agricultural incomes, tend to make up by involving more in non-agricultural activities, and hence the concentration of household income is lower than that of either agricultural or non-agricultural incomes.

The technological progress seems to improve the distribution of agricultural income. The concentration ratio is estimated at 0.60 in developed villages compared to 0.63 in underdeveloped villages, while the concentration in distribution of landownership is similar. But the distribution of non-agricultural incomes becomes more skewed, which leaves the distribution of total household income

TABLE 9.6

THE DEGREE OF INEQUALITY IN THE DISTRIBUTION OF INCOME AND LANDHOLDING, GINI RATIOS FOR SAMPLE HOUSEHOLDS, 1982

Variables	Underdeveloped Villages	Developed Villages	All Sample
Landowned	0.61	0.60	0.61
Agricultural income	0.63	0.60	0.62
Non-agricultural income	0.43	0.45	0.44
Household income	0.39	0.38	0.39
Per capita income	0.34	0.36	0.35
Per capita income with adjusted household size*	0.33	0.34	0.34

* Adjusted to adult equivalent consumption unit from age-sex composition of household members.

unchanged. With increases in income, the family size of the lower income group increases more than proportionately than higher income groups, presumably due to decline in mortality rates, which makes the distribution of per capita income relatively more skewed in the developed villages.

Alleviation of Poverty

From the welfare point of view the most appropriate indicator of the effectiveness of a development policy is its impact on the poor. So in recent years, there is a great deal of interest in measuring changes in the incidence of poverty and judging programs and policies on the basis of their impact on the alleviation of poverty.

A conventional way to measure poverty is to establish a poverty line defined as the threshhold level of income needed to satisfy the basic minimum food and non-food requirement and count the number of people living below that line, the so-called "head count method" of measuring poverty. For Bangladesh a number of studies used this method to measure the changes in poverty over time. The usual approach has been to take the normative requirement of different kinds of food, as recommended by the FAO as the minimum consumption bundle, which gives a per capita intake of 2100 kilo calories per day and estimate its cost by applying retail prices for these items. Some adjustment is then made for the requirement of the non-food necessities. Separate poverty lines are estimated for rural and urban areas by taking into account the urban-rural differences in the price level. Using this method, the poverty line for rural household was estimated by the author[6/]

at Tk 1,800 per person for 1978/79. After adjustment for the changes in the cost of living index for rural area, the poverty line for 1982 is estimated at Tk 2392.

Recently the Bangladesh Bureau of Statistics has made alternative estimates of poverty line for different levels of calorie consumption of the population, on the basis of the household level data on income and calorie intake of the population, obtained from the 1981/82 national household expenditure survey.[7/] In order to avoid the problems of (a) identification of the minimum needs of different types of food in the consumption basket and (b) choice of representative items for different consumers, the poverty line was estimated by fitting an equation of per capita income to per capita calorie intake, and then determining the income for the household calorie intake. For rural households the method yielded a poverty line of Tk 2304 for a daily intake of 2200 k. cal. per person, and Tk 1680 for an intake of 1800 k. cal. for 1981/82. The first may be referred to as the threshold income for <u>moderate poverty</u> and the second for <u>extreme poverty</u>. After adjustment for the changes in the rural cost of living, the lines are estimated for 1982 at Tk 2374 and Tk 1731 per person per year for moderate and extreme poverty respectively.

It may be noted that the two methods described above yield almost the same poverty threshold income for an intake of around 2200 k. calorie per person per day. Since the BBS estimate is based on a recent survey of a large number of households and is available for two alternative intake of energy, we have decided to apply the BBS norm to the income distribution data for this sample to estimate the proportion of population living below the poverty line.

The estimates are reported in Table 9.7. For the sample as a whole, 39 per cent of the population were below the line of moderate poverty and 21 per cent below the line of extreme poverty. The estimates are somewhat lower compared to those for rural Bangladesh derived from the 1983/84 household expenditure survey data which show that 44 per cent of the population and income below the line of moderate poverty and 29 per cent below the line of extreme poverty. The national level estimates are however comparable to our findings for the underdeveloped villages.

Technological progress seems to have a significant impact on alleviation of rural poverty. The proportion of population below the line of moderate poverty was 32 per cent in developed villages compared to 47 per cent in the underdeveloped villages, i.e., about one-third of the poor has moved up the poverty line. The progress has been achieved mainly at the bottom of the income scale. The population under extreme poverty was only 15 per cent in the developed villages compared to 27 per cent in the underdeveloped villages. For the landless group the proportion under moderate poverty was 63 per cent for the entire sample; 51 per cent in developed area compared to 73 per cent in underdeveloped area (Table 9.8). The proportion under extreme poverty for this group is down from 54 to 28 per cent (Table 9.8).

The head count measure of poverty has the limitation that it is insensitive to changes in the level and distribution of income among the poor. Two other indicators are suggested to supplement the head count measure, for a more meaningful assessment of the changes in poverty. They are the poverty gap ratio, which measures the shortfall of the mean income of the poor from the poverty line, and the

TABLE 9.7

ESTIMATES OF THE INCIDENCE OF POVERTY IN TECHNOLOGICALLY DEVELOPED AND UNDERDEVELOPED VILLAGES, 1982

Indicators	Moderate Poverty			Extreme Poverty		
	Underdeveloped villages	Developed villages	All villages	Underdeveloped villages	Developed villages	All villages
Proportion of population in poverty	0.467	0.317	0.390	0.273	0.151	0.211
Poverty gap ratio	0.329	0.264	0.303	0.262	0.216	0.246
Concentration of income among the poor (gini ratio)	0.17	0.14	0.16	0.14	0.13	0.14
Sen's index of poverty	0.207	0.116	0.162	0.100	0.048	0.74

TABLE 9.8

INCIDENCE OF POVERTY BY LANDOWNERSHIP GROUP AND TECHNOLOGY, 1982

(percent living below the poverty line)

Land owned (acres)	Moderate Poverty			Extreme Poverty		
	Underdeveloped villages	Developed villages	All areas	Underdeveloped villages	Developed villages	All areas
Less than 0.5	0.783	0.510	0.634	0.537	0.279	0.396
0.50 - 2.0	0.509	0.363	0.438	0.534	0.189	0.255
2.0 & above	0.265	0.174	0.228	0.089	0.080	0.081

Gini concentration ratio of income for the poor. Sen has suggested a weighted index of poverty incorporating all three indicators.[8/]

The estimates of the supplementary indicators of poverty as well as the Sen index are reported in Table 9.7. The results are similar to that assessed by the head count measure. The Sen index of poverty for developed villages is almost a half of that in the underdeveloped villages, whether one takes the moderate or the extreme poverty line.

Conclusions

The potential of increasing rural incomes through the diffusion of the modern technology is substantial. In technologically developed villages, where nearly three-fifths of the cropped land was under modern varieties of rice, income was about 40 per cent higher than it was in the villages where less than 10 per cent of the area had been covered. Among farmers, the income gains were higher for large landowners, indicating a trend towards inequality, but for the landless, the income difference was as high as for the large landowners. The top 20 per cent in the per capita income scale have gained in relative terms, the bottom 40 per cent have remained unaffected, while the middle 40 per cent have been squeezed, although the absolute gain has been positive for al income groups. The Gini coefficient of concentration for household income was found to be the same (0.39) for both groups of villages, but the coefficient for per capita income was only marginally higher for developed villages.

Technological progress seems to have made a significant impact on alleviation of rural poverty. The proportion of people living below the poverty line, the poverty-gap ratio, and the concentration ratio of income of the poor are all lower in the technologically developed villages compared to the underdevelloped villages. For the landless, the proportion of population living below the line of moderate poverty was estimated at 51 per cent for the developed villages, compared to 78 per cent for the underdeveloped villages. The Sen index of poverty was 0.116 for the developed villages, a substantial reduction compared to the 0.207 estimated for the underdeveloped villages.

Chapter 9 Notes

1. The 1981/82 household expenditure survey however shows that the estimated rural per capita income was less than our estimate for 1982. This may be due to the selection of a larger proportion on the technologically developed area in our sample than in the country. In Bangladesh 24 per cent of the cropped area and 28 per cent of the cereal area was under the modern varieties during 1982/83. In our sample, the proportion was 37 and 46 per cent respectively.

2. The difference was found mostly for thelandless group. Compared to underdeveloped villages, the average size of the family in he developed villages was about 13 per cent for the landless group but only 3 per cent higher for other groups. It may be the result of a reduction in mortality rates following the increases in income in very poor households.

3. A.V. Chayanov, The Theory of Peasant Economy, op. cit.

4. The equation is fitted in the form

$$Y = a_0 + a_1 (x_1 + x_2) + a_2 x_2$$

where, x_1 is the amount of unirrigated land and x_2 is the amount of irrigated land. It can be rewritten in the following form:

$$Y = a_0 + a_1 x_1 + (a_1 + a_2) x_2.$$

Thus a_1 is the coefficient of unirrigated land and $(a_1 + a_2)$ is the coefficient of irrigated land.

5. The estimate is close to the incremental-benefit cost ratio of fertilizer estimated by the IFDC from the crop-specific fertilizer response functions fitted on the farm survey data for 1979-82 periods. The weighted average value for six rice varieties evaluated at 1984 prices of fertilizer and paddy is 2.5. Mahabub Hossain, "Fertilizer Consumption, Pricing and Foodgrain Production in Bangladesh", op. cit., p. 195.

6. Mahabub Hossain, Atiur Rahman, and M.M. Akash, Agricultural Taxation in Bangladesh: Potential And Policies, Research Report No. 42, Bangladesh Institute of Development Studies, Dhaka, 1985.

7. Bangladesh Bureau of Statistics, Report of the Bangladesh Household Expenditure Survey, op. cit., p. 40-45.

8. The Sen index is given by:

$$P = H[I + (1-I) G]$$

where P is the Sen index, H is the head count ratio, I is the income gap ratio, and Go is the Gini coefficient of the income distribution of the poor.

A.K. Sen, "Poverty: An Ordinal Approach to Measurement", Econometrica 44 (March 1976: 219-231).

10: POLICY IMPLICATIONS

Technological progress is the key to overcoming the land constraint to the growth of foodgrain production in Bangladesh. Indeed, the country has maintained the food-population balance in the post-independence period mainly through technological progress. Over the last fifteen years (1970-85) the area cropped with modern varieties has gone up by more than five times from 0.5 to 2.8 million hectares, and consumption of chemical fertilizers from 0.15 million tons of nutrients to 0.59 million tons. Although the land under cultivation has remained stagnant at about 9.0 million hectares, the technological progress has made possible an acceleration of the rate of growth of crop production from 2.5 per cent per annum during 1950-71 period to 2.9 per cent during 1971-85, and the growth of cereal production from 2.6 to 3.4 per cent. The technological progress has cut the unit cost of production of rice by about one-fifth and increased gross profits per unit of land by 1.2 times. The analysis of a detailed household level data for 16 villages at different levels of technological development shows that all this may have been achieved with somewhat neutral income distribution effect and a significant reduction in the incidence of rural poverty.

There is a vast potential for further diffusion of the new technology which will have to be exploited to feed the fast growing population of the country. The following major policy directions are suggested by the study for realization of the potential.

Strengthening Agricultural Research and Extension

The credit for the diffusion of the modern technology to present levels is mainly due to the Bangladesh Rice Research Institute, which has done a commendable job to develop modern varieties suitable for local agro-climatic conditions and to tastes of consumers. The research effort has to be supported to look continuously for higher yielding varieties in order to increase production from the fixed amount of land and to keep down the cost of production.

The new varieties have spread mainly during the dry season under irrigated conditions. In Bangladesh however rice is grown mainly under rainfed conditions and the modern varieties have not spread much for this production environment. More attention should be given to the cropping system research to look for possibilities of adjustment in the existing cropping pattern to spread modern varieties in the monsoon season and to develop higher yielding varieties suitable for rainfed conditions.

The diffusion of the modern technology is also constrained by some other agro-climatic factors, e.g., continuous deep flooding of a large proportion of area during the rainy season, high levels of salinity of the soil in the large coastal area etc. More attention should be given to explore whether cost-effective higher yielding varieties could be developed for these unfavourable production environemtns.

The development of the modern technology for rice and wheat has reduced the competitiveness of some non-cereal crops like pulses and oilseeds which are important as a source of protein for the poor. It is found in this study that in technological developed villages only 10 per cent of the cropped land are allocated to pulses, oilseeds, jute and sugarcane compared to about 26 per cent in underdeveloped villages. Nationally, the sown area under non-cereal crops declined from 22 per cent during 1965-70 to 17 per cent during 1980-85 period. Obvioulsly, additional support is needed for research to develop suitable varieties for non-cereal crops in order to make them competitive with modern varieties of rice and wheat.

Farmers have experineced a faster increase in prices of modern agricultural inputs relative to output, because initially these inputs were introduced at highly subsized prices and gradually the subsidies have been phased out. There is still considerable subsidies on irrigation and the reduction of subsidies may continue for some time in the future. This phasing-out has increased the unit cost of production and cut down the profits. The changes in the relative input-output prices have affected the modern varieties more severely because they are heavy consumers of fertilizer and irrigation. It has reduced the profitability gap between the traditional and modern varieties. It is estimated that over the period 1975/76 to 1984/85, the rate of profit over the investment of working capital (cost of production) has declined from 77 to 55 per cent for the new varieties and from 49 to 43 per cent for the traditional varieties (Chapter 4).

The adverse effect of the price trends on profits can be mitigated to some extent by increasing the efficiency of input use through more effective extension services. Bangladesh has a long experience with agricultural extension and recently it has been reorganized on the lines of "Training and Visit" system, and the number of extension agents at lower administrative tiers has greatly increased. The effectiveness of agricultural extension however remains a controversial issue. The gap in the yield of modern varieties and the response of chemical fertilizers achieved in government experimental farms compared to those realized by farmers is large. Results of BRRI experiments reported by Zaman show that with 80 kg of nitrogen per hectare, the yield for modern varieties increase to 6.04 tons for the boro season and 4.43 tons for the aman season.[1/] With similar levels of application of fertilizers, farmers actually produced, during 1980-82 period, 3.74 and 2.73 tons respectively. The response of fertilizer at farmers' field is estimated at 4.3 units of paddy per unit of nutrient compared to 10:1 ratio under experimental conditions.[2/] One cannot expect that the gap would be completely eliminated since most experiments do not represent farmers' conditions, but more effective extension service can reduce the gap and increase the profitability of cultivation.

Public Investment for Irrigation

The main vehicle for the diffusion of the knew technology has been the development of irrigation facilities. It is the single most important determinant of the adoption of the new technology. About 96 per cent of the plots growing the new crops are irrigated and the villages where the new technology has not yet developed are those which do not have access to irrigation facilities. In Bangladesh, however, irrigation facilities have been developed mainly by the government and mostly with foreign aid. Only about a fifth of the land has so far been brought under modern irrigation, although it is estimated that about three fifths of the land could be irrigated with the available ground and surface water resources.3/ The small size of farm, fragmented and scattered plots and the lumpy nature of investment for irrigation development suggest that the private sector cannot be relied upon for investment in this field. The government has to take the leading role, as it has done in the past. Over the last decade the government has spent over 40 per cent of the total development budget for the agricultural sector to water resource development, and the area irrigated by modern methods increased from 7 per cent of the cultivated land in 1974/75 to 21 per cent in 1984-85. Obviously, the government will have to maintain or even accelerate the allocation of public resources for investment on irrigation, in order to maintain the moderate growth in cereal production and agricultural incomes.

The capacity of the government to accelerate investment on irrigation and to support agricultural research and extension will depend on the availability of finance. So far, the government has been largely dependent on external resources (foreign aid and loans) for financing such investment. The present low level of prices of foodgrains in the international markets and the political pressure from the food-exporting developed countries suggest that it will be increasingly difficult to mobilize foreign aid for projects which increase foodgrain production. The uncertainty about the future availability of foreign aid and the increased cost of debt servicing suggest that it is advisable for the government to seek out internal resources.

During the past, the government has had limited success in mobilizing resources from the agricultural sector.[4/] Direct agricultural taxes, collected mostly through land revenue, have lost considerable ground as a major source of government revenue since the early sixties -- the real value of tax receipts during the 1979-82 period was only about 30 per cent of the level reached in 1958-61. In recent years direct tax tapped about 2.25 per cent of non-agricultural incomes, whereas agriculture's terms of trade during the last decade did not show any consistent downward trend, and the present level of domestic prices of rice and wheat is considerably higher than the price prevailing in the international markets, indicating that the producers are protected at the expense of the consumer.

The government should take serious steps to mobilize additional resources from the agricultural sector. A move in that direction could be taken by recovering the cost of public investment from the beneficiaries. Subsidies on fertilizer have been withdrawn, but subsidy on irrigation is still large. the shallow tubewells are sold to farmers almost at a cost price, but in 1982-83 there was about 70 per cent subsidy on deep tubewells and 30 per cent on low-lift pumps.[5/] For large scale irrigation projects implemented by the Water Development Board, both the capital and the current costs are borne almost entirely by the government. The benefits of the subsidy are reaped mostly by the owners of the irrigation equipment who are large villages where the new technology has not yet developed are those which do not have access to irrigation facilities. In Bangladesh, however, irrigation facilities have been developed mainly by the government and mostly with foreign aid. Only about a fifth of the land has so far been brought under modern irrigation, although it is estimated that about three fifths of the land could be irrigated with the available ground and surface water resources.3/ The small size of farm, fragmented and scattered plots and the lumpy nature of investment for irrigation development suggest that the private sector cannot be relied upon for investment in this field. The government has to take the leading role, as it has done in the past. Over the last decade the government has spent over 40 per cent of the total development budget for the agricultural sector to water resource development, and the area irrigated by modern methods increased from 7 per cent of the cultivated land in 1974/75 to 21 per cent in 1984-85. Obviously, the government will have to maintain or even accelerate the allocation of public resources for investment on irrigation, in order to maintain the moderate growth in cereal production and agricultural incomes.

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Provision of Credit

The amount of credit obtained from both institutional and non-institutional sources is found to be a significant determinant of the adoption of the new technology (Chapter 6). This is understandable since the working capital needs on account of purchased inputs --

fertilizer, irrigation and even hired labor, are much higher for the modern varieties compared to the local varieties where the major portion of the inputs are supplied from within the household. The cash cost of production at 1984-85 prices is estimated at Tk 5241 per hectare for the modern varieties compared to Tk 1974 for traditional varieties, an increase of about 166 per cent. It is difficult for the small farmer to manage such a large investment from accumulated savings.

The government of Bangladesh recognizes the credit needs of the farmers. Over the last decade, institutions providing agricultural credit have proliferated and the number of bank branches operating in rural areas increased from 854 in 1975/76 to over 3200 in 1983/84. The supply of institutional credit at real value increased about eight times over this period. Credit disbursed during 1983/84 amounted to seven per cent of the value added in the agricultural sector, about 2.3 times the cost of chemical fertilizers consumed in the country.[6/] But owing to the weakness of the credit institutions and low interest rates, credit has remained concentrated in the hands of the medium and large farmers, and complicated loan sanctioning procedures have led to untimely disbursement, which together with the spread of corruption among bank officials, has promoted laxity in credit disciplines and poor recovery. The small farmers who need credit badly have suffered. They have to rely on the non-institutional market where the cost of a loan is substantially higher, and to that extent they benefit less from the utilization of the loan, compared to the medium and large farmers who have access to cheap loans from the institutional sources. Obviously, there is a need for overhauling the institutions and management of agricultural credit so that credit can be better targeted to smaller farmers. The government may consider elimination of subsidies on agricultural credit and/or a policy of variable cost of loan funds to banks depending on the proportion of loan they give to small and marginal farmers.

The findings of this study also point to the need for providing working capital loans to the poor so that they can generate more employment in the rural non-farm sector. The increase in agricultural income from technological progress has a sigificant impact on the expansion of the market for non-farm goods and services, which generates more employment opportunities in the non-farm sector. But some working capital is needed for self-employment in these activities. The duration of self-employment in general and in non-agriculture in particular is found to be significantly related the amount of non-land capital owned by the household (Chapter 7). Owing to the lack of capital, the poor cannot take full advantage of the employment opportunities generated in non-farm activities. The findings show that the additional employment in non-agriculture is taken up by large land-owning groups rather than by the landless (Chapter 7), and that the incremental income from non-agriculture is distributed in favor of the higher income groups (Chapter 9). The experiments conducted by the Grameen Bank show that if credit is provided to the poor they can generate productive self-employment in the non-farm sector and significantly improve their levels of living.[7] The Grameen bank provides loans to the landless without any collateral security and recovers about 98 per cent of the loans on time. The borrowers utilize the loan in family based enterprises for livestock raising, cottage industry, and trade and shopkeeping, generating employment mostly for the women. Since technological progress stimulates demand for these activities, the expansion of working capital loans for the poor in technologically developed areas should be considered to help generate more employment for the poor and improve income distribution.

SUPPLEMENTARY TABLE - 1

LONG-TERM CHANGE IN LAND ALLOCATION TO MAJOR CROPS, 1950-85

Crops	Yearly Averages for 1950-55		Yearly Averages for 1965-70		Yearly Averages for 1980-85	
	Thousand hectares	Per cent of total	Thousand hectares	Per cent of total	Thousand hectares	Per cent of total
Rice:	8,456	76.9	9,634	77.3	10,414	78.7
Aus	2,313	21.0	3,124	25.1	3,084	23.3
Aman	5,806	52.8	5,883	47.2	5,955	45.0
Boro	337	3.1	627	5.0	1,375	10.4
Wheat	40	0.4	89	0.7	574	4.3
Jute	616	5.6	918	7.4	600	4.3
Sugarcane	99	0.9	163	1.3	161	1.2
Tea	30	0.3	41	0.3	45	0.3
Tobacco	53	0.5	45	0.4	53	0.4
Pulses	380	3.5	360	2.9	297	2.2
Oilseeds	315	2.9	335	2.7	289	2.2
Potato	34	0.3	75	0.6	108	0.8
Chilli	73	0.7	84	0.7	74	0.6
Onion	25	0.2	33	0.3	33	0.3
Others	879	8.0	692	5.5	592	4.5
All crops	11,000	100.0	12,469	100.0	13,240	100.0

Compiled from figures published by the Bangladesh Bureau of Statistics.

SUPPLEMENTARY TABLE - 2

ESTIMATES OF GROWTH EQUATIONS FOR CROP PRODUCTION, 1950-85

Crops	Dependent variables	Regression Coefficients of				$\bar{R}^2$	"F" Statistics
		Cons-tant term	Time (T-1949)	Dummy (1 for 1971-85 period)	Time X Dummy		
Cereals	Area	8.973	0.0110 (8.52)	-0.0525 (-0.75)	0.0006 (0.22)	0.88	85.4
	Yield	8.340	0.0152 (8.10)	-0.2519 (-2.46)	0.0068 (1.73)	0.87	80.0
	Production	10.405	0.0262 (10.09)	-0.304 (-2.16)	0.0074 (1.36)	0.91	122.0
Non-cereals	Area	7.289	0.0127 (3.78)	0.335 (1.83)	-0.0200 (-2.84)	0.27	5.3
	Yield	8.639	0.0089 (4.78)	-0.1470 (-1.46)	0.0038 (0.97)	0.69	26.4
	Production	9.021	0.0215 (6.45)	0.1878 (1.03)	-0.0162 (-2.31)	0.59	17.6
All Crops	Area	9.145	0.0112 (8.59)	-0.0008 (-0.01)	-0.0022 (-0.82)	0.85	66.0
	Yield	8.486	0.0140 (9.38)	-0.233 (-2.86)	-0.0062 (1.96)	0.90	104.5
	Production	10.631	0.0252 (11.60)	0.234 (-1.98)	0.0039 (0.86)	0.92	140.7

Note: Dependent variables are measured in logarithms.
Figures within parentheses are estimated "t" values.

SUPPLEMENTARY TABLE - 3

VILLAGE LEVEL VARIATION IN THE USE OF FERTILIZERS IN TRADITIONAL AND MODERN VARIETIES

Survey villages	Per cent of farmers using fertilizer	Fertilizer Use per hectare (Kg of materials per hectare)		Per cent of cropped land under	
		Traditional varieties	Modern varieties	Modern varieties	Deepwater aman and local boro
Charkhamar	97.1	16	154	42.4	42.2
Rajarampur	86.8	10	141	33.7	41.3
Syedpur	79.4	21	103	3.3	26.3
Govindapur	94.0	13	189	17.6	7.6
Dandabeel	90.6	43	254	29.8	11.7
Noakhali	96.8	70	123	14.1	12.6
Harishpur	97.2	5	286	79.1	16.9
Gobrapara	88.9	33	*	nil	4.3
Birhat	33.3	11	*	nil	nil
Tuliamara	35.0	5	*	nil	nil
Khejurdanga	81.0	16	391	17.2	nil
Khunta	100.0	180	338	78.3	nil
Illashpur	100.0	120	404	72.1	nil
Chasapura	100.0	152	308	79.3	nil
Patgari	60.0	10	272	10.6	42.7
Raotora	100.0	26	325	53.1	6.0

SUPPLEMENTARY TABLE - 4

ESTIMATES OF TRANSLOG PRODUCTION FUNCTIONS FOR DIFFERENT RICE VARIETIES, 1982

Cropped Variety	Constant term	Regression Coefficients of				$\bar{R}^2$
		Log land	Log labor	Log land & log labor	Per cent of crop damage	
Aus Season:						
Local	5.026 (5.72)	0.445 (1.80)	0.556 (2.92)	0.036 (0.40)	-1.42 (-7.36)	0.82
HYV	7.452 (8.68)	0.862 (3.43)	0.323 (1.70)	-0.085 (-0.88)	-0.84 (2.65)	0.69
Aman Season:						
Local	6.156 (12.69)	0.463 (2.81)	0.473 (3.88)	0.067 (0.88)	-0.85 (-3.67)	0.82
HYV	7.562 (16.55)	0.447 (1.65)	0.299 (2.89)	0.078 (0.76)	-0.54 (-3.05)	0.83
Boro Season:						
Local	7.482 (23.73)	0.917 (8.97)	0.247 (2.93)	-0.087 (-1.54)	-1.30 (-7.76)	0.95
HYV	7.226 (27.60)	0.698 (8.00)	0.369 (5.89)	-0.047 (-1.34)	-0.69 (-8.04)	0.93

SUPPLYMENTARY TABLE - 5

MARGINAL BUDGET SHARES AND EXPENDITURE ELASTICITY OF DEMAND FOR DIFFERENT COMMODITIE

Commodity Groups	Underdeveloped Villages			Developed Villages		
	Average share	Marginal share	Expenditure elasticity	Average share	Marginal share	Expenditure elasticity
Crops:	66.97	56.47	0.84	62.91	44.95	0.71
Rice	44.55	42.33	0.95	43.78	32.81	0.75
Wheat	8.42	-0.27	-0.03	5.33	-1.57	-0.29
Pulses	1.07	1.32	1.24	0.75	1.16	1.56
Roots	1.75	1.33	0.76	1.55	1.19	0.77
Vegetables	3.68	3.39	0.92	3.27	1.95	0.60
Spices	3.44	2.88	0.84	3.66	3.33	0.91
Betelnut & Leaves	0.91	1.42	1.55	1.34	1.34	1.00
Rice husk	0.53	0.35	0.65	0.21	0.24	1.16
Jute stick	0.51	0.30	0.59	1.11	1.47	1.33
Fruits	2.12	3.42	1.62	1.92	3.02	1.57
Forestry:	4.12	3.21	0.78	3.08	2.72	0.88
Firewood	2.02	2.59	1.29	1.53	2.06	1.35
Leaves	2.10	0.62	0.30	1.55	0.66	0.43
Livestock:	4.43	5.70	1.29	4.00	6.35	1.59
Meat	1.12	2.47	2.20	1.74	3.80	2.18
Milk	0.94	1.82	1.93	1.25	2.41	1.92
Egg	0.44	0.77	1.75	0.32	0.55	1.70
Cowdung	1.93	0.64	0.33	0.69	-0.41	-0.58
Fishery:	3.55	4.22	1.19	4.35	5.32	1.22

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SUPPLEMENTARY TABLE - 5 (Contd.)

Commodity Groups	Underdeveloped Villages			Developed Villages		
	Average share	Marginal share	Expenditure elasticity	Average share	Marginal share	Expenditure elasticity
Rural Manufacturing:	9.54	12.40	1.30	9.48	10.29	1.09
Gur	1.59	2.20	1.39	1.50	2.11	1.41
Bidi	1.48	0.72	0.48	1.37	0.79	0.57
Tobacco	0.17	0.25	1.42	0.17	-0.08	-0.44
Mustard oil	2.13	2.31	1.09	2.31	2.39	1.04
Sweets	0.06	0.15	2.44	0.06	0.14	2.48
Handloom Clothes	3.77	5.98	1.58	3.70	4.22	1.14
Tailoring	0.35	0.79	2.29	0.38	0.73	1.94
Urban Manufacturing:	7.20	10.50	1.46	7.97	12.44	1.56
Mill-made Clothing	0.52	1.38	2.63	0.97	1.89	1.94
Imported Clothing	0.81	2.57	3.19	0.48	1.28	2.69
Old garments	0.29	0.20	0.66	0.28	0.15	0.53
Ready-made garments	0.42	0.79	1.86	0.51	0.87	1.73
Shoes	0.24	0.46	1.95	0.33	0.63	1.95
Sugar	0.28	0.30	1.08	0.35	0.88	2.50
Tea	0.06	0.06	1.00	0.35	0.70	2.01
Cigarette	0.13	0.34	2.60	0.35	0.90	2.58
Soyabin oil	0.34	0.19	0.57	0.13	0.25	1.90
Coconut oil	0.40	0.36	0.90	0.36	0.35	0.98
Kerosin oil	1.86	1.75	0.94	1.90	1.67	0.88
Electricity	*	*	*	0.07	0.22	2.98
Matches	0.40	0.12	0.30	0.40	0.21	0.51
Soap	0.94	1.35	1.44	1.01	1.61	1.59
Washing soda	0.25	0.15	0.62	0.10	0.05	0.47
Toiletry and Cosmetics	0.07	0.18	2.50	0.17	0.33	2.00
Others	0.19	0.30	1.58	0.21	0.45	2.14

SUPPLEMENTARY TABLE - 5 (Contd.)

Commodity Groups	Underdeveloped Villages			Developed Villages		
	Average share	Marginal share	Expenditure elasticity	Average share	Marginal share	Expenditure elasticity
Services:	4.20	7.50	1.79	8.21	17.93	2.18
Education	0.63	1.72	2.74	1.00	2.58	2.57
Health	1.36	1.90	1.39	2.49	4.58	1.84
Transport	0.73	0.95	1.30	0.98	1.93	1.96
Personal Services	0.35	0.39	1.11	0.50	0.53	1.06
Religious Services	0.60	1.25	2.10	2.38	5.48	2.30
Other Services	0.53	1.30	2.44	0.86	2.83	3.28

SUPPLEMENTARY TABLE - 6

CHANGES IN THE STRUCTURE OF INCOME FOR THE LANDLESS GROUP

Sources of Income	Underdeveloped Area		Developed Area		Difference as a per cent of income in underdeveloped area
	Income per household	Per cent of income from the source	Income per household	Per cent income of from the source	
Agriculture:	3,708	38.1	8,000	56.1	116
Cultivation	609	6.3	1,853	13.0	204
Kitchen garden	1,217	12.5	1,445	10.1	19
Livestock & poultry	397	4.1	484	3.4	22
Fishing	159	1.6	1,849	13.0	large
Wage Income	1,326	13.7	2,370	16.6	79
Non-agriculture:	6,036	62.0	6,264	43.9	4
Industry	560	5.8	175	1.2	-69
Trade	1,162	11.9	936	6.5	-19
Services	1,768	18.1	2,990	21.0	69
Wage Income	2,546	26.1	2,163	15.2	-15
Total Household income	9,743	100.0	14,264	100.0	46
Family size	4.82		5.45		13
Per capita Income	2,021		2,617		30

Chapter 10 Notes

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